THE HASHEMITE KINGDOM OF JORDAN
MINISTRY OF WATER AND IRRIGATION (MWI)
WATER AUTHORITY OF JORDAN (WAJ)
YARMOUK WATER COMPANY (YWC)

THE PROJECT FOR THE STUDY ON WATER SECTOR FOR THE HOST COMMUNITIES OF SYRIAN REFUGEES IN NORTHERN GOVERNORATES IN THE HASHEMITE KINGDOM OF JORDAN

MASTER PLAN
WATER SUPPLY

FINAL REPORT

JANUARY 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

TEC INTERNATIONAL CO., LTD.
YACHIYO ENGINEERING CO., LTD.
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Currency Exchange Rates (JICA, September, 2014)

1 JD = 147.004 JPY = 1.4166 US$

1 US$ = 103.77 JPY

1 US$ =0.7059 JD

EXECUTIVE SUMMARY

1. Since the armed conflict in Syria in 2011 the influx of Syrian refugees has further deteriorated the condition of water supply services in Jordan and particularly in the northern governorates which already suffers from limited water resources, small amount of per capita water supply, high NRW, etc.

2. This Study is undertaken to formulate a master plan for water supply in order to identify the required improvements and priority to mitigate the poor water supply services in the Study Area (Irbid and Ramtha and its suburbs, refer to Figures 1.1 to 1.3 for locations), where the Syrian refugees are largely settled in the largest urban area in the northern governorates. The Master Plan presents a water supply development plan meeting the demand of 2035 Jordanian population, which is equivalent to 2028 demand combining Jordanian population and the current level of Syrian refugees.

3. Even before the influx of Syrian refugees, Water Authority of Jordan (WAJ) has implemented the construction of transmission facilities to convey the Disi fossil groundwater nationwide. WAJ has accelerated construction of the transmission facilities to narrow the gap between the increasing demand and supply. These facilities are expected to be completed by 2017 and consequently the total amount of water available for the northern governorates is expected to increase to 91 Million Cubic Meters (MCM)/year from current level of 72 MCM/year.

4. The Master Plan intends to identify required facilities to distribute the available water to the Study Area. During the study, the proposed pipeline (refer to Figure 3.6) to convey water from the Hofa reservoir to Bait Ras district in Irbid has been earmarked as the Japan's grant aid for immediate implementation. This pipeline and all the transmission facilities are expected to complete by 2017, which will somewhat ease the gap between supply and demand.

5. Even supplying 91 MCM of water/year in the northern governorates will not satisfy the demand in 2017. Therefore, WAJ has already started development of the additional 30 MCM/year water source, totaling to 121 MCM/year water. This amount would be able to meet the 2028 demand of Jordanian and Syrian refugees combined provided that the latter's population remains at the same level as in 2013.

6. In addition to the above main objectives, the master plan has identified various issues such as high NRW, inadequate distribution management, inadequate cost recovery, insufficient corporate plan, etc. The master plan has also proposed the remedial measures for solving the above issues.

7. The master plan has been prepared considering the key objectives of a) Improvement of inadequate distribution system (strengthening and restructuring), b) Reduction of leakage through replacement of inferior pipes and adequate maintenance of pipes and c) Improvement of distribution management equipment and technical capacity for equitable supply.

8. The facility plan is prepared to achieve the planning target and following measures are proposed:
   - Strengthening and restructuring of distribution system
     - Rezoning of reservoir zones
     - Strengthening of network including increase in pipe size and addition of mains
   - Rehabilitation of inferior pipe (Galvanized Iron and old pipes)
   - Distribution management for equitable supply
     - Establishment of District Metered Area (DMA)
     - Supervisory Control and Data Acquisition (SCADA)

Irbid and Its Suburbs

9. Target values for the Irbid and its suburbs are set as shown below.

Table 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 –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

* Per capita supply and consumption are calculated based on available water supply.
Source: JICA Study Team

10. Water is planned to be distributed by gravity both from Zebdat (from the western transmission mains) and Hofa reservoirs (from the eastern transmission mains) except the use of 1 Zebdat pump zone in case of 91 MCM/year (refer to Figure 5.11). In case of 121 MCM/year, all the water requirement of Irbid is to be obtained from the western transmission mains to Zebdat reservoir, from where most part of Zebdat will be supplied by gravity except in case of 1 Zebdat pump zone (refer to Figure 5.12). Two high areas are proposed to be supplied water from Hofa reservoir through gravity. Water to Hofa reservoir will be pumped from Zebdat pumping station. The required facilities proposed in this Study are shown below.

Table Proposed Facilities in Irbid and Its Suburbs

Facility	Specifications and quantity	Required for 91 MCM/y	Required for 121 MCM/y
Zebdat Transmission Pump	Q = 732 m^3/h, H=180 m 2 numbers (1 duty and 1 stand-by)	No	Yes
Transmission pipe from Zebdat to Hofa	Ductile Iron Pipe, Diameter 500 mm x 3,700 m	No	Yes
Zebdat Distribution Pump	1,206 m^3/h, H=80 m, 2 numbers (1 duty and 1 stand-by)	Yes	Yes
Pipe for Strengthening	185 km	Yes	Yes
Pipe for Rehabilitation	305 km	Yes	Yes
SCADA	1 set	Yes	Yes

Source: JICA Study Team

11. Implementation Schedule and Cost
The facilities for strengthening of network are proposed to be implemented in Phase 1 while facilities for rehabilitation are proposed to be implemented during phases 2 to 4.

Table Implementation Schedule in Irbid and Its Suburbs

Phase	Year	Cost (million JD)	Main facilities	For 91 MCM/y	For 121 MCM/y
1	2016 – 2020	61.92	Distribution Pump Distribution Pipe (for strengthening) SCADA and DMA	Yes	Yes
			Transmission Pump and Pipe (Zebdat to Hofa)	No	Yes
2	2021 – 2025	18.87	Distribution (for replacement) and Service Pipes	Yes	Yes
3	2026 – 2030	14.86	Distribution (for replacement) and Service Pipes	Yes	Yes
4	2031 - 2035	14.86	Distribution (for replacement) and Service Pipes	Yes	Yes
Total		110.50			

Source: JICA Study Team

<u>Ramtha and Its suburbs</u>

12. Target values for Ramtha and its suburbs are set as shown below.

Table Target Values for Improvement of Service in Ramtha and Its Suburbs

Indicators for improvement		Current (2013)	Target values in 2035	Required main measures
The number of “No water” complaints (equitable supply)		1,630	100	• Distribution management for equitable supply • All measures below
Water supply pressure		0 – 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

Source: JICA Study Team

13. In the master plan, Ramtha city will be supplied from the eastern transmission mains, supplemented by Abu Al Basal pumping station. The northern localities will be supplied from the Hodod pumping station using water of Jaber wells through Mahasi pumping station, supplemented from the eastern transmission mains (refer to Figure 6.4).

14. The required facilities are transmission pipe of 300 mm diameter and 5,900 m in length to transfer water from Hodod pumping station to the transmission line at Mahasi pumping station. Reservoir is not proposed in Ramtha. All distribution pumps at the existing pump stations are very new and will be utilized for transmission pump in the plan. The total length of pipe proposed for strengthening of network is 47 km comprising 20 km of pipe required in case of 91 MCM/y and 27 km of pipe required for 121 MCM/y. In addition, 80 km of pipe is proposed for rehabilitation of network.

Table Proposed Facilities in Ramtha and Its Suburbs

Facility	Specifications and Quantity	Required for 91 MCM/y	Required for 121 MCM/y
Transmission Pipe (Hodod to Mahasi)	6 km	Yes	No
Distribution Pump	-	Yes	Yes
Pipe for Strengthening	20 km	Yes	No
Pipe for Strengthening	27 km	No	Yes
Pipe for Rehabilitation	80 km	Yes	Yes
SCADA	1 set	Yes	Yes

Source: JICA Study Team

15. Implementation Schedule and Cost
The facilities for strengthening of network are proposed to be implemented under Phase 1 while facilities for rehabilitation are proposed to be implemented during phases 2 to 4.

Table Implementation Schedule in Ramtha and Its Suburbs

Phase	Year	Cost (million JD)	Main Facilities	Required for
1	2016 – 2020	17.34	Distribution Pipe (for strengthening) SCADA and DMA Transmission Pipe (Hodod to Mahasi)	both 91and 121 MCM/y
2	2021 – 2025	3.94	Distribution (for replacement) and Service Pipes	both 91and 121 MCM/y
3	2026 – 2030	3.73	Distribution (for replacement) and Service Pipes	both 91and 121 MCM/y
4	2031 - 2035	3.73	Distribution (for replacement) and Service Pipes	both 91and 121 MCM/y
Total		28.74		

Source: JICA Study Team

Irbid and Ramtha

16. The economic evaluation reveals that the Economic Internal Rate of Return (EIRR) of the project exceeds 10 % of the opportunity cost of capital as indicated below. As a result, the project is concluded to be economically feasible.

- EIRR of Irbid project components: 12.3 %
- EIRR of Ramtha project components: 10.0 %
- Consolidated EIRR; 11.7 %

17. The financial evaluation reveals that the project is financially unfeasible because the Financial Internal Rate of return (FIRR) are lower than 6 % of the opportunity cost of capital as enumerated below.

- FIRR of Irbid project components: 3.0 %
- FIRR of Ramtha project components: -3.1 %
- Consolidated FIRR; 1.4 %

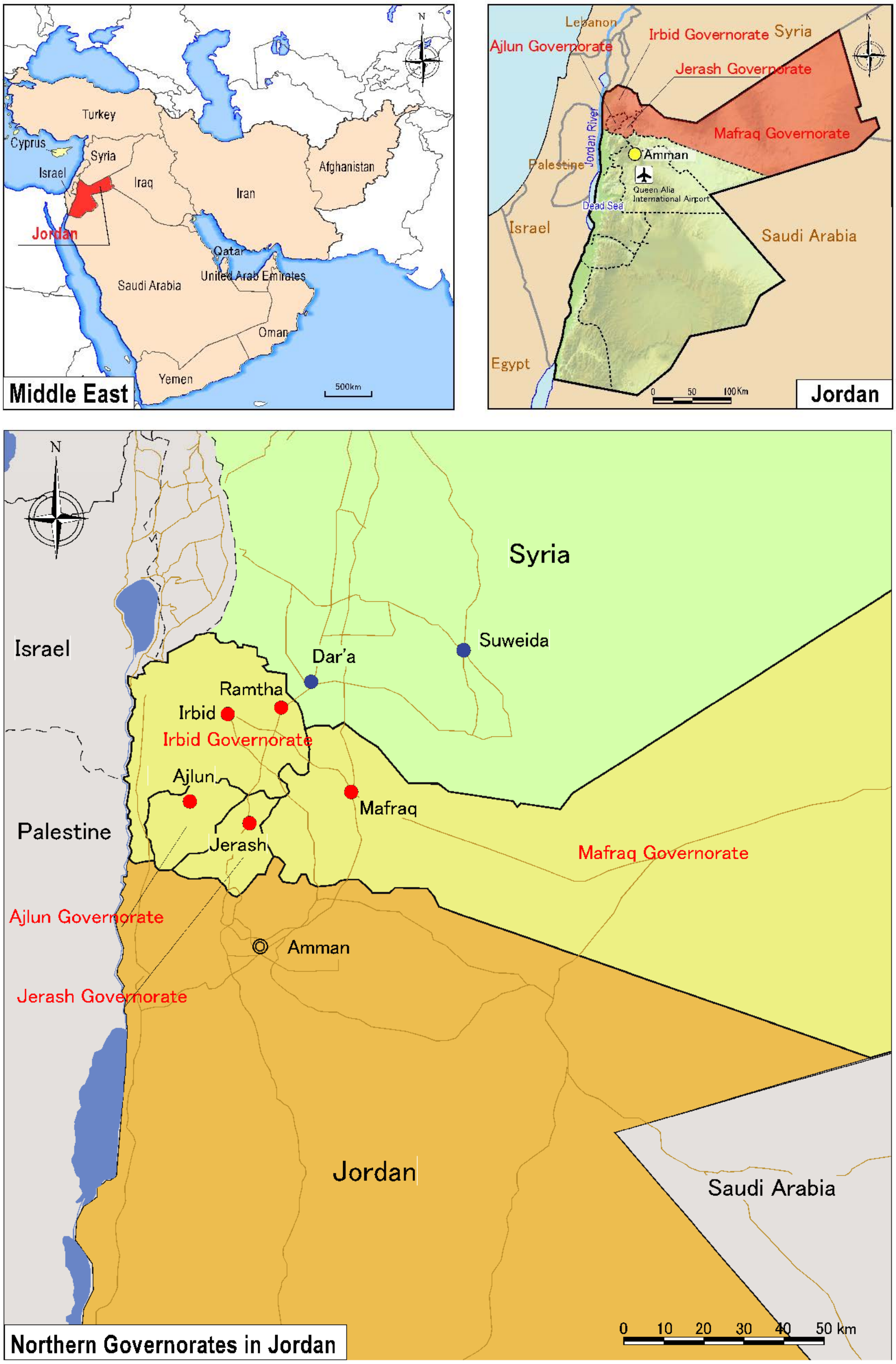
It is apparent that low level of present tariff is a major factor contributing to low FIRRs. Table below summarizes the results of sensitivity analysis by applying the conditions that can raise the FIRR of the project higher than 6 %. The table indicates measures such as substantial increase in the tariff and drastic reduction in the investment cost for attaining the financial feasibility. However, these measures may not be easily put into effect. Therefore, the government grants as a part of the investment costs are likely to be the most desirable measures to make the project viable.

Table Sensitivity Analysis

Project	Conditions to lift the FIRR more than 6 %		FIRR
Irbid	1) Tariff increase	+ 12 %	6.2 %
	2) Investment cost	- 16 %	6.1 %
Ramtha	1) Tariff increase by	+ 58 %	6.0 %
	2) Investment cost	- 70 %	6.1 %
	3) Investment cost + Tariff increase	- 50 % + 17 %	6.2 %

Source: JICA Study Team

18. Environmental and social impacts are expected during construction period like noise, vibration, etc., and the negative impacts are not expected to be significant. These impacts can be mitigated by appropriate measures. For this, monitoring plan is proposed. One more concern is occurrence of antiquities during excavation for construction. If found, consultation with the concerned agency is required.



Location Map

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ABBREVIATION

AWC	Aqaba Water Company
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
CF	Cash Flow
DCIP	Ductile Cast Iron Pipe
DI	Ductile Iron
DMA	District Metered Area
DOS	Department of Statistics
DWCP	Disi Water Conveyance Project
E/N	Exchange of Notes
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EIRR	Economic Internal Rate of Return
FIRR	Financial Internal Rate of Return
G/A	Grant Agreement
GDP	Gross Domestic Product
GI	Galvanized Iron
GIS	Geographic Information System
GRDP	Gross Regional Domestic Product
HDPE	High Density Polyethylene Pipe
HRD	Human Resource Development
HWL	High Water Level
IBNET	International Benchmarking Network for Water and Sanitation Utilities
ICT	Information Communication Technology
IEC	Information, Education and Communication
IEE	Initial Environmental Examination
JICA	Japan International Cooperation Agency
JOD/JD	Jordanian Dinar
JWCM	Jordan Water Company - Miyahuna
KfW	Kreditanstalt für Wiederaufbau
LLC	Limited Liability Company
lpcd	Liters per Capita per Day
LWL	Low Water Level
MBAS	Methyl alkyl benzene sulfonate
MCM	Million Cubic Meter
MOE	Ministry of Environment
MOF	Ministry of Finance
MOI	Ministry of Interior
MOMA	Ministry of Municipal Affairs
MOTA	Ministry of Tourism and Antiquities
MPWH	Ministry of Public Works and Housing
MCM	Million Cubic Meters
MWI	Ministry of Water and Irrigation
NGWA	Northern Governorates Water Administration
NRW	Non-Revenue Water
O & M	Operation & Maintenance
OJT	On-the-Job Training
PE	Polyethylene Pipe
pH	Potential of Hydrogen

PIs	Performance Indicators
PMU	Performance Management Unit
pph	Persons per Hectare
PRV	Pressure Reducing Valve
RFP	Request for the Proposal
ROU	Regional Operating Units
RSCN	Royal Society for the Conservation of Nature
RSWC	Red Sea Water Company
SCADA	Supervisory Control and Data Acquisition
SOP	Standard Operating Procedure
THM	Trihalomethanes
TDS	Total Dissolved Solids
TOR	Terms of Reference
ToT	Training of Trainers
UFW	Unaccounted-for Water
UN	United Nations
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
UV	Ultraviolet
WAJ	Water Authority of Jordan
WASH	Water, Sanitation and Hygiene
WLRP	Water Loss Reduction Program
WWTP	Wastewater Treatment Plant
YWC	Yarmouk Water Company

CHAPTER 1 INTRODUCTION

1.1 Study Background

Jordan is one of the 10 poorest countries in the world[1] in terms of water resources with available annual per capita water resources of only 120 - 145 m^3, which is far below the internationally recognized water scarcity level of 500 m^3. The increase in population and resulting water demand have caused enormous pressure on the limited water resources and created a chronic poor water supply and demand imbalance prevailing in Jordan now.

The abrupt influx of a large number of Syrian refugees started in March 2011. As a consequence, poor water supply and demand imbalance has further aggravated in Jordan, particularly in the northern governorates.

This has necessitated international support from organizations including JICA (Japan International Cooperation Agency) to improve the water supply services in affected areas. In this context, the Minutes of Meetings and the Record of Discussions on "The Project for the Study on Water Sector for the Host Communities of Syrian Refugees in the Hashemite Kingdom of Jordan (hereinafter called the Project)" were signed between JICA and the Water Authority of Jordan (WAJ) on 30 October 2013 and on 13 November 2013, respectively.

1.2 Goals of the Project

The expected goals which will be attained after completion of the Project are described below, based on the Record of Discussions and successive discussions with the Jordanian side:

- Goals of the Project

The goals of the Project are to assess the effects of migration of Syrian refugees on water supply and wastewater management services in the northern governorates, to prepare a master plan for improving the water supply and wastewater management services in the host communities of Syrian refugees, including networks, pumps, reservoirs and transmission pipelines, and to recommend sustainable solutions.

- Goals of the Proposed Master Plan

The goals to be attained by implementing the proposed master plan are to achieve sustainable development of water sector in the host communities of Syrian refugees.

The Record of Discussions defines three outputs of the Project:

Components A: Preparation of outline designs for the most prioritized projects
Components B: Preparation of water supply and wastewater master plan
Components C: Pilot activities

This report focuses on Component B related to water supply, and its objectives are as follows:

- ✓ To assess the effects of influx of Syrian refugees on the water supply services.
- ✓ To formulate the master plan of water supply in the areas affected due to Syrian refugees or host communities.
- ✓ To identify, assess and prioritize short- and mid- term projects in the master plan.

This volume of report is prepared for the master plan for water supply and the master plan for

[1] Water security and protection, June 2012, Eng. Ali subah, Secretary General Assistant, Ministry of Water and Irrigation, Jordan

wastewater is prepared in the separate volume.

The short and mid-term projects are prepared by sharing ideas with the process of providing “National Resilience Plan 2014–2016 (see Section 2.5.2)” in the water sector developed by the Task Force. The master plan aims to provide a strategic roadmap for the development of the water sector so that the concerned authorities and organizations can share the development policy and sustain certain projects by aligning with the plan. Furthermore, the master plan will be continuously revised according to the changes in circumstances of Syrian refugees as well as host communities in Jordan.

1.3 Study Component of Water Supply

This study is in line with the WASH sector-proposed interventions under the National Resilience Plan 2014 - 2016. Out of these interventions, the restructuring of transmission and distribution systems and network reinforcement/rehabilitation have been selected for the main part of the master plan study under the Component B. This report describes the water supply content of the master plan including the restructuring and rehabilitation plan as a result of the study. The discussion on the selection of the main study components is given in Appendix 1.

1.4 Study Area

The areas related to the Study Area are classified into the following three categories:

- Irbid city and its suburbs and Ramtha city and its suburbs in the Irbid Governorate (the Study Area)
- Bani Kinana district in the Irbid Governorate
- Northern governorates (Irbid, Jerash, Ajloun and Mafraq)

The maps of the northern governorates, the Study Area of Irbid and Ramtha, and the detailed location of the Study Area are shown in Figure 1.1, Figure 1.2 and Figure 1.3, respectively, and the nature of the Study Area is described below.

Irbid and Ramtha cities and their suburbs are selected as the Study Area for preparing the master plan of water supply under Component B. Initially, the three cities of Irbid, Ramtha and Mafraq were selected for preparing the master plan to alleviate water demand and supply imbalance in the most affected areas. However, the study on Mafraq water distribution system was dropped later because KfW showed its intention to study and finance the improvement of water supply network system.

In addition, the water supply system and water demand in Bani Kinana district, and the water supply network, which is connected to Irbid city water supply network at the downstream, are studied because water to a part of this district has to be supplied from the Irbid system in future and the capacity of planned facilities in the Study Area must consider the water supply system and demand of this district.

Furthermore, all the northern governorates are studied to evaluate the regional water transmission system and balance of water demand and supply because most of the water supplied to the Study Area is from outside the Study Area through the regional water transmission system in the northern governorates managed by Yarmouk Water Company (YWC).

Figure 1.1 Location of Northern Governorates

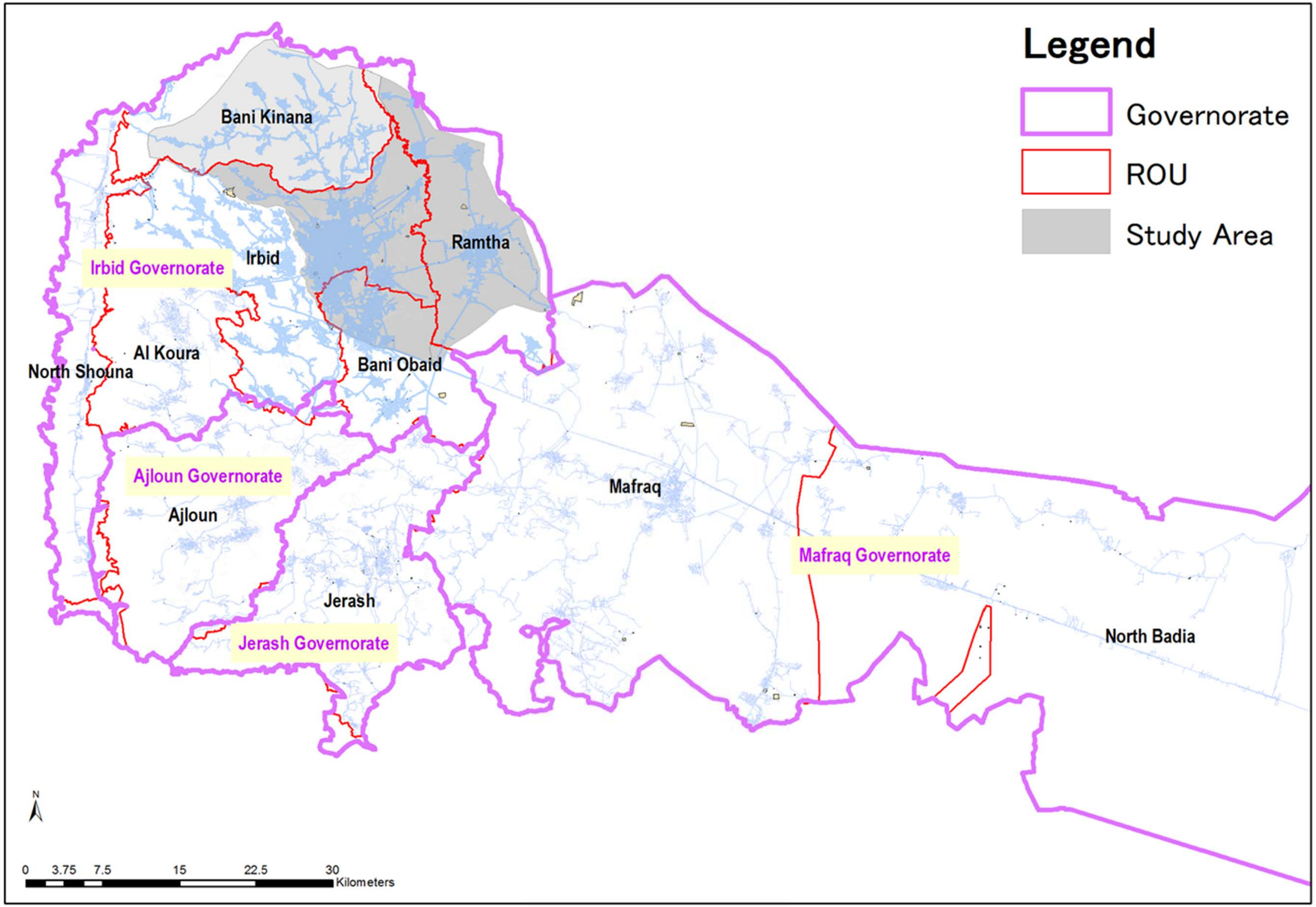


Figure 1.2 Northern Governorates with YWC Regional Operating Unit Area

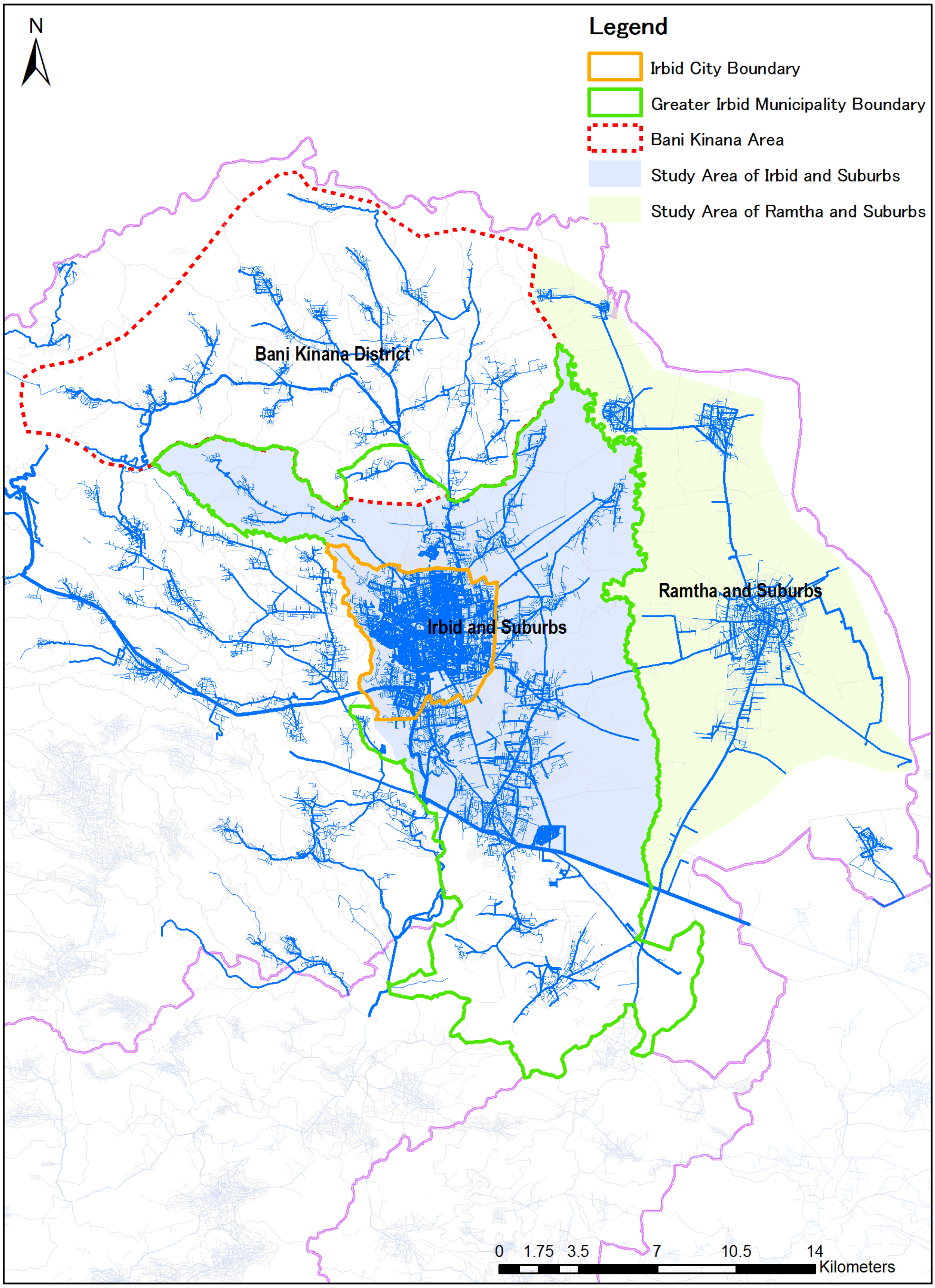


Figure 1.3 Study Area of Irbid and Ramtha and Its Suburbs

1.5 Target Year

The target year of the water supply master plan is set as 2035, about 20 years ahead. This target has been changed from the target year set in the original Terms of Reference (TOR) of the Project, after discussion with Jordanian side. If the number of Syrian refugees is counted, the target year is regarded as 2028 (see section 2.1.3 (2)).

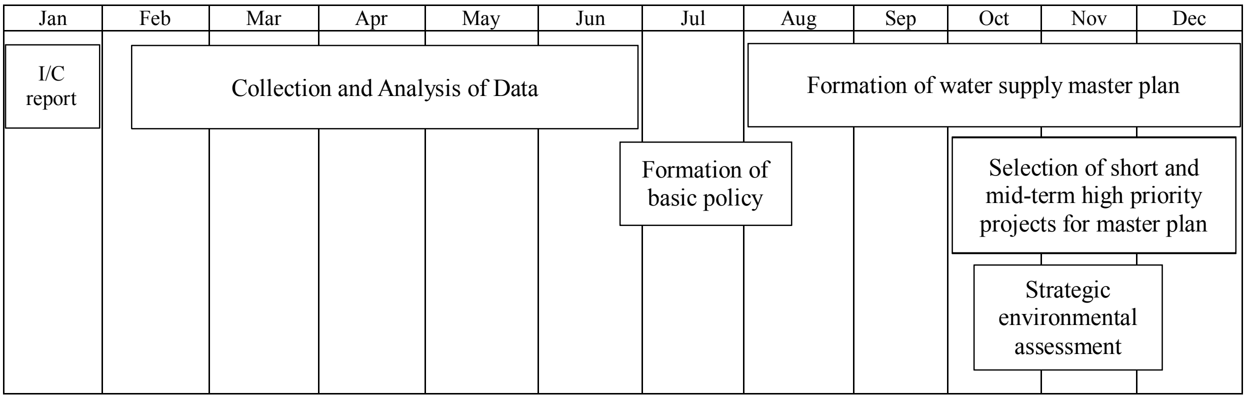
1.6 Study Objectives

The objective of this study is to prepare a master plan of water supply in the Study Area (hereinafter called "the Plan"), updating the previous plans to reflect the current situation of the increasing number of Syrian refugees.

Presently, two water supply development plans exist for the Study Area. The "Hydraulic Analysis of the Water Systems in the Irbid Governorate" was developed from 1996 to 1997. The study covers system layouts, network analysis, un-accounted for water (UFW) and leakage control, system improvement and rehabilitation. After about 10 years, the study was updated and the "Water Loss Reduction Program (WLRP)" for the Northern Governorates was prepared from 2004 to 2005.

1.7 Study Schedule

This Study started in January 2014 in agreement with the Inception (I/C) Report on 7 January 2014. The study schedule and major milestones are shown below and this report corresponds to the draft final report of the water supply master plan.



<u>Major Milestones</u>

January 2014 : Selection of Study Component
February 2014 : Selection of Study Area
March 2014 : Start of Study
August 2014 : Presentation of Study Concept
October 2014 : Presentation of Study Progress
December 2014: Submission and Discussion of Draft Final Report
January 2015 : Submission of Final Report

1.8 Report Component

Chapter 1 gives the introduction, and Chapters 2 and 3 focus on the existing situation of the Study Area in Chapter 2 and the existing water supply in Chapter 3, to understand current issues and problems in the water supply system. The last section of Chapter 3 summarizes issues and problems in the water supply sector in the Study Area.

Planning is described from Chapter 4 onwards. Chapter 4 describes demand and water source projection of not only the Study Area but also the northern governorates and projects the allocated water sources for the Study Area. Chapter 5 and Chapter 6 describe plans for water supply facilities in Irbid city and its suburbs and Ramtha city and its suburbs, respectively, based on the allocated water source amounts.

Chapter 7 explains operation and maintenance (O&M) plan and institutional aspects of YWC based on the conditions of the Study Area. Chapter 8 describes the cost estimate and the implementation schedule.

Chapter 9 evaluates financial and economic viability for the proposed project, while Chapter 10 describes environmental and social considerations of the proposed projects. Finally, Chapter 11 presents conclusions and recommendations.

CHAPTER 2 EXISTING CONDITIONS OF THE STUDY AREA

2.1 Socio-Economic Conditions

2.1.1 Administrative Organization and Boundary

Jordan consists of 12 governorates (see Figure 1.1), and the Irbid Governorate is divided into 9 Liwas (see Figure 2.1). “Liwa” is an administrative unit under governorate. For statistical purposes by Department of Statistics (DOS), Liwa is almost the same as “District,” which has a hierarchy of Governorate – District – Sub-district – Locality. In addition, a large city has “Neighborhood” under Locality. In the Study, statistical classification is used for population distribution and water demand estimation because population data is available by this classification.

A municipality may be formed by combining several Liwas such as the Greater Irbid Municipality which consists of a part of the Qasabat (central) Irbid Liwa and all of the Bani Obaid Liwa; or it may be a part of a Liwa, such as, the Ramtha Liwa, which has two municipalities namely, the Ramtha Municipality and the Sahel Horan Municipality, as shown in Figure 2.1. The old Irbid Municipality was abolished and has become a part of the Greater Irbid Municipality since 2011. However, the old Irbid Municipality is often called Irbid city today. Following this custom, the old Irbid municipality is referred to as “Irbid city” and the remaining villages are referred to as “suburbs” in this Study (see Figure 1.3).

In addition, another classification for Irbid municipal area for planning purpose according to the Ministry of Municipal Affairs is: urban growth area, rural growth area and rural settlement (see Figure 2.2). The population distribution in the Study Area uses this classification as well as statistical classification in Chapter 5.

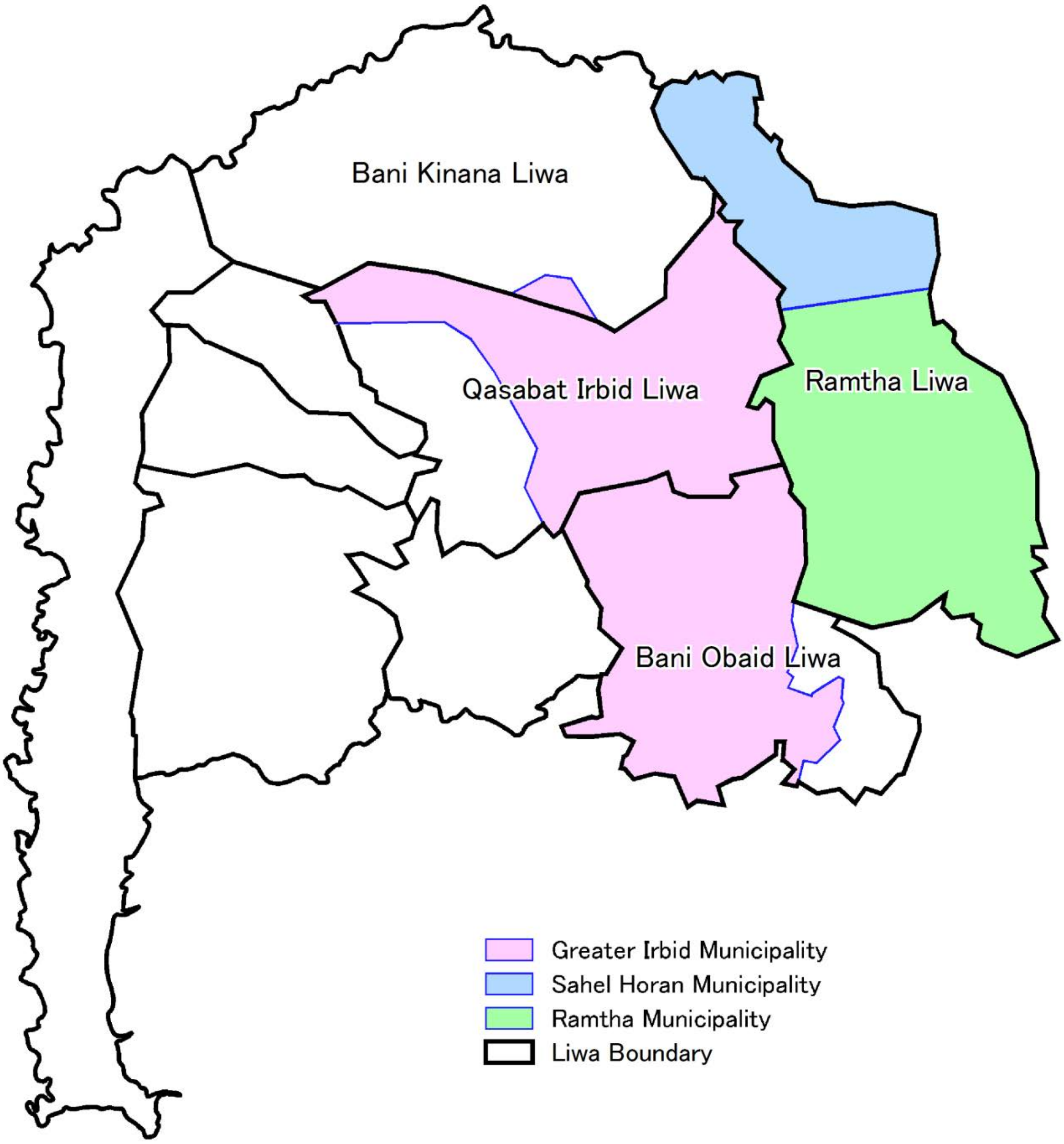
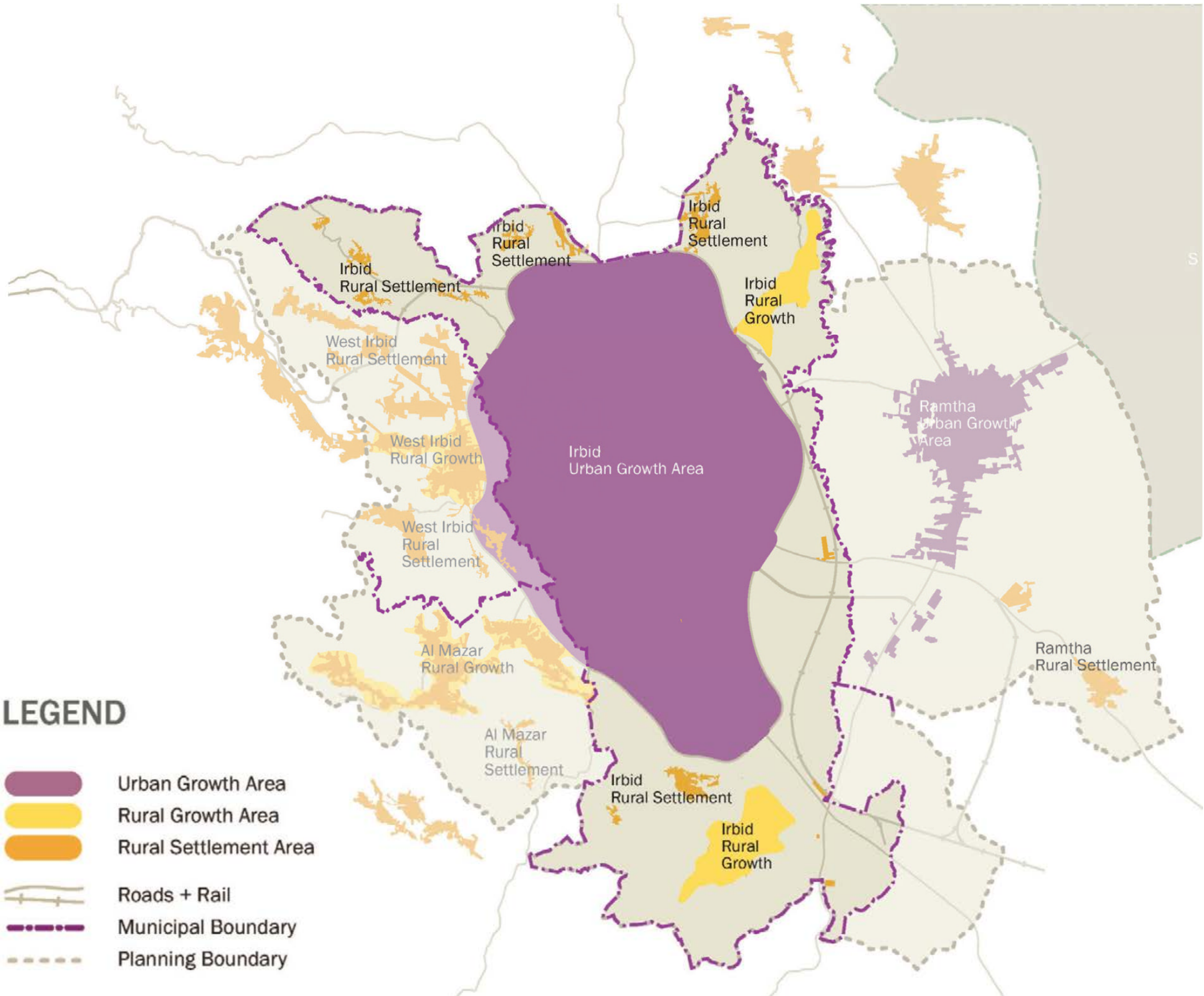


Figure 2.1 Liwa and Municipalities in Irbid Governorate



Source: Irbid 2030: Greater Irbid Area Plan, the Ministry of Municipal Affairs

Figure 2.2 Greater Irbid Municipality with Urban Growth Area

2.1.2 Economy

Gross Domestic Product (GDP)

Table 2.1 shows the Gross Domestic Product (GDP) of Jordan. The nominal GDP in 2012 is 22 billion JD (approximately 3 trillion Yen), and the GDP growth rate compared to the previous year is 7.3 %. The GDP growth rate in 2008 was 29 % due to the contribution of the mineral resource sector and the government sector. GDP growth rate still remains high although it has slowed down after 2009.

Tertiary sector accounts for approximately 70 % of the whole sector in Jordan, 30 % of which is contributed by the government sector, followed by the finance, transport, and wholesale and retail sectors. The contribution of the agriculture sector (3 %) and the manufacturing sector (18 %) to the whole sector has been growing year after year.

Table 2.1 GDP and Its Growth Rate in Jordan

Item	2008	2009	2010	2011	2012
GDP (Nominal) (Billion JD)	15.6	16.9	18.8	20.5	22.0
Primary industry	1.2	1.0	-	-	-
Secondary industry	3.9	4.3	-	-	-
Tertiary industry	10.5	11.6	-	-	-
GDP growth rate (%)	29.3	7.7	11.2	9.0	7.3
Primary industry	89.0	-16.7	-	-	-
Secondary industry	26.3	9.9	-	-	-
Tertiary industry	24.8	10.8	-	-	-
Contribution by industry (%)					
Primary sector	7.8	6.0	-	-	-
Secondary sector	24.9	25.3	-	-	-
Tertiary sector	67.3	68.7	-	-	-

Note: 1) GDP by sector after 2010 is void because the data have not been obtained.
2) GRDP of the Northern governorates is not available.

Source: JICA Study team based on Jordan Statistical Yearbook 2012 (2008-2009), Jordan in Figures, Department of Statistics (2010-2012)

The main economic sectors in Irbid are agriculture, real estate, transport and communication, electricity, water supply and public administration. The GDP of Greater Irbid has been estimated at 445 Million JD, with a GDP per capita of 978 JD in 2002 at current prices against 1,240 JD per capita for Jordan.[2]

2.1.3 Population

(1) Jordanian Population

Population growth rates in Jordan were high in the past: 4.8 % per annum (p.a.) during the period 1961–1979, 4.4 % p.a. between 1979 and 1994, 2.6 % p.a. between 1994 and 2004, and 2.2 % p.a. between 2004 and 2012. The high rates of growth were due to the influx from the West Bank in the late 1960s, the high rate of natural increase, and the return of Jordanians after the 1990 Gulf crisis and the 2003 Second Gulf War. On the other hand, fertility declines in Jordan have contributed to slowing down of the population growth rate from 3.2 % p.a. in the second half of the 1990s to 2.3 % p.a. in 2007 and 2.2 % p.a. in 2012[3].

Populations in the Irbid Governorates are shown in Table 2.2. Populations in Irbid and Ramtha cities in 2012 are estimated at 307,024 and 87,499, respectively.

Table 2.2 Governorate Population

(Unit: persons)

Year/ Governorate	1994 Census (persons)	2004 Census (persons)	2012 Estimate (persons)
Irbid	751,634	927,892	1,137,100
Mafraq	178,634	244,188	300,300
Jerash	123,190	153,602	191,700
Ajloun	94,548	118,725	146,900
4 Governorates	1,148,006	1,444,407	1,776,000
Jordan	4,139,458	5,103,639	6,388,000

Source: Department of Statistics (DOS)

2 Meso-economic Analysis of the Greater Irbid, Jordan (2005)
3 Population and Family Health Survey 2012, Department of Statistics

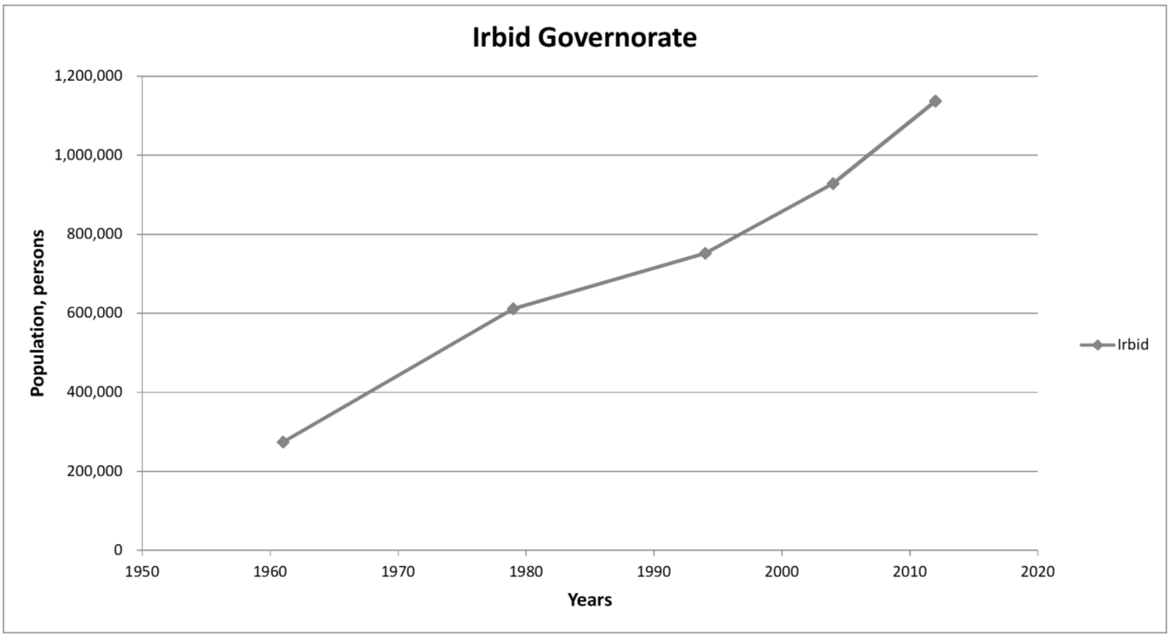


Figure 2.3 Population in Irbid Governorate

(2) Population of Syrian Refugees

As is seen in Figure 2.4, the influx of Syrian refugees started in the first quarter of 2012 and the number of Syrian refugees has increased drastically during the first quarter of 2013, reaching to about 500,000. Then, the growth was slowed down in April 2013 and the number of Syrian refugees reached to about 600,000 in April 2014. As of October 2014, this number is about 619,000. Half of the total Syrian refugees in Jordan, about 322,000 persons stay in the northern governorates.

Table 2.3 Syrian Refugees Registered with UNHCR

(Unit: persons)

Northern Governorates		Other Governorates		Total
Mafraq	156,013	Amman	170,980	
Irbid	144,438	Zarqa	70,683	
Jerash	11,184	Balqa	19,695	
Ajloun	9,990	Other	25,610	
Sub-total	**321,625**	**Sub-total**	**286,968**	**608,593**

Source: UNHCR: Date is not clear, however, probably as of July 2014.

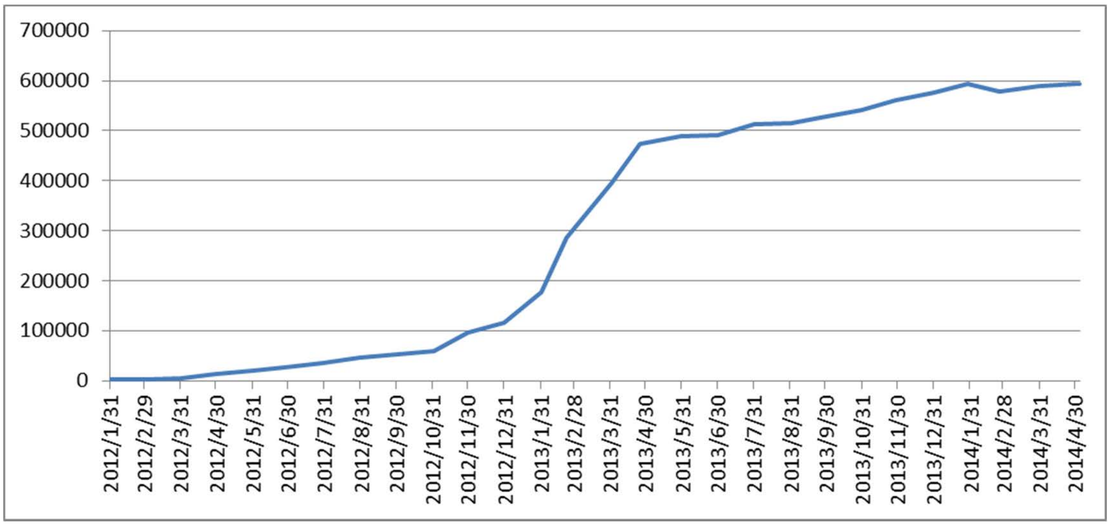


Figure 2.4 Syrian Refugees Registered with UNHCR

The number of Syrian refugees in the northern governorates as of July 2013 was estimated separately by the Ministry of the Interior (MOI). This number is 394 thousands as shown in Table 2.4, which is larger than 322 thousands according to the UNHCR estimate. It seems MOI estimate includes un-registered persons, so the number is larger than that presented by the UNHCR. The total number of Syrian refugees including unregistered refugees is not known, but it is more than this figure.

Table 2.4 Syrian Refugees and Jordanian Population in the Northern Governorates

Governorate	Refugees Population in July 2013	Jordanian Population in 2012	Total
Irbid	239,750	1,137,100	1,376,850
Mafraq	134,900	300,300	435,200
Jerash	10,218	191,700	201,918
Ajloun	9,066	146,900	155,966
Total	393,934	1,776,000	2,169,934

Source: Ministry of Interior

In the Study, the MOI estimate for July 2013 is used as a fixed number for future refugee population because it may include un-registered persons also, and because the recent trend of change in the refugee population is relatively stable. The population estimated by the MOI is shown in Table 2.4 together with the Jordanian population in the northern governorates in 2012. The total population is approximately 2.2 million consisting of 1.8 million Jordanians and 0.4 million refugees. The refugee population accounts for 18 % of the total population.

Table 2.5 and Figure 2.5 show the projected Jordanian population and population of Syrian refugees. The sum of the current Jordanian population and refugee population is equivalent to the Jordanian population in 2022; the projected Jordanian population in 2035 is equivalent to the sum of the Jordanian population and the refugee population in 2028. If the number of refugees is counted in this master plan, the target year becomes 2028. In such a case, facilities need to be completed earlier than the planned implementation schedule.

Table 2.5 Projected Jordanian Population and Syrian Refugees in the Northern Governorates

Year	Jordanian Population	Syrian Refugee Population	Population Including Refugees
2012	1,776,000	393,934	2,169,934
2015	1,890,248	393,934	2,284,182
2020	2,097,312	393,934	2,491,246
2022	2,185,447	393,934	2,579,381
2025	2,327,175	393,934	2,721,109
2026	2,375,590	393,934	2,769,524
2028	2,477,087	393,934	2,871,021
2030	2,582,356	393,934	2,976,290
2035	2,865,668	393,934	3,259,602

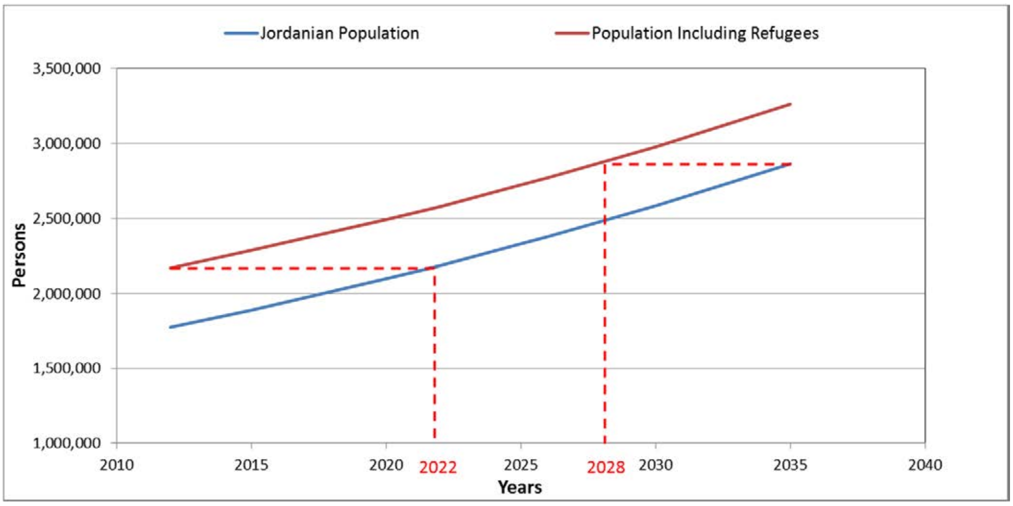


Figure 2.5 Projected Jordanian Population and Total Population Including Syrian Refugees

2.1.4 Household Income and Expenditure

A main source of data for household income is the Household Expenditures and Income Survey in 2010 conducted by the DOS. The following table shows annual income from employment of the northern governorates, Amman, and the country average. It shows that the income of Irbid is lower than that of the country average.

Table 2.6 Average Household Income from Employment of Northern Governorates

(Unit: JD)

Governorate	Household Income from Employment	Total Household Income
Irbid	3,442	7,877
Mafraq	3,606	7,276
Jerash	3,568	7,946
Ajloun	3,342	7,471
Amman	4,099	10,619
Country Average	3,843	8,824

Note: Total income includes employment, own account, rent, transfer and property.
Source: Household Expenditures & Income Survey 2010, Department of Statistics

Table 2.7 and Figure 2.6 show the results of expenditure survey for the northern governorates. In terms of the lowest expenditure decile, Ajloun and Irbid are less than 3,000 JD per year and Jerash is around 3,600 JD per year. The country average is less than 3,600 JD per year. These show that relatively low income people reside in the Study Area.

Table 2.7 Distribution of Households by Governorate and Household Expenditure Group

(Unit: %)

Household Expenditure Group (JD/year)	Irbid	Mafraq	Jerash	Ajloun	Amman	Average
<14,000	**11.8**	8.2	**12.1**	6.1	**24.7**	**16.0**
- 12,000	6.8	5.7	**14.8**	4.5	8.1	7.4
- 10,000	**10.3**	9.9	**17.8**	8.3	**11.3**	**10.6**
- 9,000	7.0	6.4	7.1	6.0	6.6	6.9
- 8,000	7.8	7.1	5.0	8.1	9.2	8.4
- 7,000	**10.1**	**12.7**	**11.3**	**13.7**	9.0	9.8
- 6,000	**12.0**	**10.2**	9.6	**13.4**	**10.1**	**11.1**
- 5,400	6.6	8.2	6.7	6.5	5.5	6.5
- 4,800	6.7	6.5	1.9	8.7	4.8	6.0
- 4,200	5.9	7.6	3.2	7.5	4.2	5.5

Household Expenditure Group (JD/year)	Irbid	Mafraq	Jerash	Ajloun	Amman	Average
- 3,600	5.1	5.6	5.9	4.2	3.3	4.7
- 3,000	5.1	5.2	1.3	6.6	1.5	3.4
- 2,400	2.3	2.9	1.7	3.2	0.8	1.8
- 1,800	1.4	2.2	0.1	1.3	0.6	1.2
>1,800	1.0	1.6	1.4	1.8	0.2	0.8
	100.0	100.0	100.0	100.0	100.0	100.0

Source: Household Expenditure & Income Survey 2010, Department of Statistics

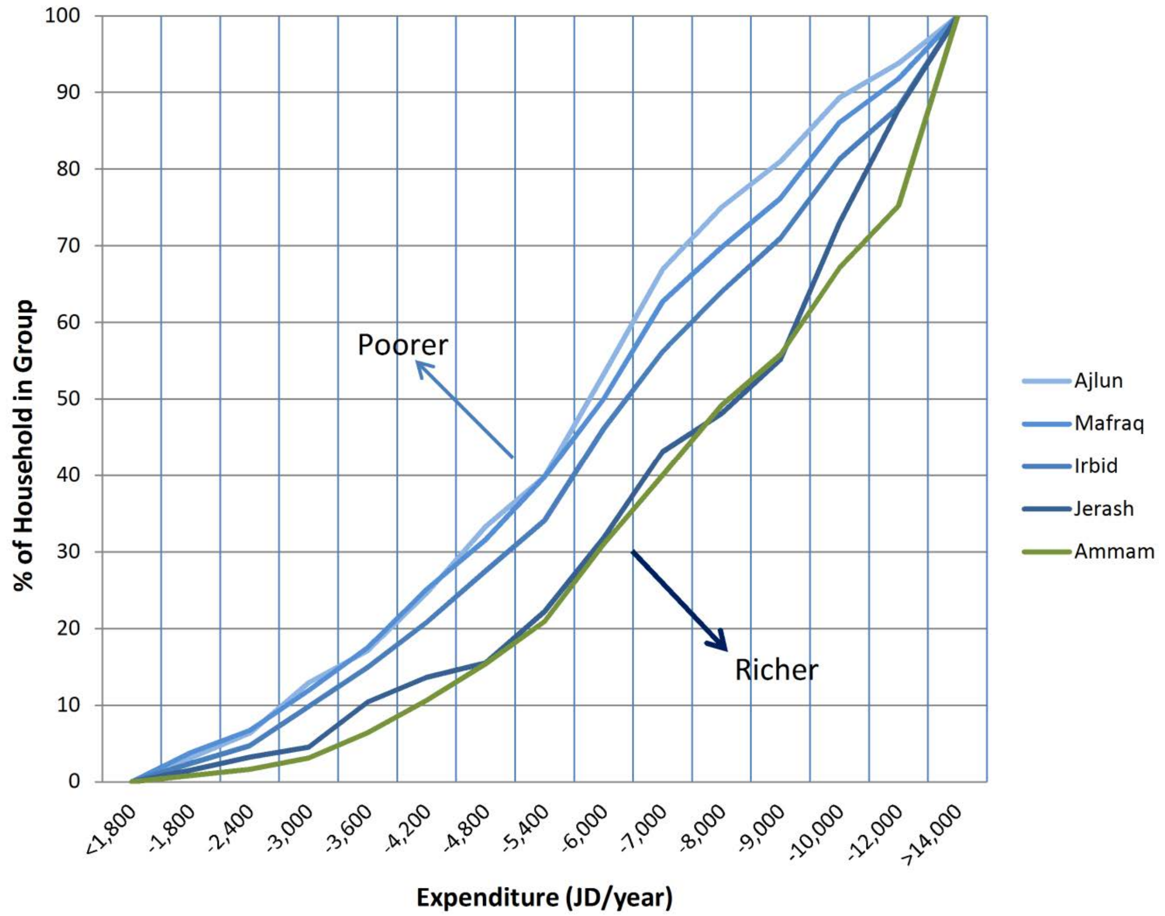


Figure 2.6 Household Expenditure Survey Results 2010

2.1.5 Health Status

The life expectancy of Jordan is 73.7 years - 72.1 years for males and 75.4 years for females in 2012 (World Bank). The table below shows the crude birth rate, crude death rate, and infant mortality rate of the Irbid Governorate from 2000 to 2009. The world median (2005-2010) and Jordan average (2012) are also shown in the same table.

Table 2.8 Birth and Mortality Rate of Irbid Governorate

(Per 1,000 persons)

S. No.	Impact Indicators	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Jordan average 2012	World median 2005-2010
1	Crude Birth Rate	28.6	29.0	30.0	30.1	29.7	29.9	31.9	35.2	33.5	32.9	28.1	20.1
2	Crude Death Rate	2.8	3.3	3.2	3.2	3.1	3.2	3.4	3.5	3.1	3.3	7.0	8.1
3	Infant Mortality Rate	-	-	-	-	-	-	-	19.0	-	21.0	17.0	42.3

Source: KNOEMA.com, Web site, Development Statistics of Jordan, 2014
UN, World Population Prospects: The 2012 Revision

The crude death rate in Irbid Governorate is lower than the world median and Jordan average, but the crude birth rate is higher than the world median and Jordan average. It indicates that the population growth rate in Irbid governorate is higher than that of the country average and relatively high growth trend will continue. It also indicates that sanitary conditions including water supply surrounding infant is poor and need to be improved since the crude death rate in Irbid Governorate is lower but the infant mortality rate is higher than the Jordan average.

2.2 Natural Conditions

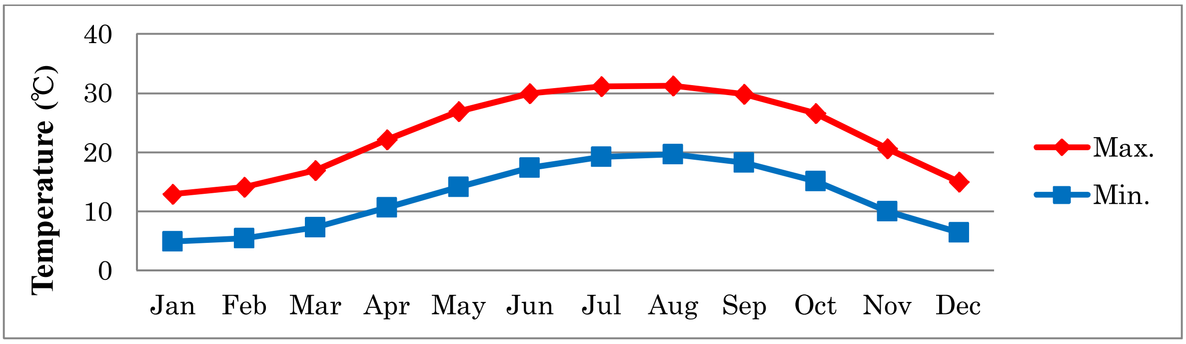
2.2.1 Meteorology

The water demand fluctuates in the Study Area during a year according to climate; high water demand in dry and hot summer and low demand in rainy and cold winter.

(1) Climate
Irbid and Ramtha have a hot, summer Mediterranean climate with two seasons as listed below. It has an annual rainfall of 470 mm/year, average temperature of 17.5°C, maximum mean temperature of 23.1°C, and minimum mean temperature of 12.4°C.

Summer season: April–October
Winter season: November–March

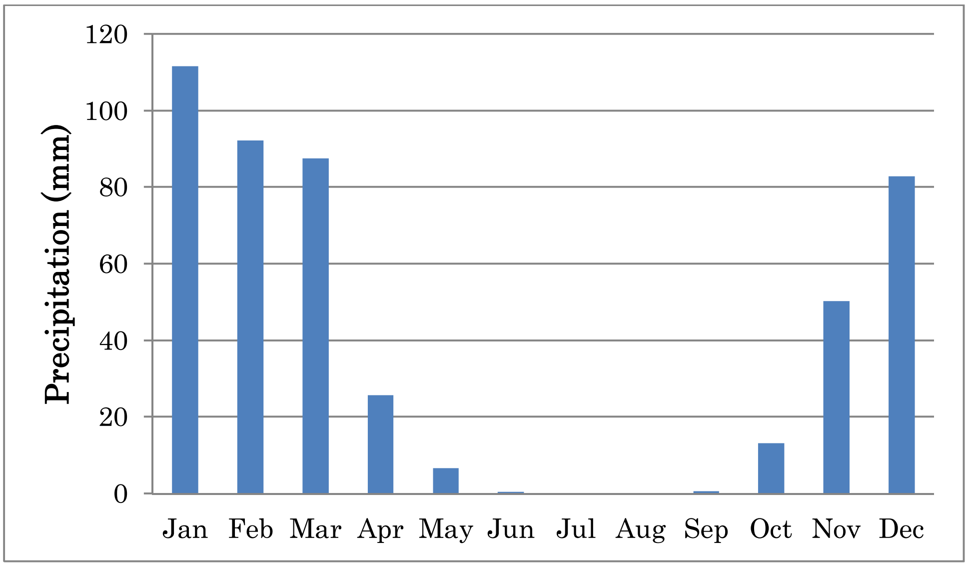
(2) Temperature
Figure 2.7 shows the maximum and minimum mean temperatures in Irbid city (30-year period). The difference between the monthly maximum and monthly minimum temperatures is about 10°C.



Source: World Weather Information Service, Web site

Figure 2.7 Mean Maximum and Minimum Temperatures in Irbid City (30-year period)

(3) Rainfall
Figure 2.8 shows the monthly mean rainfall in Irbid. The annual mean rainfall is calculated at 470 mm. About 95 % of the total rainfall throughout the year is from November to March.

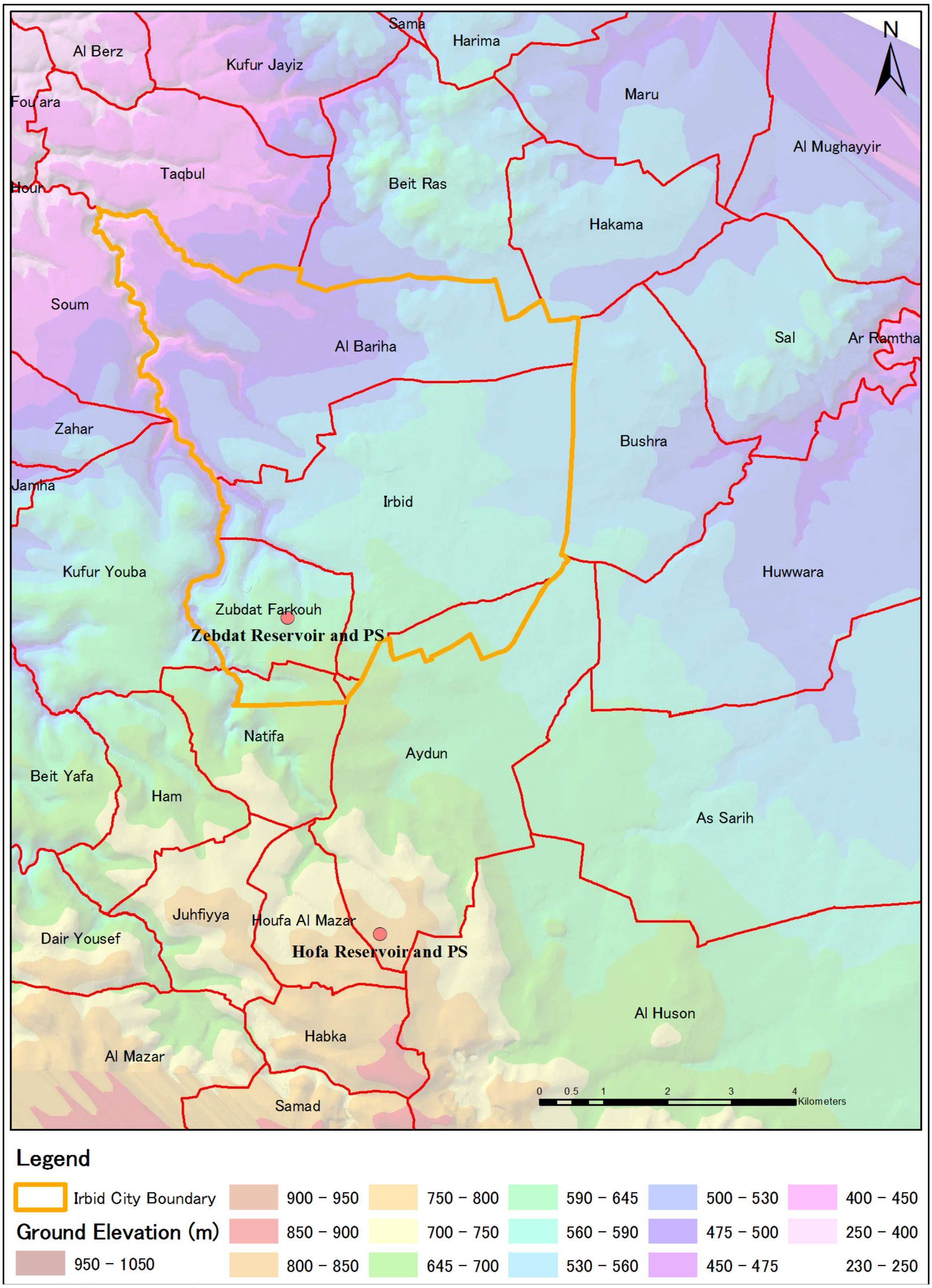


Source: World Weather Information Service, Web site

Figure 2.8 Mean Monthly Rainfall in Irbid City (30-year period)

2.2.2 Topography

The undulated topography in the Study Area makes water supply pressure control difficult. Irbid is situated on a large plateau with ground elevation ranging from 250 m to 750 m, as shown in Figure 2.9. Ramtha is situated on a small hill with elevation ranging from 400 m to 600 m in Figure 2.10.



Compiled by JICA Study Team

Figure 2.9 Ground Elevation in Irbid and Its Suburbs

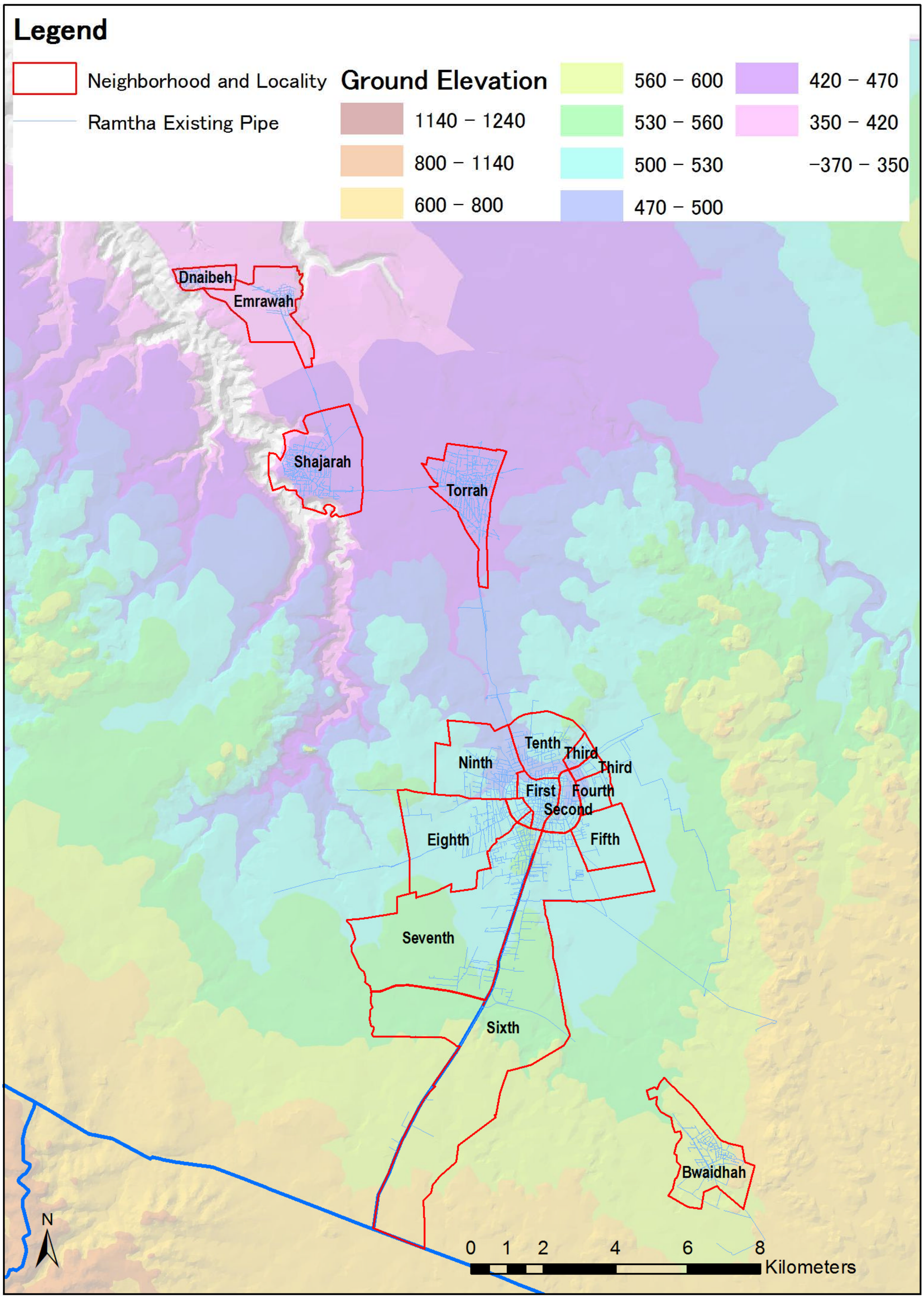


Figure 2.10 Ground Elevation in Ramtha

2.2.3 Hydrogeology

The geological structure of the Study Area is attributed to a large plateau with ground elevation ranging from 400 m to 700 m. The geological formations (Table 2.9 and Figure 2.11) in the Study Area are classified into two main periods based on the geological age (from old to new): (1) the Upper Cretaceous Period and (2) the Paleogene Tertiary Period. The plateau consists of limestone, dolomite and chalk. In these formations, the third formation, that is, B2/A7 is mostly utilized for groundwater abstraction.

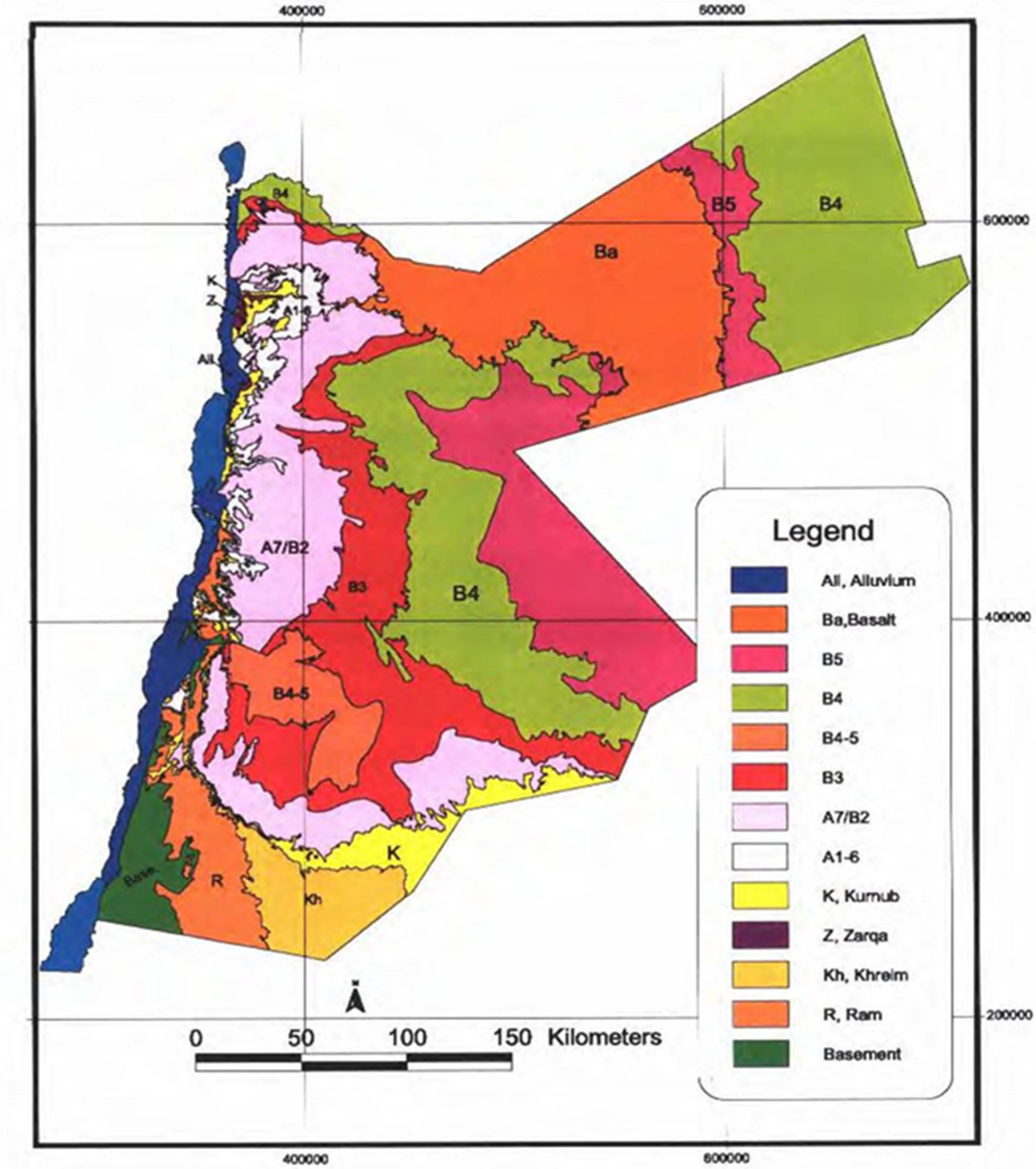
Table 2.9 Geological Formations

ERA	PERIOD		EPOCH	Group	Formation	Symbol	Lithology	Aquifer Characteristics	Aquifer Cond. (m/s)
CENOZOIC	Quarter-nary		Holocene	Alluvium	Fuviatile	Rc	Soil, sand, and gravel	Poor to Good (Aquifer)	Not Available
			Pleistocene	Diluvium	Lacst and Eolian				
	Tertiary	Neogene	Pliocene	J. Valley	Jafer – Azraq	Ja-Az	Marl, clay, and evaporites conglomerate with siliceous sand, gravel, and basalt	Poor Fair	Not Available
			Miocene	Volcanics	Basalts	Ba	Basalt	Good (Aquifer)	4.0 E -04 *
		Paleogene	Oligocene	Volcanics	Basalts	Ba	Basalt		
			Eocene	Balqa	Wadi Shallah	B5	Limestone, chalk, and marl	Good (Aquifer)	5.0 E -05 *
			Paleocene		Rijam	B4	Chert, limestone, chalk, and marl	Good (Aquifer)	5.0 E -05 *
					Muwaqqar	B3	Marly limestone, and shale	Poor (Aquifer)	1.0 E -09 **
					Amman	B2	Chert, limestone, and phosphate	Good (Aquifer)	2.0 E -05 *
MESOZOIC	Cretaceous	Upper	Meastrichtian		Wadi Ghudran	B1	Chalk, marl, and marly limestone	Poor (Aquifer)	Not Available
			Campanian Santonian						
			Taronian	Ajlun	Wadi Sir	A7	Limestone, dolomite, and chert	Very Good (Aquifer)	2.0 E -05 *
			?????		Shueib	A5, A6	Limestone, and marly limestone	Poor (Aquitard)	1.0 E -09 **
			Cenomanian		Hummar	A4	Dolomite, and dolomitic limestone	Fair to Good (Aquifer)	2.0 E -05 *
					Fuheis	A3	Marl, and marly limestone	Poor (Aquitard)	1.0 E -09 **
					Naur	A1, A2	Limestone, and dolomitic limestone	Good (Aquifer)	1.0 E -05 **
			Albian	Kurnub	Subeihi	K2	Sand and shale	Fair to Good (Aquifer)	3.0 E -05 *
		Lower	Aptian				Clay and sandy limestone		
			Neocomian						
			Berriasian		Aarda	K1	Sandstone, marl and shale		
	Jurassic	Malm	Tithonian						
			Kimmeridgian						
			Oxfordian						

(Source; Northern Governorates Water Transmission System Feasibility Study Final Report CDM International Inc. 2005, Modified from JICA 2001 and BGR 2001)

The main aquifer is following 6 aquifers from the surface and the salient features are shown in Table 2.10.

1) Basalt (Ba, eruption in Oligocene Paleogene-Neogene Miocene)
2) Balqa group, Wadi Shallalah formation / Rijam formation (B5/B4, Paleogene Eocene/ Paleocene)
3) Balqa group, Wadi Amman formation / Ajloun group, Wadi Sir formation (B2/A7, Paleogene Paleocene/ Upper Cretaceous)
4) Ajloun group, Hummar formation (A4, Upper Cretaceous)
5) Ajloun group, Naur formation (A1, A2, Lower Cretaceous)
6) Kumub group, Subeihi formation, Aarda formation (K, Lower Cretaceous-Jurassic)



Source: Northern Governorates Water Transmission System Feasibility Study Final Report
CDM International Inc. 2005, Modified from JICA 2001 and BGR 2001

Figure 2.11 Geology of Jordan

Table 2.10 Main Aquifers from the Top

Symbol	Formation	Lithology	Formation Thickness (m)	Hydraulic Conductivity (m/s)	Specific Yield (m^3/h/m)
Ba	Basalts	Basalt	10->500	4.0E-04	0.01
B4/B5	Shallalah/Rijam	Limestone , Chert	0-850	5.0E-05	0.05
B2/A7	Amman/Wadi as Sir	Limestone	80-650	2.0E-05	0.05
A4	Hummar	Limestone	30-100	2.0E-05	0.01
A1/2	Naur	Chert, Limestone	90-220	1.0E-05	0.01
K	Kurnub	Sand and Shale	120-350	3.0E-05	0.025

Many wells abstract water from the B2/A7 deep aquifer in the northern governorates. Some wells take water from the B4/B5 shallow aquifer in Ramtha and Badia. Some wells take water from the Ba aquifer (Basalt) in Badia, Mafraq, and Za'atary. Deeper aquifers are utilized by some wells in Ramtha, North Shouna, Ajloun and Jerash. Groundwater is extracted from all "A" aquifers in part of Irbid, from "K" aquifer of the deepest part in almost half of Jerash, and from the "K" aquifer in part of Ajloun.

2.3 City Plans

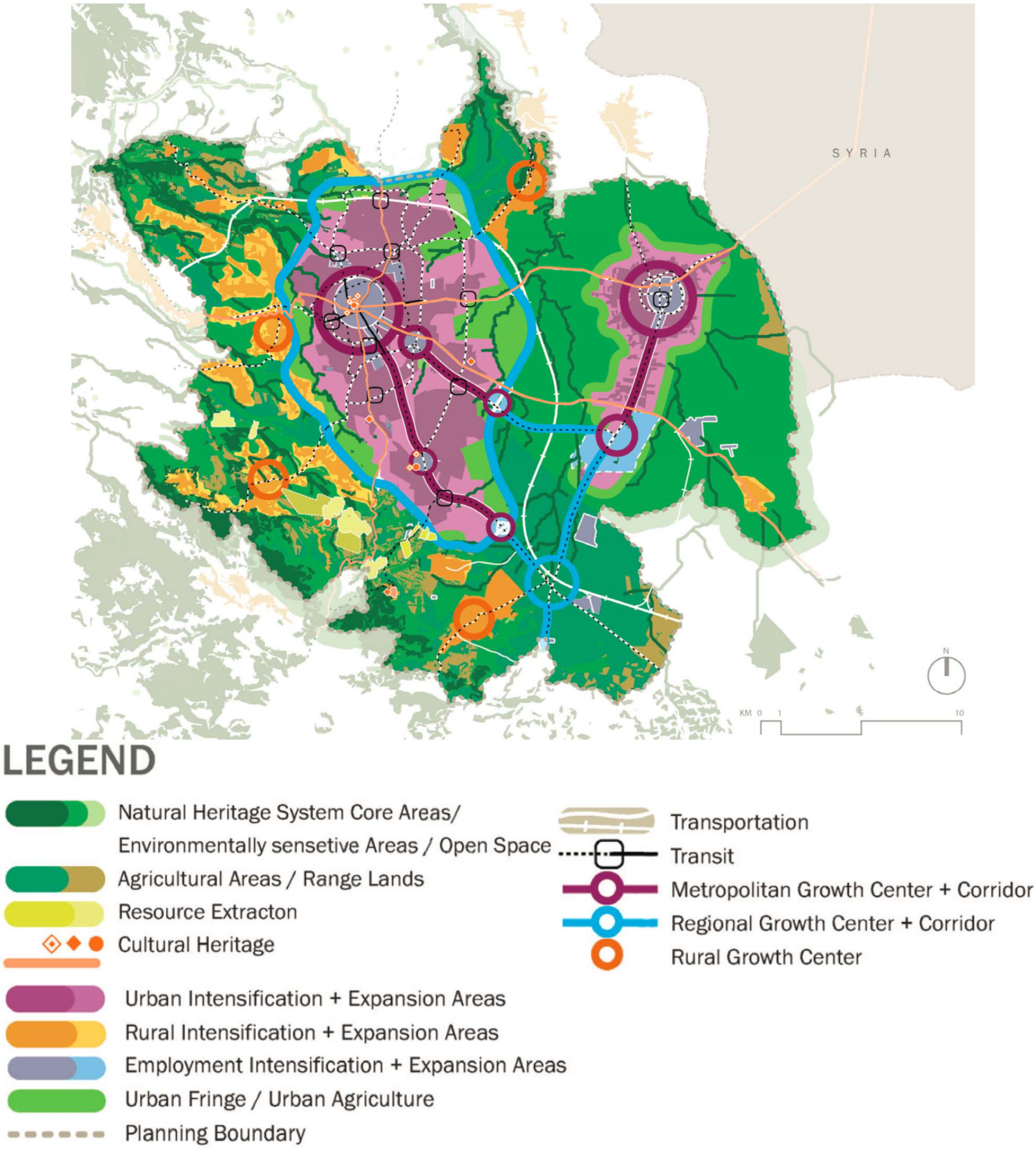
2.3.1 Irbid and Suburbs

The existing municipal-level master plan is called "Irbid 2030: Greater Irbid Area Plan" (Ministry of Municipal Affairs: MOMA). The following are excerpts from the Plan related to the Study:

- Figure 2.12 shows the projected urban growth area for Irbid city and its suburbs. Appendix 2A shows the detailed maps
- Irbid and suburbs are classified as follows and are shown in Figure 2.12 as well.

a) Residential Stable
b) Residential Intensification
c) Residential Expansion

- Development is to be encouraged in designated residential intensification areas taking advantage of existing infrastructure and services on first priority, to be followed by new expansion areas that will accommodate the population and promote employment growth to 2030.
- Residential stable area is also defined with recommendation to avoid accepting additional population in such areas so as to prevent severe congestion that may lead to an unhealthy environment.
- Planned population densities for sound living environment are 100 persons per hectare (pph) for Irbid city and 30-50 pph for the suburbs in the urban growth area. Projected population densities for Irbid and suburbs are as shown in Appendix 2A.
- Population of Irbid city is not projected; however, total population of the Greater Irbid Municipality is projected to almost double from 395,472 in 2004 to 741,276 by 2030.



Source: Irbid 2030: Greater Irbid Area Plan of MOMA

Figure 2.12 Residential Intensification and Expansion Areas in Irbid, Ramtha and Its Suburbs

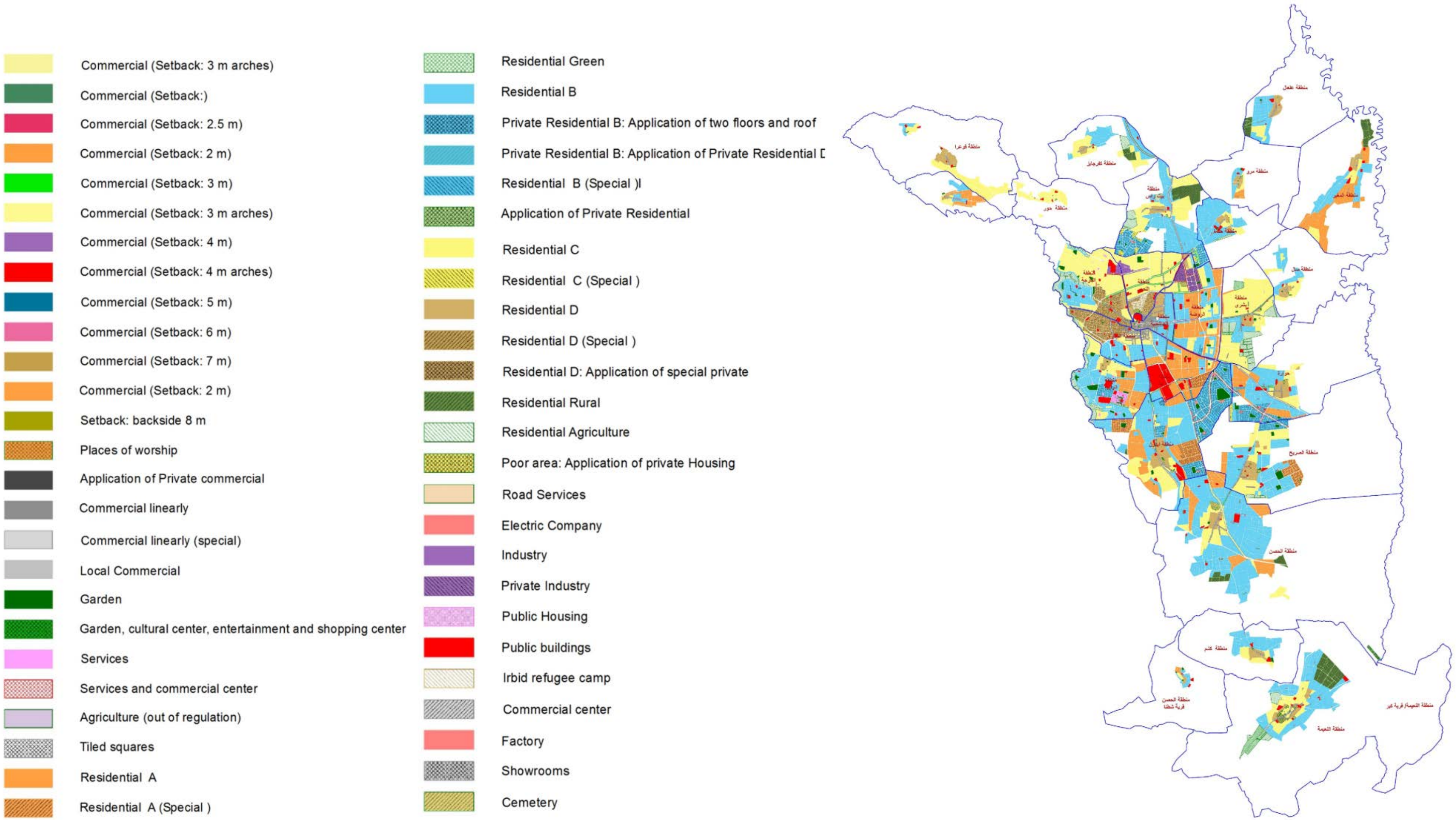
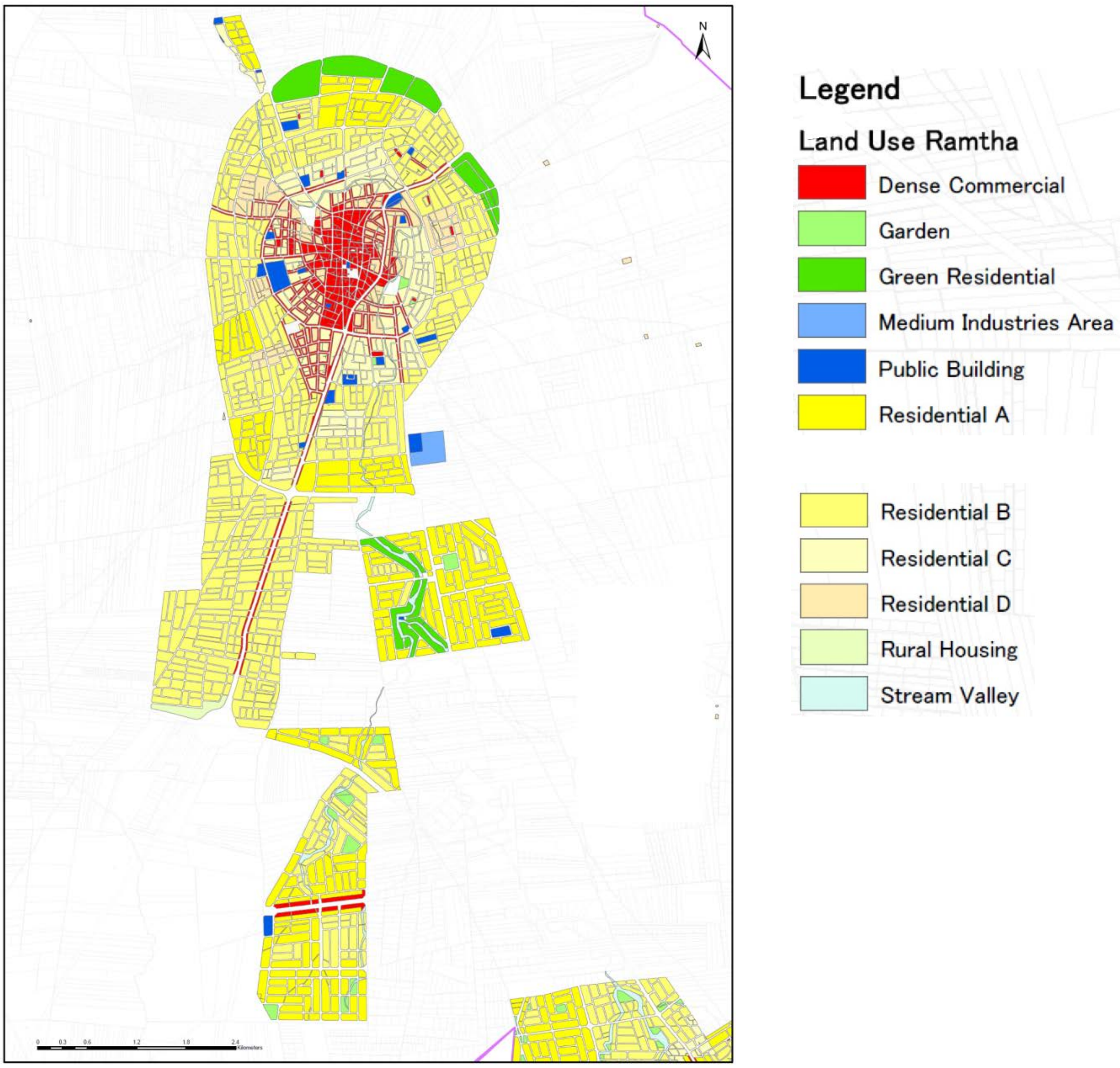


Figure 2.13 Land Use Plan in Irbid

2.3.2 Ramtha City

Urbanization in Ramtha is planned southwards according to the Growth Plan on Regional Scale in the "Irbid 2030: Greater Irbid Area Plan" of MOMA (Refer to Appendix 2B). Ramtha is divided into the core areas of urban intensification and growth, rural intensification and growth, urban fringe, and agricultural area according to the Plan.

Figure 2.14 shows the land use plan of Ramtha prepared by the Ramtha municipality. The central part of Ramtha is mainly occupied by dense commercial buildings. Commercial blocks are surrounded by residential areas. Some stretches of green residential areas lie on the outskirts.



Source: Ramtha Municipality and JICA Study Team

Figure 2.14 Land Use Plan in Ramtha City

2.4 Institution and Organization of Water Sector

2.4.1 Policies, Laws, and Regulations

A list of existing plans, strategies, policies, and legislations for the water sector of Jordan is given in the table below.

Table 2.11 Existing Plans, Strategies, Policies, and Legislations

Year	Document Title	Type	Theme
1988	Water Authority Law No. 18 of 1988	Law	Institutional
1992	Ministry of Water and Irrigation By-law No. 54 of 1992	By-law	Institutional
1994	Wastewater Regulation No. 66 of 1994	Regulation	Wastewater
	Drinking Water Subscription Regulation No. 67 of 1994	Regulation	Drinking water
1997	**Water Strategy of Jordan 1997**	**Strategy**	**Water sector**
	Water Utility Policy of 1997	Policy	Water utility
1998	Ground Water Management Policy of 1998	Policy	Groundwater
	Irrigation Water Policy of 1998	Policy	Irrigation
	Wastewater Management Policy of 1998	Policy	Wastewater
2001	Jordan Valley Development Law No. 30 of 2001	Law	Institutional
2002	Underground Water Control By-Law No. 85 of 2002 and its amendments of 2003, 2004 and 2007	By-law	Groundwater
2003	JVA Strategy Plan for 2003 - 2008	Strategy	Water sector
2004	National Water Master Plan of 2004	Water master plan	Water sector
	Jordan's Water Strategy and Policies of 2004	Strategy and policy	Water, wastewater, and irrigation
2006	**National Agenda 2006-2015**	**Strategy**	**All sectors**
2008	Irrigation Equipment and System Design Policy of 2008	Policy	Irrigation
	Irrigation Water Allocation and Use Policy of 2008	Policy	Irrigation
	National Water Demand Management Policy of 2008	Policy	Water demand management
	Water Authority Strategic Plan 2008-2012	Strategy	Water sector
2009	**Jordan's Water Strategy 2008-2022: Water for Life**	**Strategy**	**Water sector**
2010	Water Reallocation Strategy between Governorates	Strategy	Water sector

The following major policy documents for the water sector in Jordan are described below:

- Jordan's Water Strategy and Policies adopted by the Council of Ministers, 1997;
- The National Agenda, 2006-2015;
- Water for Life: Jordan's Water Strategy, 2008-2022.

(1) Jordan's Water Strategy and Policies

Jordan's Water Strategy and Policies are strongly committed to:

1) Reducing groundwater extraction to renewable rates;
2) Ongoing monitoring effort to control groundwater withdrawals;
3) Careful planning and judicious withdrawals from fossil aquifers;
4) Quest for the highest possible efficiency in the conveyance, distribution, and use of water;
5) Integrated and temporally dynamic approach to the management of demand and supply;
6) Use of the most advanced technology to enhance resource management capabilities;
7) Keeping operation and maintenance costs as low as possible.

There was a commitment to increased co-operation and co-ordination among public and private entities involved in water development and management. The government promised to undertake periodic reviews of the existing institutional arrangements and legislation to assess the adequacy of the status quo in light of changed settings and circumstances. The government advocated frequent monitoring and scoring of the performance of water and wastewater systems.

The Ministry of Water and Irrigation (MWI) was directed to set municipal water and wastewater tariffs at levels that would cover the cost of operation and maintenance. The Ministry was also directed to launch a program to recover all or part of the capital costs of water infrastructure.

There was a rather modest commitment to cost recovery for operation and maintenance expenses for utilities. The recommendation was "capital cost recovery must be carefully approached," suggesting the political difficulties associated with this commitment. It is reported that the role of water tariffs should be considered to attract private investment in water projects.

With respect to groundwater, the government promoted irrigated agriculture in the arid southeast from 1984. The agriculture promoted by the government over two decades ago is now a threat to urban water supply. The report suggests that there will be a vigorous campaign focused on illegal drilling of tube wells and drilling will be stopped, rigs confiscated and legal action taken against violators. The Ministry is said to be implementing a program effective in gradually reducing groundwater withdrawals to the level of sustainability.

At the time of the report, the Ministry was providing wastewater collection and treatment services to 14 major populated areas. The Ministry was also reorganizing to become more effective in monitoring and enforcing wastewater regulations. The Ministry was directed by the Councils of Ministers to establish a unit responsible for planning, designing, constructing and managing sewerage system projects and for reusing treated effluent.

Wastewater was recognized as an essential component of renewable water resources and it was expected to become an integral part of the national water budget. Industries were encouraged to recycle part of their wastewater and to treat the remainder to meet specific standards. Priority was given to treated effluent for irrigation. Blending of treated wastewater with fresh water was encouraged where possible.

There is a commitment in this report to "institutional restructuring" in which proper legislation and effective law enforcement would form the basis of a new policy climate.

The MWI would play a central role in planning and development of the water sector, formulation of a coherent policy framework, and regulation of the sector. This new policy framework would have three general principles:

1) MWI would retain responsibility for sectorial governance. This would entail policy formulation, decision making, data collection, geo- referenced data systems, monitoring, and overall national planning;
2) The Water Authority of Jordan (WAJ) would separate its bulk water supply and retail functions shifting water delivery to the private sector. WAJ would monitor retail supply contracts, and would become a smaller organization. For those bulk supplies that are not privatized, WAJ would remain the purveyor of bulk supplies not privatized, and it would provide support to smaller retail distribution units not operated by the private sector;
3) The Jordan Valley Authority (JVA) has seen its programs in social infrastructure diminish in the recent past; so there was a call for the reassessment of its functions and programs. Jordan's Water Strategies and Policies required the JVA to launch a new program to focus on tourism, industry, manufacturing, and advanced technologies. Law No. 19 of 1988 would remain a mandate of the water sector to the JVA. The private sector was expected to become more active in development and activities concerned with operation and maintenance.

(2) The National Agenda: 2006-2015

This document acknowledged the water sector as strategically important because water scarcity can significantly impede socio-economic growth. The document acknowledged that the water sector suffered from distribution inefficiencies, inadequate tariffs, limited wastewater treatment capabilities, and restricted private sector involvement in addition to the scarcity of renewable water resources and depletion of underground water.

Proposed initiatives pertinent to institutional assessment included:

1) Improvements in the efficiency of water distribution networks to decrease operational costs and non-revenue water;
2) Restructuring tariffs and gradual reductions in subsidies;
3) Development (and upgrading) of wastewater treatment facilities by using state-of-the-art technology and re-use of treated water for agriculture and industry; and
4) Greater involvement of the private sector in developing the water sector and creating an investment-friendly environment. The National Water Master Plan of 2004 reinforced the

importance of these reforms.

(3) Water for Life: Jordan's Water Strategy, 2008-2022

The government of Jordan is committed to:

1) Providing adequate, safe and secure drinking water supply;
2) Promoting greater understanding and more effective management of groundwater and surface water;
3) Providing healthy aquatic ecosystems;
4) Sustainable use of water resources;
5) Fair, affordable and cost-reflective water charges; and
6) Timely adaptation to increased population growth and economic development across the water sector and water users.

The ISSP (Institutional Support and Strengthening Project, USAID) report analyzed this strategy and admitted that the prevailing motivation for water "management" in Jordan was dominated by the flawed imperative to supply water rather than the more logical approach that focuses on justified water needs. As a result, groundwater levels had dramatically declined, and the imbalance between supplies and claimed "needs" had grown to unsustainable levels. Moreover, the quality of the nation's water had declined significantly.

The Water for Life report calls for:

1) Efficient and effective institutional reforms;
2) More efficient use of water resources;
3) Dramatic reduction in the exploitation of groundwater;
4) Implementation of the Disi water conveyance and the Red-Dead conveyance projects
5) More attention to problems created by irrigated agriculture in the highlands; and
6) Appropriate water tariffs and water-conserving incentives.

2.4.2 Organization

The organizations responsible for water sector are the Ministry of Water and Irrigation (MWI), Water Authority of Jordan (WAJ), and public operators namely, Miyahuna, the Aqaba Water Company and the Yarmouk Water Company (YWC). The organizational structure of the water sector is shown in the following figure:

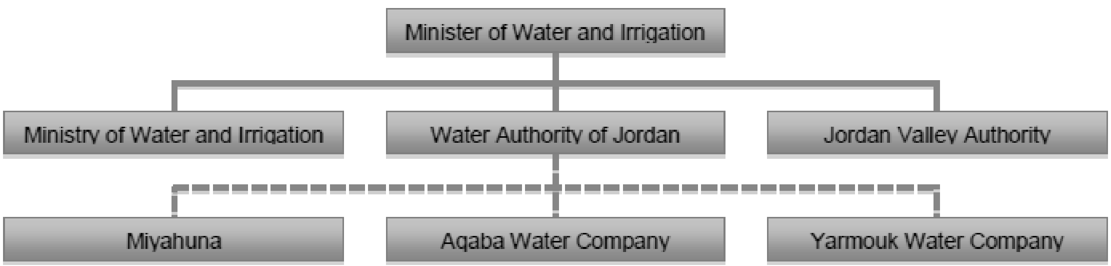


Figure 2.15 Organization of the Water Sector

The MWI, which is the main government agency entrusted with responsibility for water resources, drinking water supply and wastewater services, was formed in 1992 to manage the country's water resources. The MWI is responsible for formulating and implementing water and wastewater development programs and for recommending water sector policies and tariff revisions to the Council of Ministers for approval.

The WAJ established by the "Water Authority Law No. 18 of 1988," is an autonomous entity with financial and administrative independence beholden to government and civil service regulations. The WAJ is governed by a Board of Directors chaired by the Minister for Water and Irrigation with representatives from the Ministries of Planning, Agriculture and Health, as well as the Secretary Generals of the WAJ and the JVA.

The WAJ is responsible for implementing policies related to the provision of water supply and wastewater disposal services. Its responsibilities include the design, construction, operation of these services, supervision and regulation of the construction of public and private wells, as well as licensing well drilling rigs and drillers, and issuing permits to engineers and licensed professionals to perform water and wastewater related activities.

The Yarmouk Water Company (YWC), established in 2010, serves the northern governorates of Jordan, namely Irbid, Jerash, Ajloun and Mafraq. The YWC is also a 100 %-subsidiary of the WAJ and replaces the Northern Governorates Water Administration (NGWA).

2.5 Water Supply Plans and Programs

2.5.1 Restructuring/ Rehabilitation Plan

Two development plans for water supply facilities exist presently. The "Hydraulic Analysis of the Water Systems in the Irbid Governorate" was developed in 1996-1997. The plan covers system layouts, network analysis, un-accounted for water (UFW) and leakage control, system improvement and rehabilitation. After about 10 years, the plan was updated and the "Water Loss Reduction Program (WLRP)" for the northern governorates was prepared in 2004-2005. The goals of above plans are summarized below.

- Reduce network pressure
- Increase pump efficiency and reduce pumping costs
- Establish distribution zones
- Establish reliable flow and pressure measurement systems
- Establish SCADA system
- Rehabilitate the most deteriorated parts of the system

These plans recommend both rehabilitation and restructuring to achieve the project goal, and from the allocated budget by KfW at that time; about 80 % is designated for rehabilitation and 20 % for restructuring. Rehabilitation work entails replacing steel mains and galvanized iron service connections with ductile iron/HDPE mains and HDPE service connections. Restructuring work includes strengthening the transmission and distribution capacity of water supply facilities including pipes, pumps and reservoirs and creating zoning systems.

Later, rehabilitation works were implemented based on these plans in several areas mostly by KfW funding for immediate leakage reduction. Only a few restructuring works have been implemented in Irbid. These development plans is now outdated and needs to be updated.

2.5.2 Transmission System Plan

(1) Water Reallocation Strategy between Governorates 2010
Total water supply flow of 100 MCM/year started from Disi in July 2013. Amman gets most of the Disi water but the additional water from Disi is shared among all the governorates in the country including the northern governorates. In addition to Disi, development of a few other new sources is included in the implementation plan of the MWI, including desalination of Hosban wells (10 MCM starting in 2013) and water from Al Wehdeh Dam (17 MCM). After adding these sources, additional water will become available to some cities, while other cities will still need more. For example, the total water supplied to Amman will be greater than its requirement after Disi water comes in. This requires reallocation of sources.

Another aspect requiring reallocation of water is different production cost for different source, with higher cost of newer sources. From the cost basis, water must be reallocated so that the benefit and the burden are shared proportionately by all citizens.

In addition to its own (internal) production, Amman currently receives water from external sources such as the King Abdulla canal through the Zai WTP, the Zarqa governorate through the Khaw pumping station, and Karak and Madaba. A simple reallocation policy would be to reduce the amount of water from external sources when Amman starts receiving water from Disi, and use the saved amount elsewhere.

MWI has formed a task force (committee) to formulate the policy and plans for water reallocation. The committee has reassessed the water demand of the whole kingdom according to the per capita consumption criteria developed by the Ministry. Water will be reallocated based on the demand and resources available within the governorates.

(2) Regional Transmission System in Northern Governorates

The feasibility study for water transmission in the northern governorates was prepared in 2004-2005. This study report is a key document on the current and planned transmission systems in the northern governorates. This study has cooperated mutually with the WLRP study; the feasibility study has concentrated on the transmission system while the WLRP study has concentrated on the distribution system.

The trunk transmission system has already been implemented and sub-transmission lines have been studied separately in 2013. A study was also carried out in 2013 on a part of the national corridor from the Abu Alanda pumping station in Amman to connect with the above-mentioned transmission system in the northern governorates. The planned and on-going projects are described in section 3.1.2.

(3) National Resilience Plan 2014 – 2016, Draft

The National Resilience Plan (NRP) is a three year program of high priority investments by the Government of Jordan in response to the impact of the Syrian crisis on the Kingdom of Jordan. Now in its fourth year, the crisis in Syria continues to adversely impact Jordan in a variety of ways. The NRP represents an attempt by the GOJ to take initial stock of its consequences in the primary sectors, locations and communities most affected. In doing so the GOJ has reached out to its national, regional and international partners for assistance, both in the preparation, as well as in the financing and implementation of the NRP. This plan will help mitigate the potentially destabilizing political, demographic, social, economic, and fiscal effects of the crisis.

The total cost of response interventions contained within the NRP is about US$2.48 billion. Critical investment area includes the Water & Sanitation (WASH) sector, with a cost of US$670.8 million. A list of the projects related to water supply in the northern governorates is presented in Table 2.12.

Table 2.12 Water and Sanitation Sector Projects in National Resilience Plan

(USD)

Water and Sanitation	2014	2015	2016	All Years
Specific Objective 1: To enhance the GOJ water and sanitation management and implementation capacity				
Project Summary 1.1: Establishment of YWC implementation capacity (IMU)	2,100,000	2,520,000	2,520,000	7,140,000
Project Summary 1.5: Performance-based contracting NRW reduction in Mafraq & Zarqa city	1,400,000	4,200,000	4,200,000	9,800,000
Specific Objective 2: Improving the quantity, quality and efficiency of water and its delivery				
Project Summary2.1: Rehabilitation of wells in different governorates (Irbid, Jerash, Ajloun, Mafraq, Amman, Zarqa, Madaba, Balqa)	8,400,000	8,400,000	-	16,800,000
Project Summary2.2: Restructuring the YWC main transmission/ distribution systems & network reinforcement (Irbid, Jerash, Ajloun, Mafraq, Balqa)	14,000,000	49,000,000	35,000,000	98,000,000
Project Summary 2.3: Water network rehabilitation & reinforcement in Mafraq city	5,000,000	7,000,000		12,000,000
Project Summary2.6: Supply of materials & equipment to YWC	8,568,000	-	-	8,568,000
Total	39,468,000	71,120,000	41,720,000	152,308,000

Note: Only projects related to water supply in the northern governorates are extracted from the original list.

CHAPTER 3 EXISTING WATER SUPPLY SYSTEM

3.1 Existing Water Supply System in the Northern Governorates

3.1.1 Water Sources

Water sources are groundwater and a few springs in the northern governorates. The water facilities in 2012 were mainly about 210 wells and springs, 11 treatment plants, 83 pumping stations and 8,100 km pipes.

(1) Well Characteristics
The third formation B2/A7 from the surface is mostly utilized for groundwater abstraction. The depth of wells ranges from 11 m to 1,183 m with an average depth of 375 m, and the yield of the wells ranges from 6 m^3/h to 280 m^3/h with an average of 59 m^3/h. Information on well depth, and yield in 2012 are given in Table 3.1.

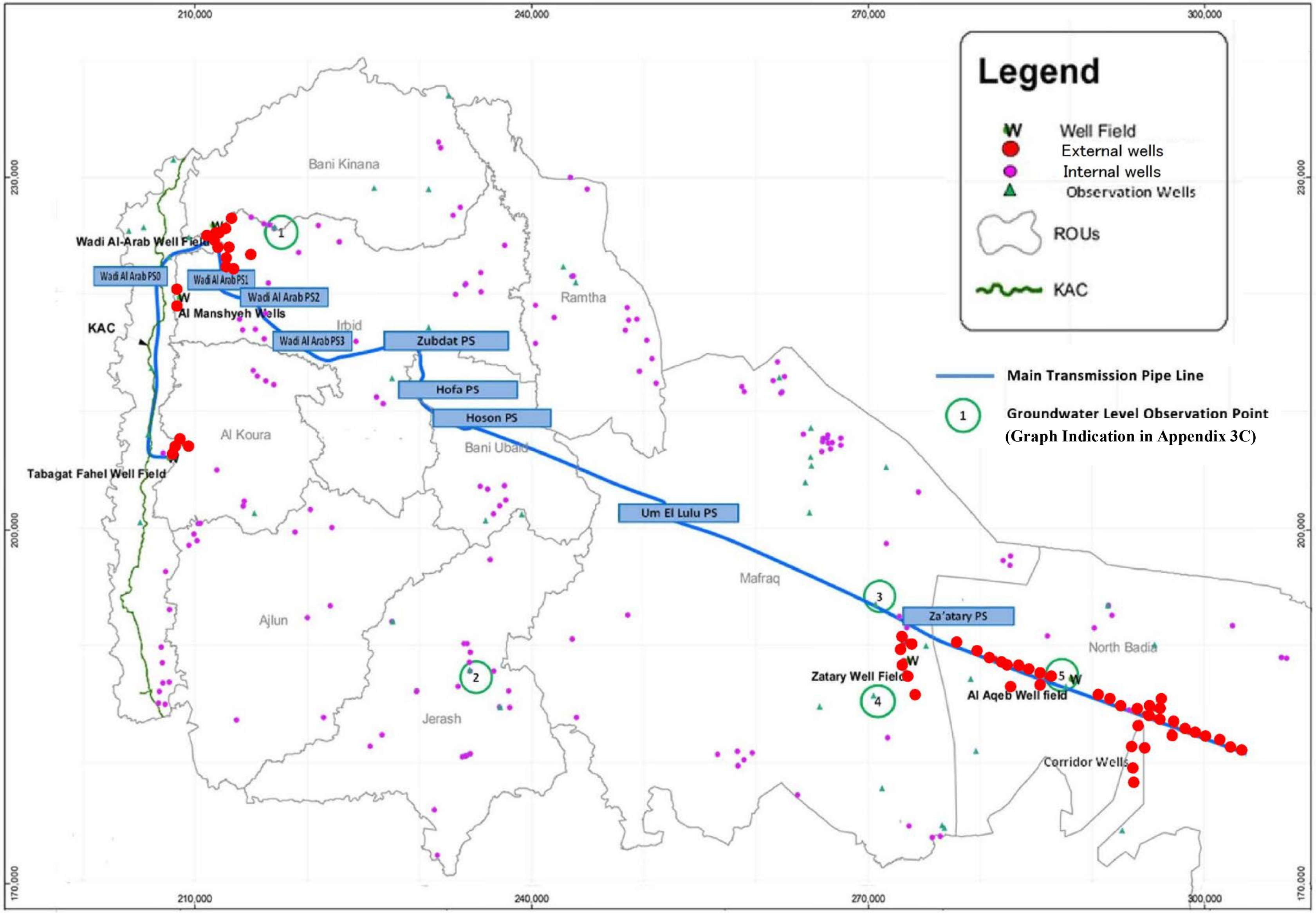
Table 3.1 Well Characteristics by Regional Operation Unit (ROU)[4]

ROU	Surface Elevation (m)			Well Depth (m)			Yield in 2012 (m^3/h)			Number of Wells
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	
Wadi Al Arab*	257	-200	-6	1183	11	384	280	25	132	21
Ramtha	590	435	532	680	104	477	80	11	40	14
Irbid	628	200	424	615	286	436	115	8	46	19
Bani-Kinana	480	53	254	750	210	437	80	42	59	8
Bani-Obaid	746	700	716	435	196	350	75	12	40	5
Al Koura	746	180	496	495	192	307	85	38	49	7
North Shouna	50	-165	-89	471	138	246	100	15	45	8
Ajloun	860	215	513	589	397	499	150	8	57	9
Jerash	961	242	625	506	73	230	130	7	52	28
(North) Badia	1050	653	787	622	264	426	90	20	47	27
Mafraq	800	578	640	590	100	360	120	6	45	30
Za'atary*	825	640	738	500	290	387	100	15	57	33
Total	1050	-200	522	1183	11	375	280	6	59	209

Source: Compiled by the JICA Study Team using YWC data
Note: * Wadi Al Arab and Za'atary are not the ROU name but the well fields' name.

(2) Water Production Amount
The wells in the northern governorates are shown as dots in Figure 3.1. The well production amount in million cubic meters per year (MCM/year) by ROU is shown in Table 3.2. Details are shown in Appendix 3A.

[4] Refer to Figure 1.2 and section 3.6.3 for ROU.



Compiled by the JICA Study Team using YWC data

Figure 3.1 Location of Wells (External well, Internal wells and Observation wells)

Table 3.2 Water Yield by ROU in the Northern Governorates

ROU	Water Yield (MCM/y)		
	2011	2012	2013
Wadi Al Arab (mostly for Western Source)	23.36	21.87	22.32
Bani Kinana	1.07	3.10	3.29
North Shouna (mostly for Western Source)	1.08	1.42	1.78
Al Koura	3.11	3.20	3.12
Irbid Qasabat	6.96	5.99	5.97
Ramtha	2.41	2.21	1.99
Bani Obaid	0.79	1.03	1.03
Ajloun	2.53	3.27	3.50
Jerash	3.51	4.20	4.61
Mafraq Bwaida, Za'atary (partly for Eastern Source)	26.73	27.35	26.31
Total	71.55	73.64	73.92

Source: YWC
Note: refer to Appendix 3A for yield of each well.

(3) Change of Water Level
There are 48 observation wells in the northern governorates; their locations are shown in Figure 3.1. Water levels were measured for 40 wells in 2011 and 38 wells in 2012. The observed water levels are summarized in Table 3.3. Details are given in Appendix 3C. Water level is observed to decline by 1.03 m/year. As a result, the water yield has reduced. The amount of water pumped in 2003 is described in the report issued by CDM in 2005. The amount of water pumped in 2012 is observed to be 30 % less in the same wells compared to the pumped amount in 2003. As a countermeasure, YWC has continued to rehabilitate wells and drill new wells to maintain the water production volume at a constant level.

Table 3.3 Observed Water Levels between 2010 and 2012 in Meters

	2010-2011	2011-2012	Average
Annual maximum water level change (upward)	0.17	4.87	1.92
Annual maximum water level change (downward)	-7.79	-5.81	-6.53
Annual average water level change	-1.42	-0.79	-1.03
Number of observation wells	40	38	78

Note: + upward, - downward
Source: Compiled by the JICA Study Team based on groundwater level data of YWC Well Division

(4) Internal and External Sources
The wells are classified into two groups in this Study - internal sources and external sources. Internal sources in a locality supply water to its own locality or neighboring localities while external sources supply water widely through the regional transmission system. There are two groups of external sources: eastern sources consisting of Aqeb wells, Za'atary wells, and Corridor wells (since summer, 2013) and western sources consisting of Tabaqat Fahel wells, Mansheya wells, and Wadi Al Arab wells.

(5) Water Source by Sub-transmission Zone
The regional transmission system in the northern governorates consists of main transmission lines and sub-transmission lines. The main transmission lines are the eastern transmission line (Za'atary to Hofa) and the western transmission line (Wadi Arab to Zebdat). The sub-transmission lines are branch lines from the main transmission lines. Sub-transmission zones are water supply zones to which water is supplied from sub-transmission lines, as shown in Figure 3.2.

Figure 3.3 shows water production from external sources and internal sources by sub-transmission zone in 2013. Details of well water production by sub-transmission zone are given in Appendix 3B. Water from Za'atary or Wadi Arab will be supplemented to localities in sub-transmission zones adding to internal sources through sub-transmission lines.

The available water to Zebdat and Hofa reservoirs for Irbid city and its suburbs and the available water for Ramtha city and its suburbs are estimated based on the demand of localities and available amount of water from internal and external sources in the sub-transmission zones.

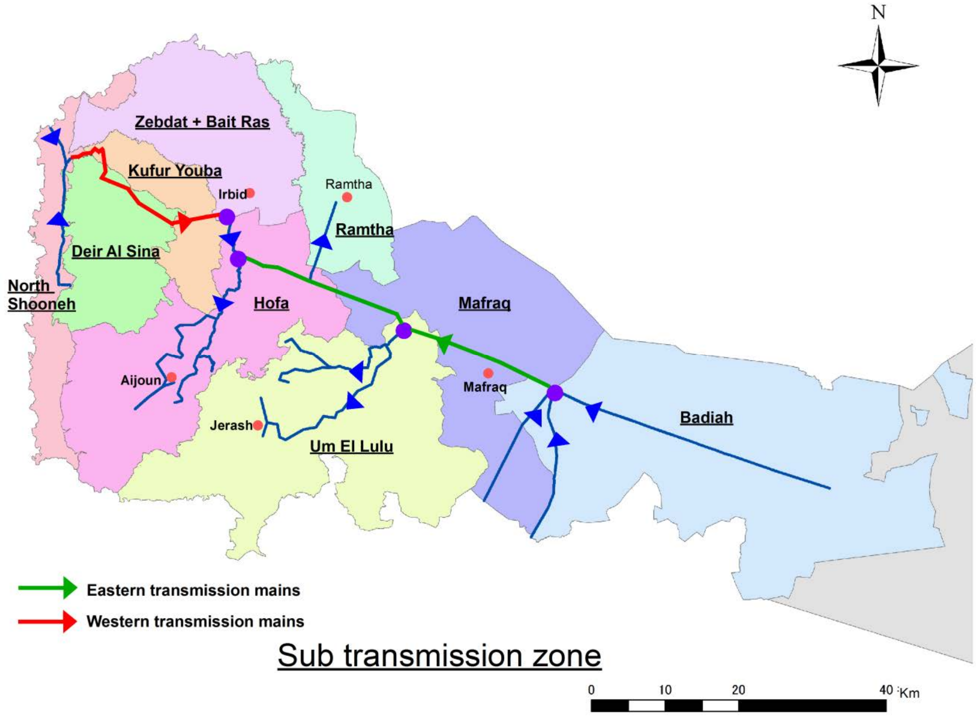
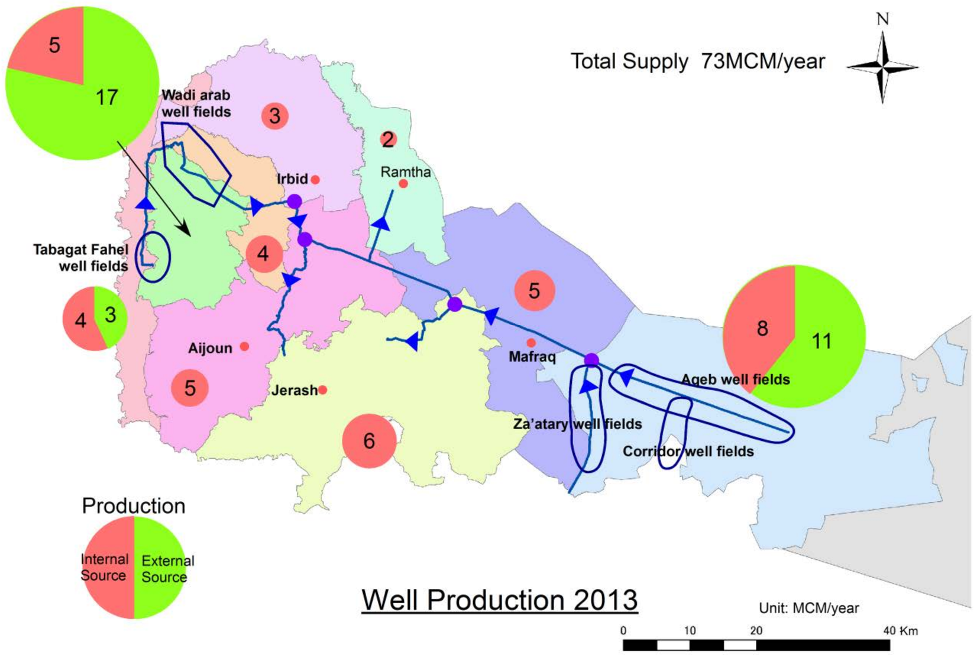


Figure 3.2 Main and Sub-Transmission Lines and Sub-Transmission Zones



Source: JICA Study Team

Figure 3.3 Average Well Production by Sub-Transmission Zone in 2013

3.1.2 Transmission System

(1) Existing Transmission System

Water supply systems for conveying water from sources to demand sites in the northern governorates consist of the following three systems (refer to Figure 3.4):

- Eastern well system (about 35 % of water) from Za'atary to Hofa
- Western well system (about 30 % of water) from Wadi Arab, etc., to Irbid and Hofa
- Local well systems (about 35 % of water) scattered in the northern governorates

(2) Japanese Grant Aid Scheme

The transmission and distribution lines from the Hofa reservoir to Bait Ras district in Irbid city is under planning in the Component A of this Study and will be implemented through Japan's grant aid scheme. The construction work will be awarded in early 2015 and commissioned in 2017.

(3) Transmission System Planning before 2017

The Disi fossil groundwater was developed in the southern part of Jordan to reduce the water supply-demand gap in the country. Water supply to Amman began in August 2013. The Disi water will be conveyed to the northern governorates through the following transmission facilities (Figure 3.5):

- From Abu Alanda reservoir in the Amman Governorate to the Khaw pumping station in the Zarqa Governorate: Work awarded in 2014; to be commissioned in 2017.
- From Khaw pumping station to the Za'atary pumping station in the Mafraq governorate: Work awarded in 2014; to be commissioned in 2017.

In addition, water that was earlier conveyed to Amman from Corridor wells of the eastern wells in Mafraq has been stopped, and this water is now being used by the northern governorates.

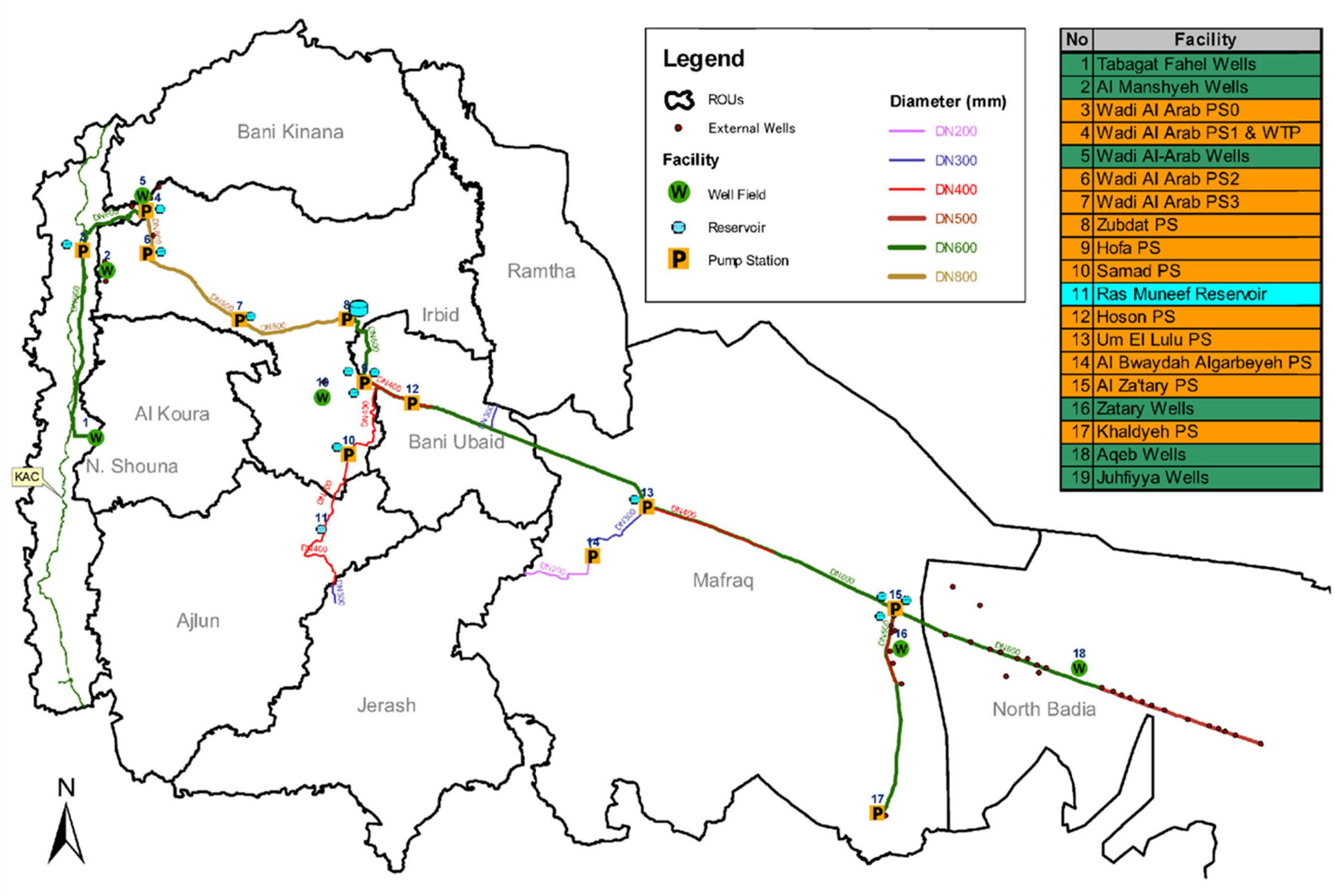
To supply this additional water to the northern governorates, the eastern transmission system (Figure 3.6) is already upgraded or will be upgraded as given in the table below.

Table 3.4 Work Progress of the Eastern Transmission Line

No.	Segment	Status
1	Main transmission line from the Za'atary pumping station in the Mafraq governorate to the Hofa reservoir/ pumping station in the Irbid governorate	Already upgraded and commissioned
2	Sub-transmission line from the Um El Lulu pumping station to the Jerash governorate	Work awarded in 2014; to be commissioned in 2017
3	Sub-transmission line from the Hofa pumping station to the Ajloun governorate	Work awarded in 2014; to be commissioned in 2017

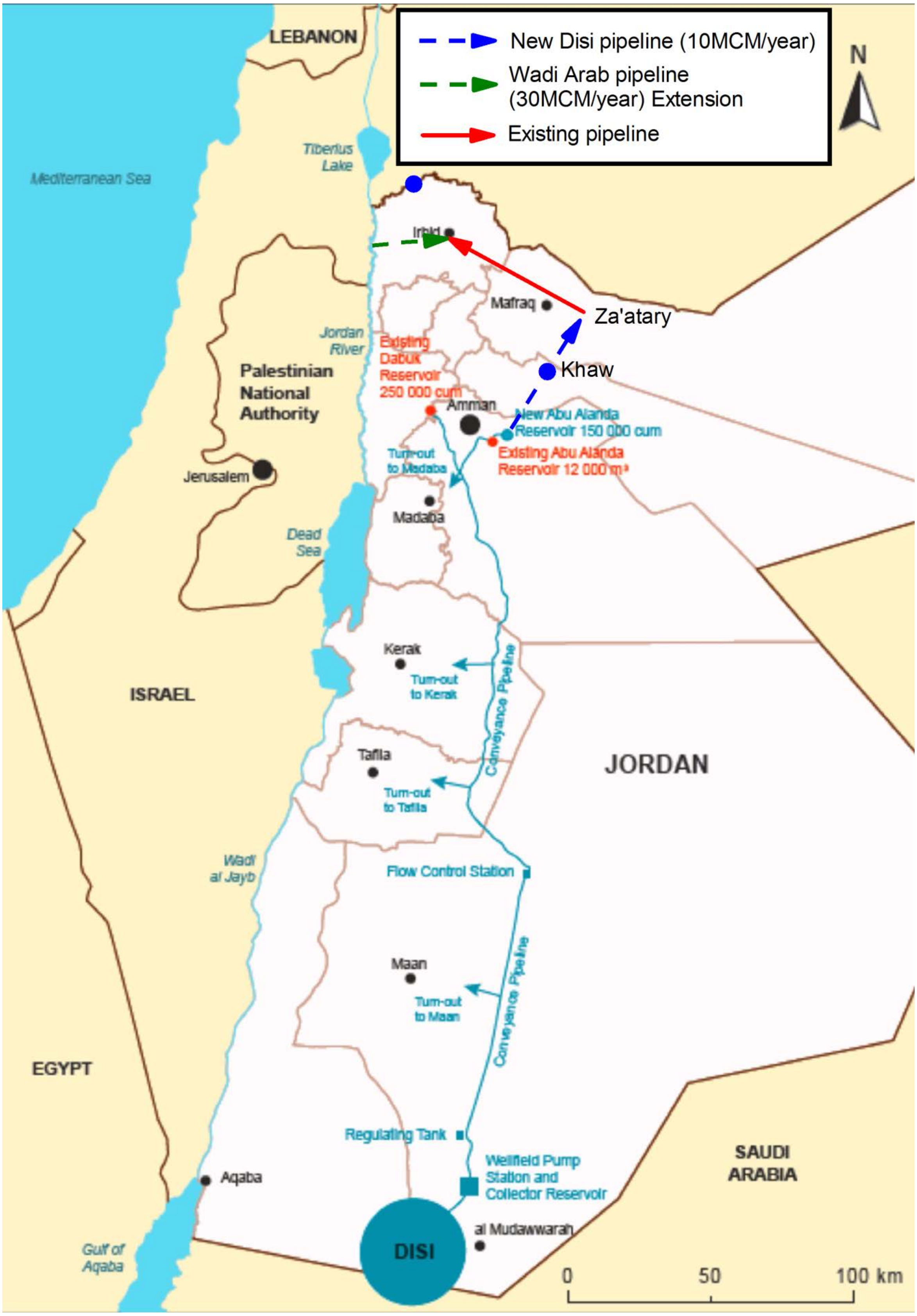
(4) Transmission System Planning after 2017

The western transmission lines from the King Abdul canal in the Jordan valley to the Zebdat reservoir in Irbid will be added to the existing western transmission system to transmit additional 30 MCM/y water in the future. Following the feasibility study in 2013, a study of preliminary design is being conducted as of October 2014 and the design will be ready by May 2015. The facilities will have a capacity of 30 MCM/y in the initial stage, with provisional capacity of 45 MCM/y finally. This study assumes that facilities with capacity of 30 MCM/y will be commissioned in 2020 at the earliest.



Source: Compiled by the JICA Study Team based on "Northern Governorates Water Transmission Feasibility Study"

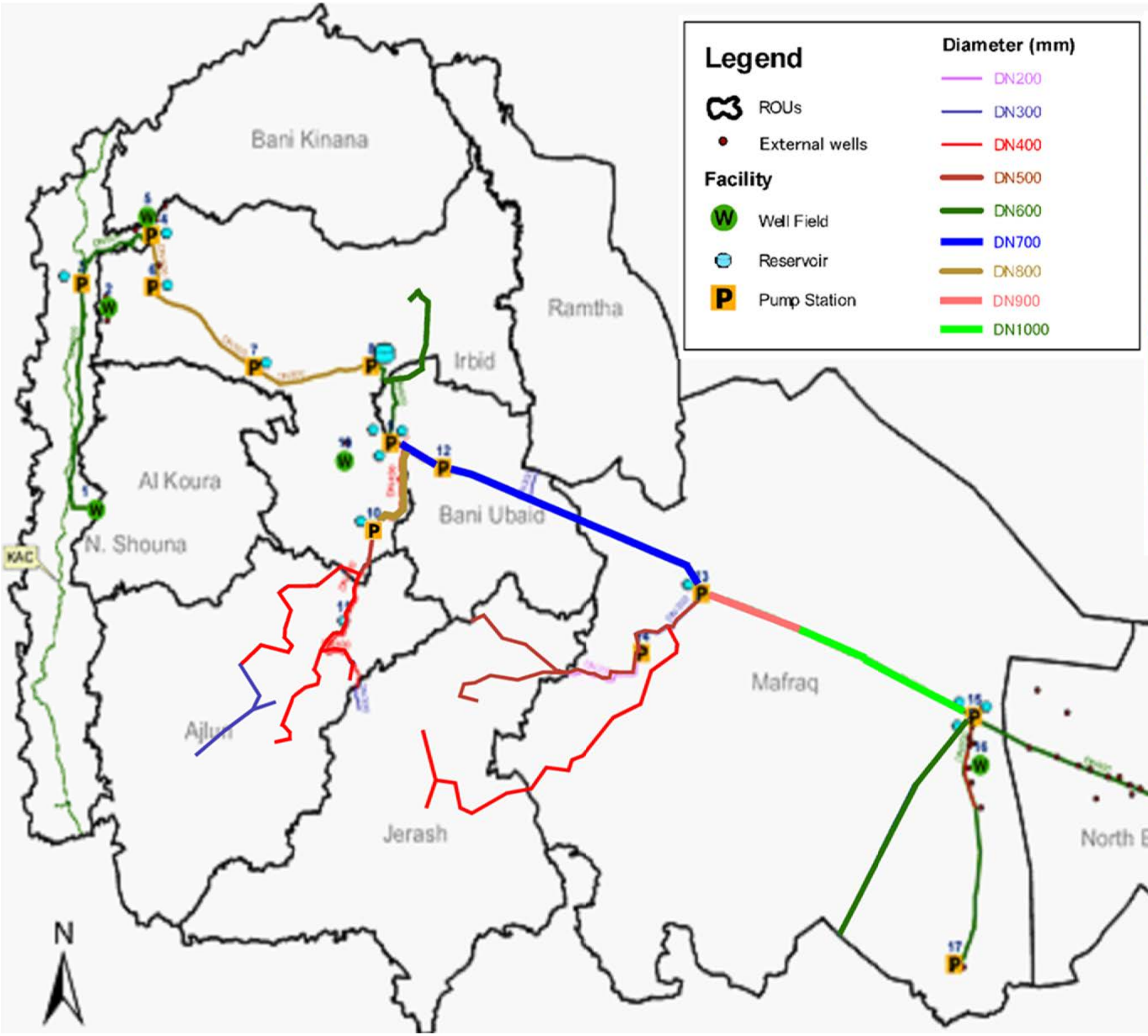
Figure 3.4 Current Transmission System



Note: Wadi Arab pipeline extension is under consideration

Source: Compiled by the JICA Study Team based on "Khaw to Za'atary Pipeline Project - Draft Report"

Figure 3.5 Transmission System from DISI Wells to Za'atary in Mafraq



No	Facility
1	Tabagat Fahel Wells
2	Al Manshyeh Wells
3	Wadi Al Arab PS0
4	Wadi Al Arab PS1 & WTP
5	Wadi Al-Arab Wells
6	Wadi Al Arab PS2
7	Wadi Al Arab PS3
8	Zubdat PS
9	Hofa PS
10	Samad PS
11	Ras Muneef Reservoir
12	Hoson PS
13	Um El Lulu PS
14	Al Bwaydah Algarbeyeh PS
15	Al Za'tary PS
16	Zatary Wells
17	Khaldyeh PS
18	Aqeb Wells
19	Juhfiyya Wells

Source: Compiled by the JICA Study Team based on "Northern Governorates Water Transmission Feasibility Study"

Figure 3.6 Planned Transmission System (Operation will start in 2017)

3.1.3 Water Allocation

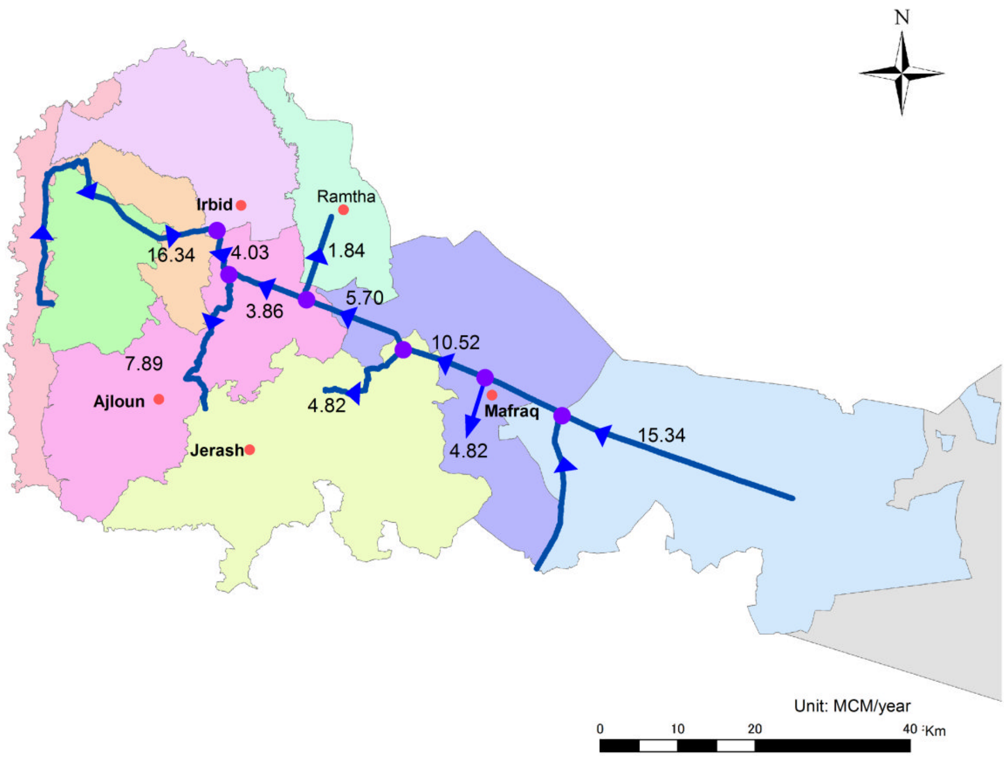
Water allocation in the northern governorates through the regional transmission system in 2013 is shown in Figure 3.7 and Figure 3.8. For the Study Area of Irbid, 16.34 MCM/y are transmitted to Zebdat from the western transmission line and 3.86 MCM/y transmitted to Hofa from the eastern transmission line. The amount of water transmitted to Hofa from Zebdat is 4.03 MCM/y and the total amount of water transmitted to Hofa is 7.89 MCM/y. A total amount of 13.84 MCM/y is supplied to the Study Area of Irbid, of which 12.31 MCM/y is supplied from Zebdat and 1.53 MCM/y from Hofa.

In the Study Area of Ramtha, 1.84 MCM/y are supplied directly to the Study Area from the eastern transmission line.

Table 3.5 Allocated Water to Irbid and Ramtha in 2013

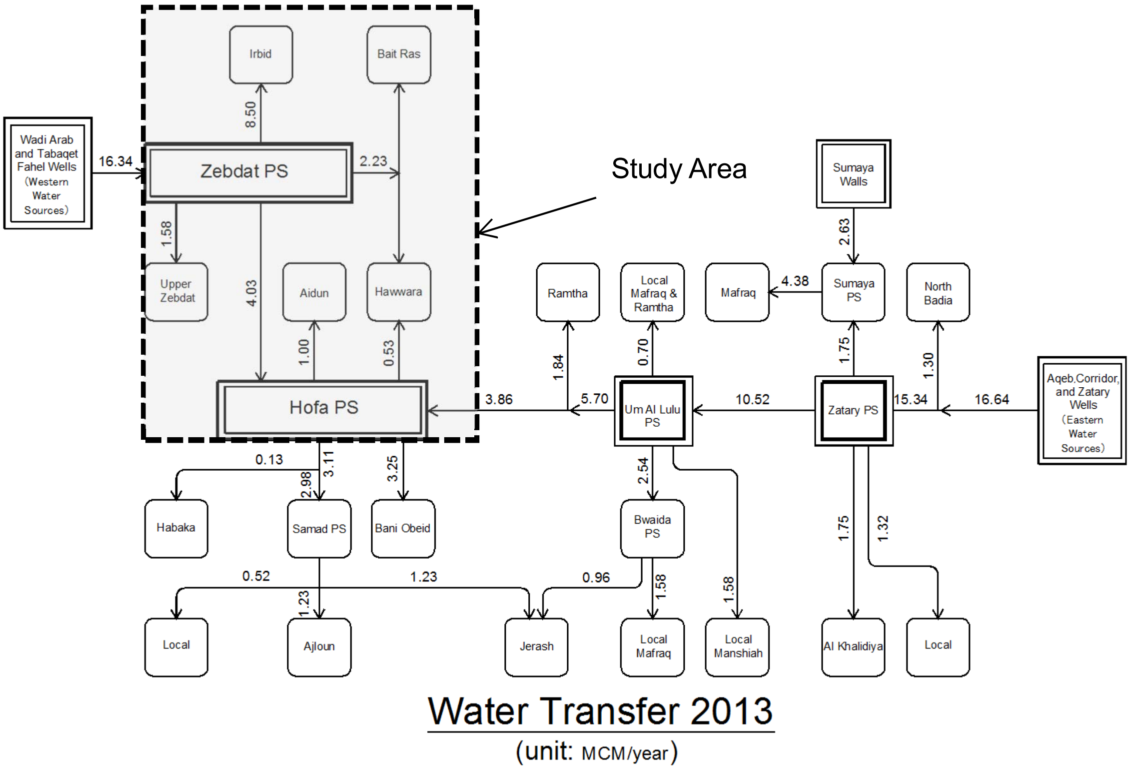
(MCM/year)

Location/Area	Inflow	Outflow	Supply to the Study Area
1. Irbid Study Area			
Zebdat	16.34	4.03 (to Hofa)	12.31
Hofa	7.89 (3.86 + 4.03)	6.36 (to outside of study Area)	1.53
Total	24.23	10.39	13.84
2. Ramtha Study Area	1.84	-	1.84



Source: JICA Study Team based on YWC data

Figure 3.7 Existing Water Allocation in 2013 in the Northern Governorates



Source: JICA Study Team based on YWC data

Figure 3.8 Schematic of Existing Water Allocation in the Northern Governorates

3.2 Existing Water Supply System in Irbid and Its Suburbs

3.2.1 Water Sources and Transmission System

(1) Irbid and its Suburbs

Only external sources are used for Irbid city, while both external and internal sources are used for the Irbid suburbs and the Bani Kinana district. Water from external sources is supplied to two reservoirs/pumping stations at Zebdat and Hofa. The localities which include internal sources are shown in Figure 5.3 in Chapter 5.

(2) Ramtha and its Suburbs

The total amount of water supply to the Study Area in Ramtha is 3.83 MCM/y with 1.84 MCM/y supplied by external sources and 1.99 MCC/y supplied by internal sources as shown in Table 3.7.

Table 3.6 Water Sources for Irbid and Its Suburbs in 2013

(MCM/y)

Area	External Sources		Internal Sources	
	Name	Amount	Name	Amount
Irbid City and Suburbs	From western transmission line to Zebdat	12.31	Fo'arah	0.13
			As'ara	0.02
	From eastern transmission line to Hofa	1.53	Bushra	0.30
			Mghayyer	0.02
	Sub total	13.84	Sub total	0.47
Total	14.31			
Bani Kinana District			Hariema	0.47
			Abu El-Loqas	0.25
			Hartha	0.61
			Saidoor*	2.21
	Sub total	0.00	Sub total	3.54
Total	3.54			
Total by source	13.84		4.01	
Grand total	17.85			

Note: * Saidoor or Kufur Asad wells are located near the Wadi Arab wells to the west of Irbid Qasabat district.
Source: YWC

Table 3.7 Water Sources for Ramtha and Its Suburbs in 2013

(MCM/y)

Area	External Sources		Internal Sources	
Ramtha	Eastern transmission line	1.84	Jaber and Abu Al-Basal wells in Ramtha City	1.99
Total	3.83			

Source: YWC

3.2.2 Existing Distribution Facilities in Irbid and Its Suburbs

(1) Layout of Facilities

The existing distribution network system in Irbid and suburbs including the locations of Zebdat and Hofa reservoirs and pumping stations are shown in Figure 3.9. The existing distribution network has pipe diameters that vary from 50 mm to 800 mm.

This figure shows not only Irbid and suburbs but also the Bani Kinana district to which water is currently supplied from local (internal) sources. However, in the future, water has to be supplied to some areas in the district from the Irbid system because the production of water from internal sources in this district cannot meet the increase in demand. The Bani Kinana district is situated at a lower elevation than Irbid city so water can be distributed by gravity from the Zebdat system.

Figure 3.10 shows the areas in Irbid city with water supply from the Zebdat and Hofa systems. Water from Hofa reservoir is supplied by gravity to the southern suburbs such as Aidoon, Sarieh, Hoson, Hawwara, with elevation below that of the Hofa reservoir but above that of the Zebdat reservoir. Water from Hofa is also supplied by pumps to the areas south of the Hofa reservoir located at elevations higher than the Hofa reservoir. These areas to which water is pumped are excluded from the Study because they do not affect the hydraulic conditions of Irbid city. The water supply system to these areas is located outside the urban growth area and is regarded as a separate water supply system.

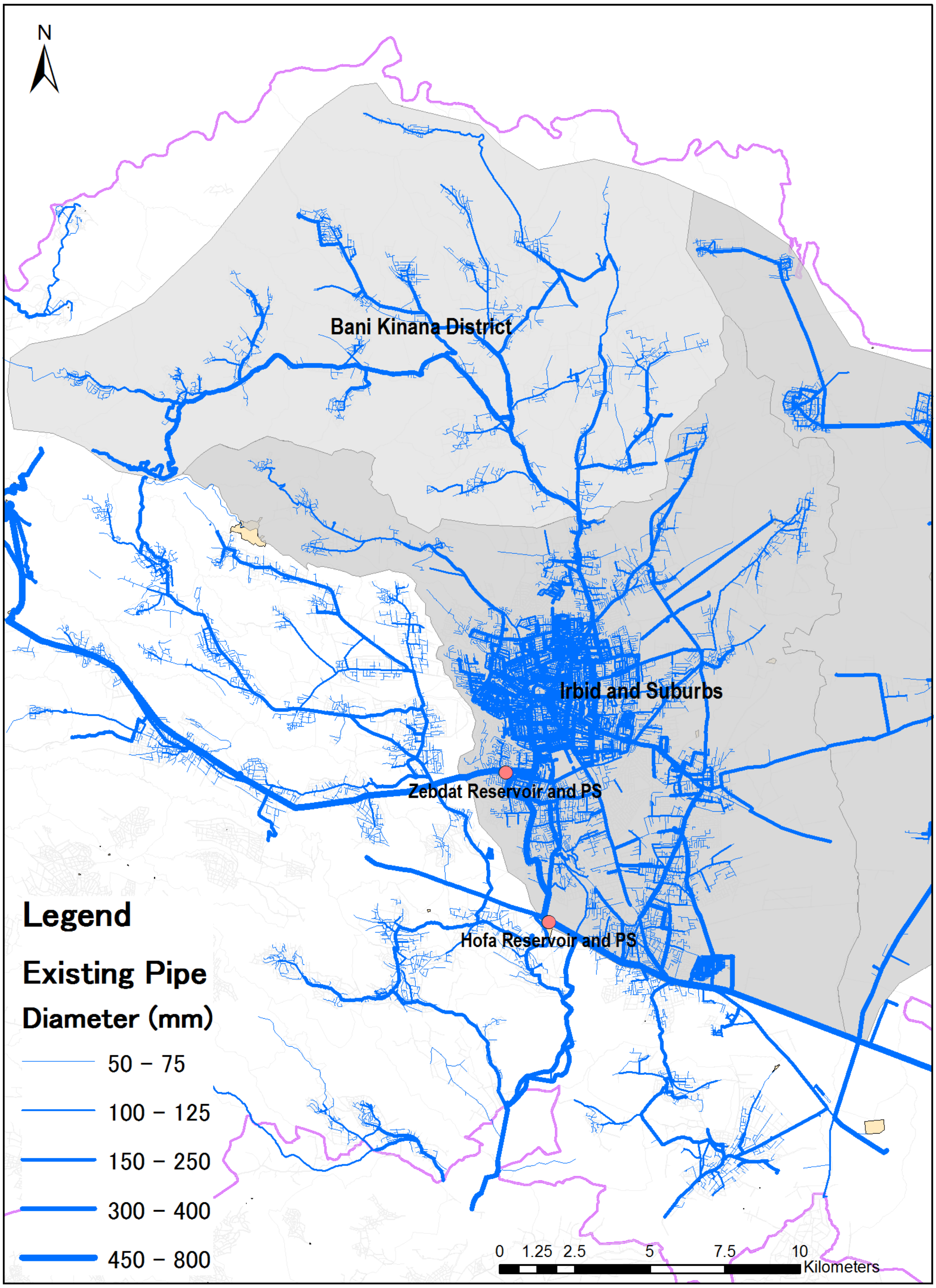


Figure 3.9 Distribution Network in Irbid City and Suburb with Bani Kinana District

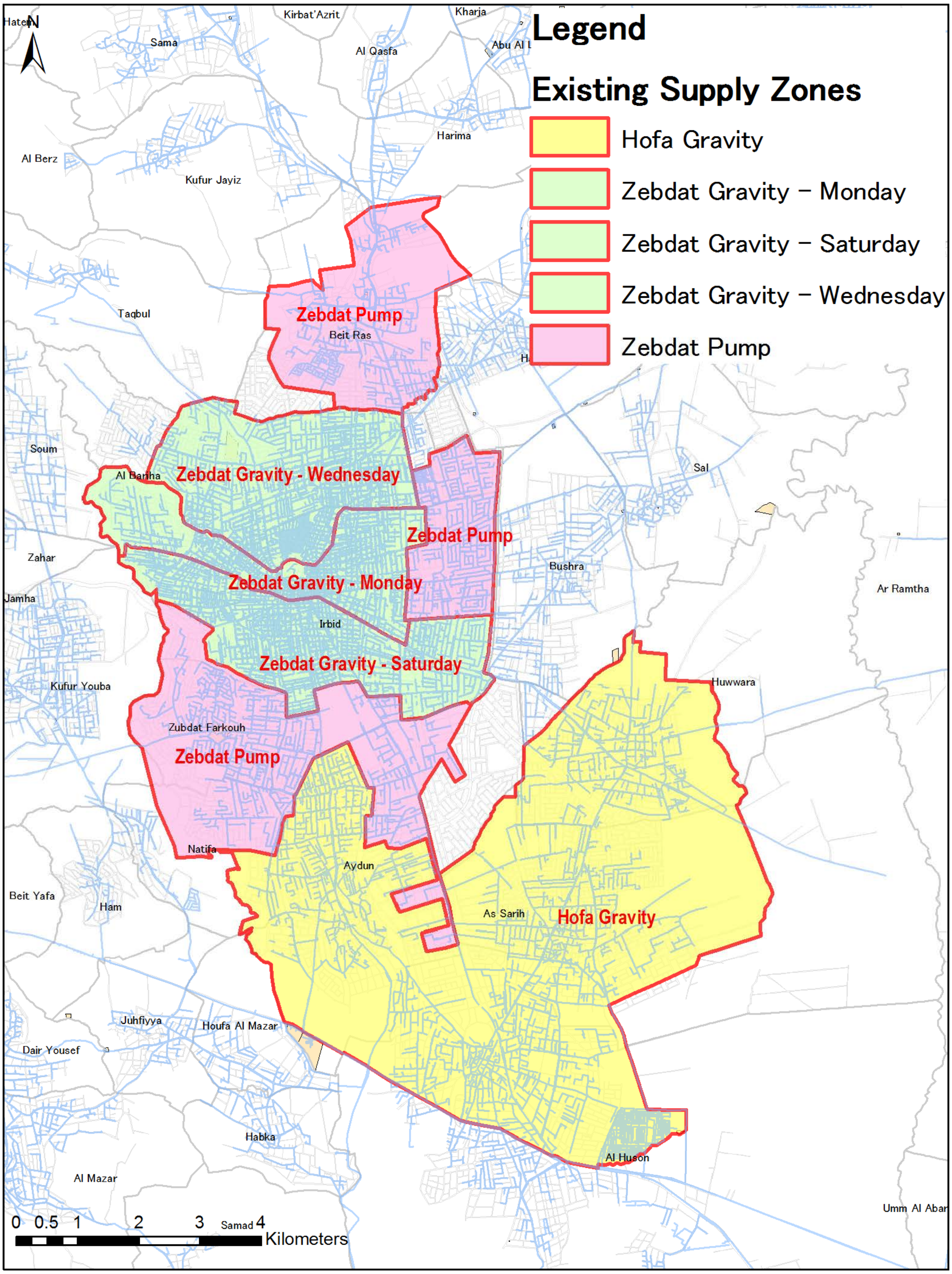


Figure 3.10 Supply Area of Zebdat Gravity and Pumping System and Hofa Gravity System

(2) Reservoirs and Pumping Stations

Two existing reservoirs with pumping stations (PS) are located at Zebdat and Hofa. The specifications of reservoirs and pumping stations at Zebdat and Hofa are given in Table 3.8 and Table 3.9, respectively.

The current condition of the reservoirs is good based on the visual observation by JICA Study Team and they could be continuously used during the project life of this Study.

The current condition of the pumps is fair without abnormal sound and vibration based on the observation by JICA Study Team but it is reported by YWC that the frequency of motor and valve maintenance is increasing. Therefore, pumps need to be replaced when the efficiency of pumps is uneconomically worse or pump is damaged.

Table 3.8 Reservoirs in Zebdat and Hofa Systems

Reservoir	Capacity (m^3)	High Water Level (m)	Low Water Level (m)	Year of Installation	Structure	Conditions
Zebdat	110,000	631	625	1983	Reinforced Concrete	Good
Hofa	12,000 5,000	790	780	1983 1970	Reinforced Concrete	Good

Table 3.9 Zebdat and Hofa Pumping Stations

Pump	Year of installation	Q (m^3/h)	H (m)	kW	Remarks	Conditions
Zebdat PS						
No. 1	2002	500	200	550	For pumping to Hofa reservoir	Fair
No. 2	2002	500	200	550	For pumping to Hofa reservoir	Fair
No. 3	2002	300	250	350	Pumps water to south Irbid high area	Fair
No. 4	2002	300	190	350	Pumps water to south Irbid high area	Fair
No. 5	2002	300	250	290	Pumps water to Irbid eastern area and Bait Ras	Fair
Hofa PS						
No. 1	2002	380	256	N.A.	For pumping to Samad reservoir	Fair
No. 2	2002	270	250	N.A.	For pumping to Habaka or to Samad reservoir	Fair
No. 3	2002	150	250	N.A.	For pumping to Habaka or to Samad reservoir	Fair
No. 4	2014	150	300	N.A.	For pumping to Habaka or to Samad reservoir	Fair

Note: Hofa pump supply area is excluded from the Study.
Source: JICA Study Team

(3) Pipe
Water supply system of Irbid and its suburbs in the Study Area is administered by two regional operation units (ROU), namely Irbid ROU and Bani Obaid ROU. Irbid city and the eastern suburbs belong to the Irbid ROU and the southern suburbs belong to the Bani Obaid ROU (Figure 1.2). Data of distribution pipes in these two ROUs are collected and summarized below. The details of pipe data are given in Appendix 3D.

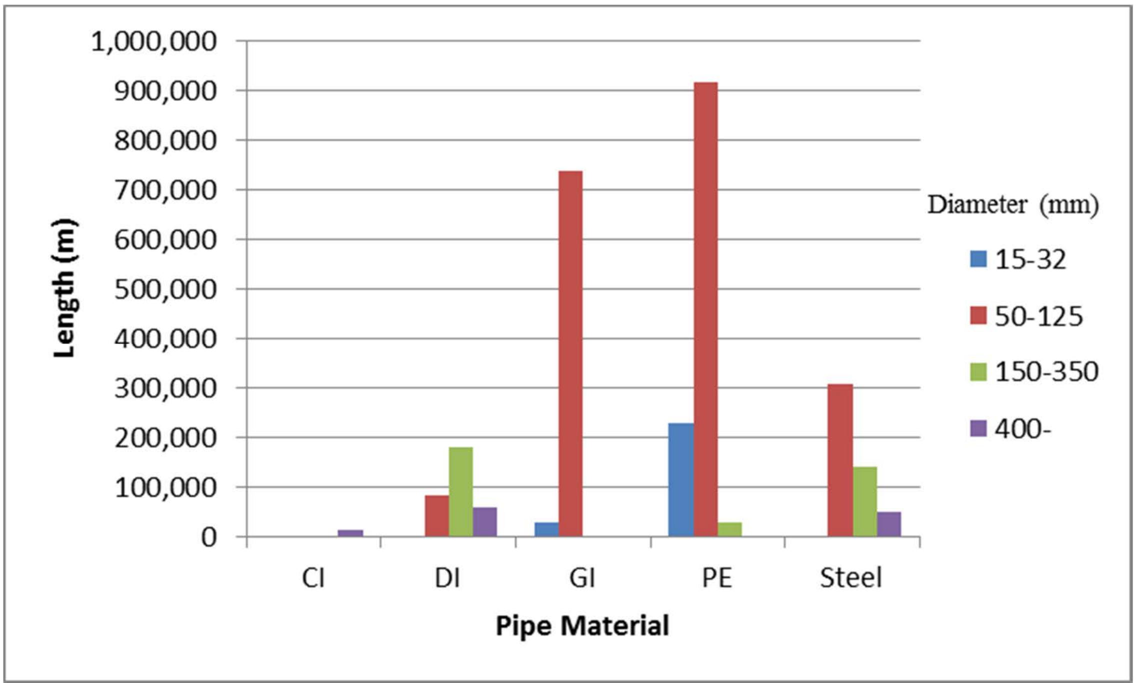
Pipe lengths by pipe material and diameter are summarized in Table 3.10 and Figure 3.11. The total length is 2,790 km of which 42 % is polyethylene (PE), 27.6 % is galvanized iron (GI) and 17.9 % is steel. The diameter in about three quarters of the total length ranges from 50 mm to 125 mm.

Table 3.10 Pipe Length by Materials and Diameter in Irbid and Bani Obaid ROUs

(meter)

Diameter (mm)	CI	DI	GI	PE	Steel	Unknown	Total	% of Total
15-32	0	0	30,072	227,350	0	0	257,422	9.2
50-125	0	84,134	738,492	915,991	308,512	7,949	2,055,078	73.7
150-350	0	179,142	970	28,000	140,412	0	297,042	10.7
400-	15,490	60,123	0	581	51,089	0	178,765	6.4
Total	15,490	323,399	769,534	1,171,922	500,013	7,949	2,788,307	100.0
% of Total	0.6	11.6	27.6	42.0	17.9	0.3	100.0	

Note:Ductile Iron (DI), Galvanized Iron (GI), Polyethylene (PE), Cast Iron (CI)
Source:Compiled by the JICA Study Team using data provided by YWC



Source: Compiled by the JICA Study Team using data provided by YWC

Figure 3.11 Pipe Length by Material and Diameter in Irbid and Bani Obaid ROUs

Pipe lengths by installation year and diameter are summarized in Table 3.11 and Figure 3.12. Three quarters of the total length were installed before 2000 and are more than 14 years old. 35 % of the pipes were installed before 1980 and are more than 35 years old; their lifetime has been reached or will soon be reached.

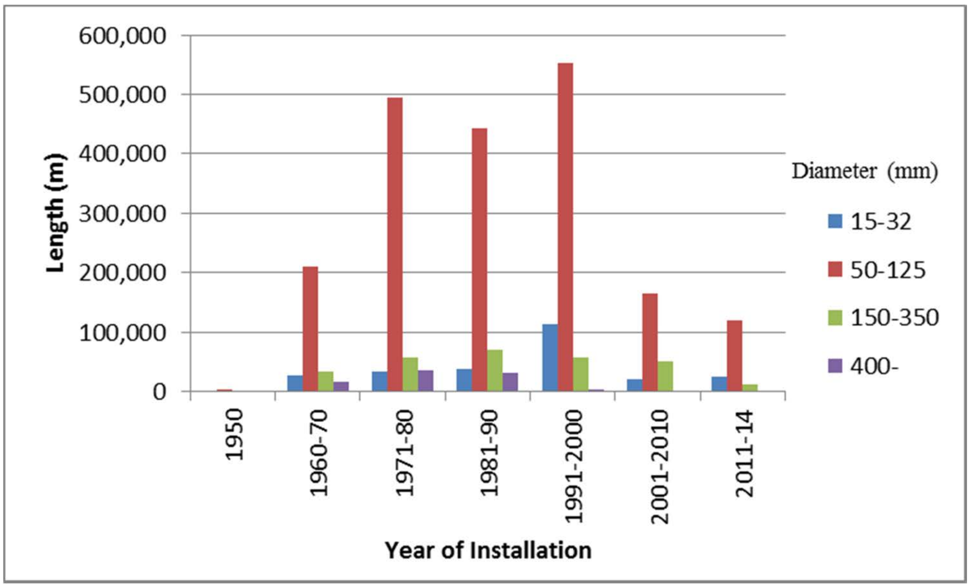
According to information from YWC, most of the pipes in the central part of Irbid city were installed in the1990's. Pipes to the east of Irbid in Bushra and Hawwara were installed in 1974, while pipes in Hakama, Bait Ras and Al'al located to the northern part of Irbid city were installed in the 1970's.

Table 3.11 Pipe Lengths by Installation Year and Diameter in Irbid and Bani Obaid ROUs

(meter)

Diameter (mm)	1950	1960-70	1971-80	1981-90	1991-2000	2001-10	2011-14	Unknown	Total	% of Total
15-32	0	27,836	33,579	37,502	112,326	19,667	24,506	2,007	255,416	9.8
50-125	610	210,661	493,650	442,780	552,393	163,831	120,342	70,808	1,984,267	76.3
150-350	0	32,710	57,817	70,217	57,337	50,056	11,375	69,013	244,209	9.4
400-	0	15,743	35,997	30,169	581	0	0	44,794	117,793	4.5
Total	610	286,950	621,043	580,668	722,637	233,554	156,223	186,622	2,601,685	100.0
% of Total	0.0	11.0	23.9	22.3	27.8	9.0	6.0	7.2	100.0	

Source: Compiled by the JICA Study Team using data provided by YWC



Source: Compiled by the JICA Study Team using data provided by YWC

Figure 3.12 Pipe Lengths by Installation Year and Diameter in Irbid and Bani Obaid ROUs

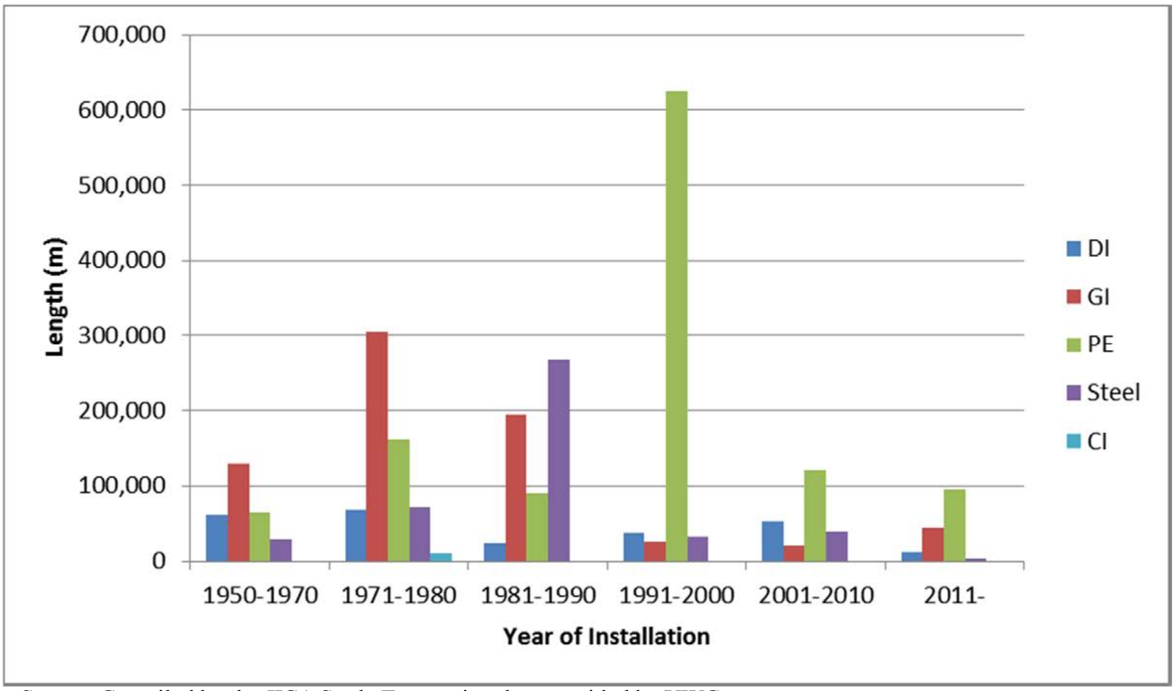
Pipe lengths by installation year and material are shown in Table 3.12 and Figure 3.13. Most of the GI pipes were installed before 1990 and are past their lifetime since more than 25 years have elapsed. The recent trend in pipe materials shows that PE pipes are increasingly being used.

Table 3.12 Pipe Lengths by Installation Year and Material in Irbid and Bani Obaid ROUs

(meter)

Installation year	DI	GI	PE	Steel	CI	Unknown	Total	% of Total
1950-1970	61,907	129,981	64,733	29,407	0	0	286,028	10.3
1971-1980	68,438	304,460	161,505	72,075	10,516	4,229	621,223	22.3
1981-1990	24,588	193,717	91,203	267,605	0	3,554	580,667	20.8
1991-2000	37,681	26,371	624,942	33,293	0	347	722,634	25.9
2001-2010	52,160	20,966	121,270	39,156	0	0	233,552	8.4
2011-	11,794	44,207	96,407	3,814	0	0	156,222	5.6
Unknown	66,829	48,296	11,861	54,662	4,974	0	186,622	6.7
Total	323,397	767,998	1,171,921	500,012	15,490	8,130	2,786,948	100.0
% of Total	11.6	27.6	42.1	17.9	0.6	0.3	100.0	

Note: Ductile Iron (DI), Galvanized Iron (GI), Polyethylene (PE), Cast Iron (CI)
Source: Compiled by the JICA Study Team using data provided by YWC



Source: Compiled by the JICA Study Team using data provided by YWC

Figure 3.13 Pipe Lengths by Installation Year and Materials in Irbid and Bani Obaid ROUs

(4) Distribution Network

The highest elevation in the Study Area in Irbid is almost 700 m while the lowest is about 450 m. The difference is as large as 250 m. If water is supplied simultaneously to every part of Irbid, particularly under limited water supply conditions, hydraulically advantageous areas such as areas near the reservoir or pumping station, or areas located at low elevation will continue receiving water all the time, while the areas at the tail-end or at a high elevation may not receive sufficient water. Therefore, YWC had no choice but to implement a rationing system to supply water equitably since a long time ago. However, “No Water” complaints are the largest complaints yet and have increased recently, especially rapidly after the influx of Syrian refugees.

Ground elevations in a large part of the Study Area are below 600 m and except for some high-elevation areas, water can be supplied by gravity from the Zebdat reservoir (LWL 625 m) or the Hofa reservoir (789 m). Some parts such as Bait Ras, located far from the Zebdat reservoir and at a relatively high elevation, and eastern Irbid city, which is also located far from the reservoir, receive water pumped from Zebdat with a high lift pump (200 m head). Their ground elevations range between 520 m and 600 m, which is lower than the low water level of the Zebdat reservoir; therefore, water can theoretically be supplied from the reservoir by gravity. Water pressure to the customers is very low even when water is supplied by high lift pump. This is due to the low distribution capacity or smaller pipe diameter than required.

Pipes in Irbid city were mostly replaced in the 1990’s. Since then, distribution facilities have been unattended. As a result, existing facilities cannot cope with the increased water demand, particularly in the suburbs.

In addition, the water distribution network with trunk mains, mains, sub-mains and service pipes, is not well organized. This makes it difficult to manage water distribution ensuring equitable supply to the all customers. Large differences exist in elevation in the entire supply area, and even within the rationing zones; however, supply zones have not been clearly defined considering elevation differences within the zone.

3.2.3 Existing Distribution Facilities in Ramtha and Its Suburbs

(1) System Layout

The existing distribution network in Ramtha and its suburbs is shown in Figure 3.14. The distribution system is geographically divided into five areas by locality: Ramtha city, Torrah, Shajarah, Emrawah, and Dnaibeh.

(2) Reservoir and Pumping Station

There is no reservoir in the Study Area. Supply areas and pumping stations are as follows;

- Hodod pumping station collects groundwater from Jaber wells in east of Ramtha and supplies it to the east Ramtha city.
- Abu Al Basal pumping station collects groundwater in west of Ramtha and supplies to the west Ramtha city.
- Both pumping stations also transfer water to Mahasi pumping station, from where water is supplied to the northern localities of Torrah, Shajarah, Emrawah and Dnaibeh.
- To the central part of Ramtha city, water is supplied directly from the Za'atary pumping stations through the eastern transmission line. This water coming from Za'atary pumping station is supplied to the Study Area by pressure remaining in the pipeline by operating valves located on the branch pipe of the transmission line.

Supply hours are limited; for example water from Za'atary is 2 to 3 days per week. Valve operation is indispensable for water rationing to supply limited water. Out of about 400 valves in the Ramtha Study Area, about 50 valves are operated daily for supply of local (internal) groundwater while about 100 valves are operated for supply of the Za'atary water. Valve operating teams are 3, consisting of 2 staffs each so total number is 6.

Table 3.13 Pumps at Mahasi and Hodod Pumping Stations

Pumping Station	Pump No.	Commissioning Year	Q (m^3/h)	H (m)	Supply Area	Conditions
Hodod	No. 1	2011	120	180	• Ramtha city • Mahasi pumping station	Good
	No. 2	2009	200	180		Good
	No. 3	2014	150	300		Good
Abu Al Basal	No. 1	2010	100	150	• Ramtha city • Mahasi pumping station	Good
	No. 2	2014	240	100		Good
Mahasi	No. 1	2013	100	150	• Northern localities	Good
	No. 2	2008	100	250		Good
	No. 3	2004	150	200		Good

Source: YWC

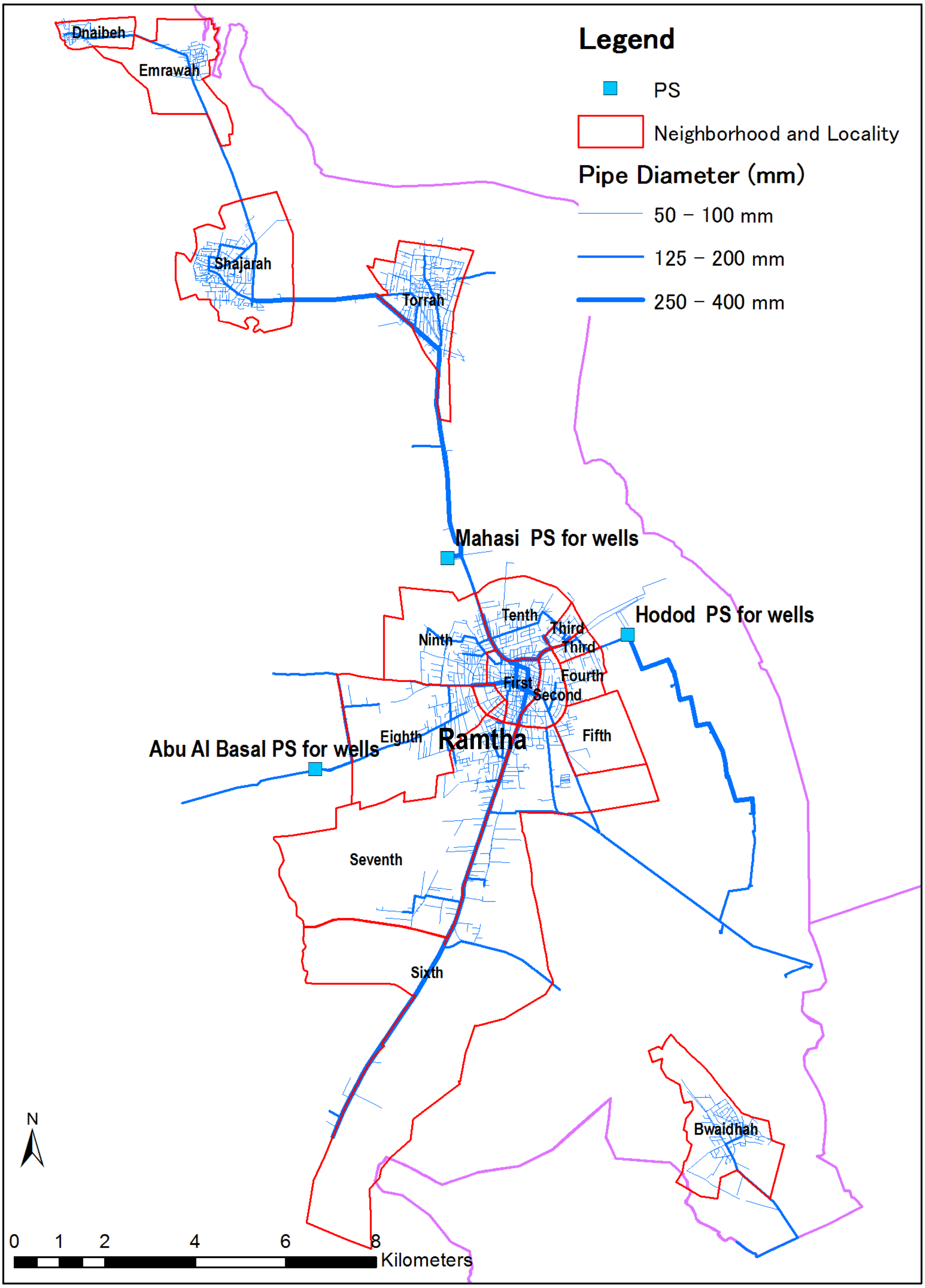


Figure 3.14 Distribution System in Ramtha City and Suburbs

(3) Pipe

Table 3.14 and Figure 3.15 show the pipe lengths by material and diameter. The diameter of existing pipes in the Ramtha area ranges from 15 mm to 400 mm. The major part of the pipe is made of PE (49.7 %), followed by DI (18.2 %), GI (16.8 %), and steel (15.3 %). Seventy percent of the total pipe length has diameter between 50 mm and 125 mm. The longest length of pipe is PE with diameter ranging from 50 mm to 125 mm.

Table 3.14 Pipe Lengths by Material and Diameter in the Ramtha ROU

(meter)

Diameter (mm)	DI	GI	PE	Steel	Total	% of Total
15-32	17	1,215	38,341	168	39,741	7.6
50-125	38,057	86,092	221,239	20,911	366,299	70.0
150-350	53,219	353	387	57,989	111,948	21.4
400	3,912	0	0	1,295	5,207	1.0
Total	95,205	87,660	259,967	80,363	523,195	100.0
% of Total	18.2	16.8	49.7	15.3	100.0	

Note: Ductile Iron (DI), Galvanized Iron (GI), Polyethylene (PE), Cast Iron (CI)
Source: Compiled by the JICA Study Team using data provided by YWC

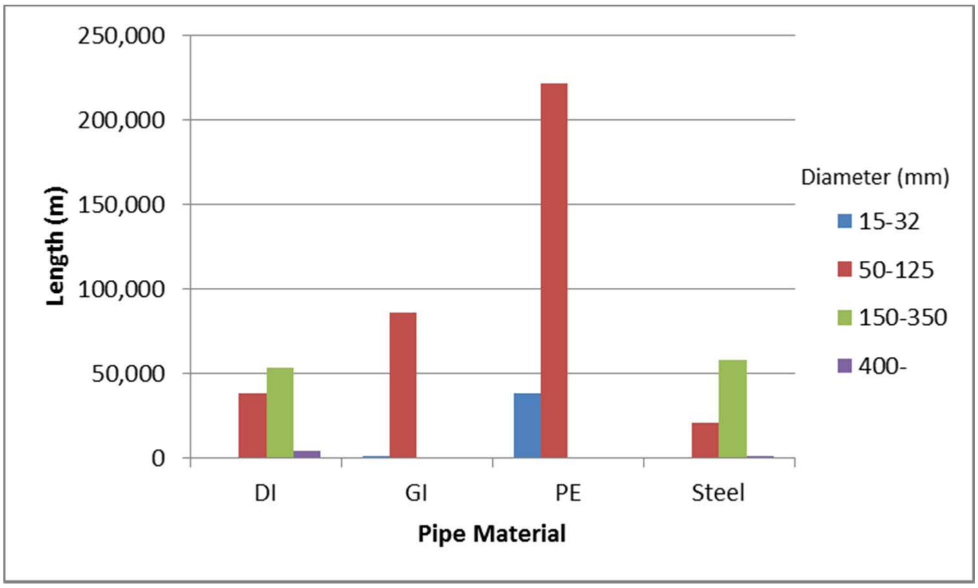


Figure 3.15 Pipe Lengths by Material and Diameter in the Ramtha ROU

Table 3.15 and Figure 3.16 give pipe lengths by installation year and diameter. Pipes in the Ramtha Study Area are relatively new compared with those in the Irbid Study Area. Half of the total pipeline length was installed in the 1980's and the remaining half in 2000 or later.

Table 3.15 Pipe Lengths by Installation Year and Diameter in the Ramtha ROU

(meter)

Diameter (mm)	1981-90	1991 -2000	2001 -2010	2011-14	Total	% of Total
15-32	5,379	0	32,641	1,722	39,742	7.6
50-125	204,391	0	157,870	4,039	366,300	70.0
150-350	66,477	0	44,491	980	111,950	21.4
400-	5,207	0	0	0	5,207	1.0
Total	281,454	0	235,002	6,741	523,199	100.0
% of Total	53.8	0.0	44.9	1.3	100.0	-

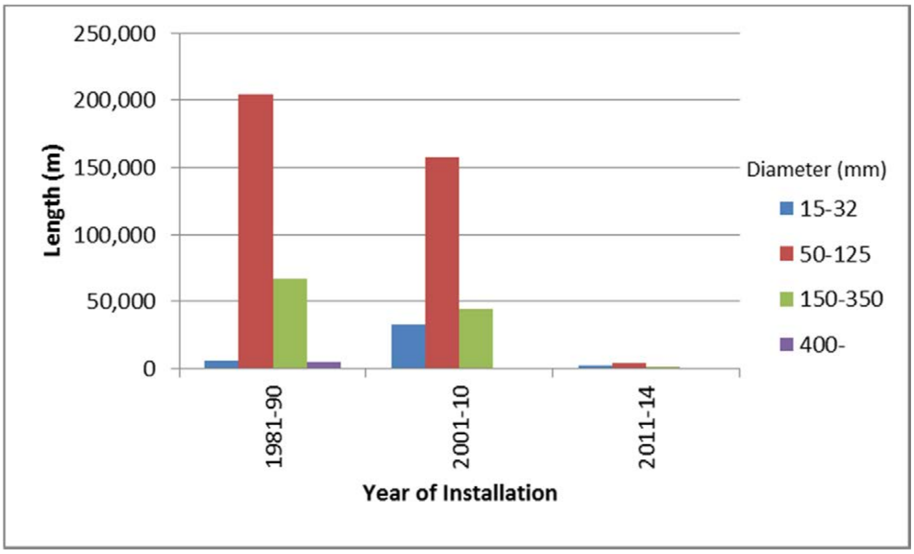


Figure 3.16 Pipe Lengths by Installation Year and Diameter in the Ramtha ROU

Table 3.16 and Figure 3.17 show the pipe lengths by installation year and material. Half of the pipeline length was installed in 1990 and the remaining half was installed between 2007 and 2009. Most of GI pipes were installed in 1990, more than 25 years ago; so most of GI pipes are past their life time. The recent trend of pipe materials shows that PE and DI pipes are increasingly being used.

Table 3.16 Pipe Lengths by Installation Year and by Material in the Ramtha ROU

(meter)

Installation year	DI	GI	PE	Steel	Unknown	Total	% of Total
1986	0	0	0	682	0	682	0.1
1990	20,538	81,103	106,075	73,057	2,610	283,382	53.9
2007	12,168	6,558	30,215	848	0	49,789	9.5
2008	45,529	0	89,310	0	0	134,838	25.6
2009	12,535	0	28,495	0	0	41,030	7.8
2010	3,230	0	338	5,777	0	9,345	1.8
2011	1,207	0	2,473	0	0	3,680	0.7
2012	0	0	2,199	0	0	2,199	0.4
2014	0	0	862	0	0	862	0.2
Total	95,206	87,661	259,967	80,364	2,610	525,808	100.0
% of Total	18.1	16.7	49.4	15.3	0.5	100.0	-

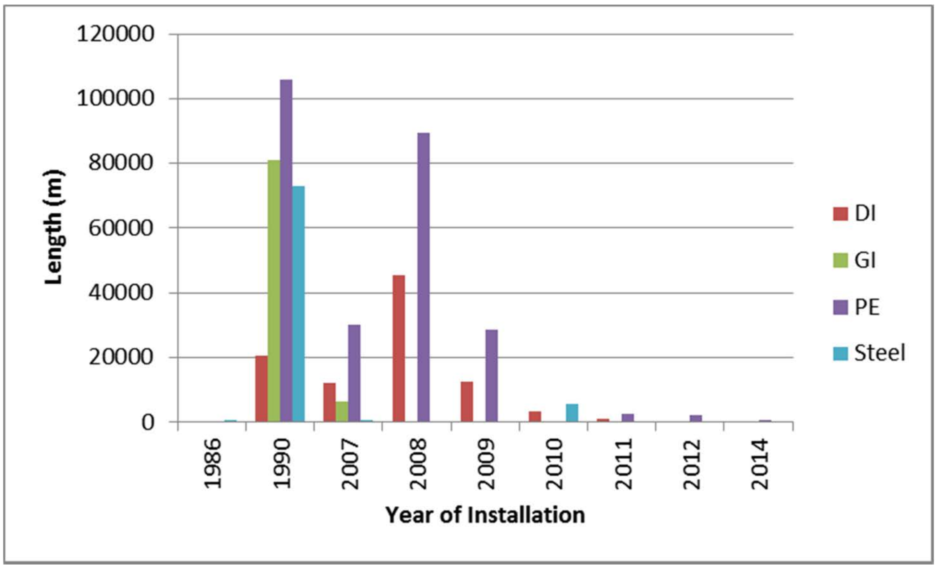


Figure 3.17 Pipe Lengths by Installation Year and by Material in the Ramtha ROU

(4) Distribution Network

The highest elevation in the Ramtha Study Area is almost 600 m while the lowest is about 370 m. The difference is as large as 230 m. If water is supplied simultaneously to every part of the Study Area, particularly under limited water supply conditions, hydraulically advantageous areas or Ramtha city will continue to receive water all the time while the areas downstream may not receive sufficient water. Therefore, YWC had no choice but to implement a rationing system to supply water equitably since a long time ago. However, “No Water” complaints are the largest type of complaints yet and have increased in recent years, especially rapidly after the influx of Syrian refugees.

The water pressure to the Ramtha area at the branch point of the transmission line is estimated at about 170 m at the ground level of 630 m. Ground elevations in Ramtha city are below 600 m and water is supplied by gravity; however, the water pressure in Ramtha city is low at 35 m maximum. Water pressure to the customers is very low even with high residual water pressure at the branch point. This is due to low distribution capacity or smaller diameter than required.

3.3 Water Supply Service

3.3.1 Customer Complaints

YWC has a complaint redressal center that operates round the clock to respond to claims from customers. The total number of complaints related to “No Water” in Irbid and Bani Obaid is 52,372 (41 complaints per day) and for “Leakage” is 20,384 (16 complaints per day) for the period from January 2011 to June 2014. The complaints are from all parts of the Irbid Study Area, as seen in the location map of “No water” and “Leakage” in Appendix 3E.

“No Water” and “Leakage” account for about 90 % of all the claims related to water supply (65 % “No Water” and 25 % “Leakage”) in 2013. The remaining claims relate to pipe clogging, improper connection, and so on (Table 3.17).

Table 3.17 Breakdown of Claims Related to Water Supply in 2013

Area	No Water	Leakage	Blockage	Water meter	Replacement of valve	Illegal use	Other	Total
Irbid City	20,801	4,439	384	119	536	43	2,638	28,960
	71.8 %	15.3 %	1.3 %	0.4 %	1.9 %	0.1 %	9.1 %	100.0 %
All the service area	28,146	10,681	677	216	771	63	2,839	43,393
	64.9 %	24.6 %	1.6 %	0.5 %	1.8 %	0.1 %	6.5 %	100.0 %

Note: Compiled by the JICA Study Team based on data from YWC.

The list of the claims includes “replacement of valves” and “clogged pipes” in addition to “No Water” and “Leakage.” These are mainly due to inadequate skills of the relevant staff-members in pipeline work.

Judging from past trends, “Leakage” has been stable but “No Water” has increased very rapidly since 2012 when Syrian refugees started entering Jordan (Figure 3.18).

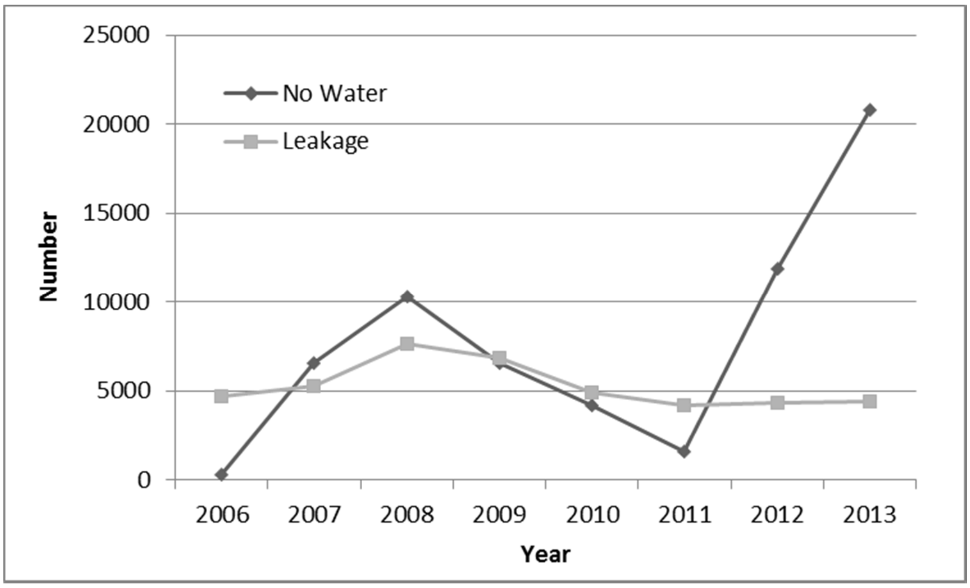


Figure 3.18 Number of Complaints of No Water and Leakage in Irbid City

During the period 2006 to 2013, remedial measures were taken against leakage claims; nonetheless, it has not reduced significantly and the number of claims per year has remained at more than 4,000. No fundamental measures have been adopted yet. On the other hand, the "No Water" complaint is mainly related to the limited water source and capacity of water distribution infrastructure and distribution control. Hence, leakage control and distribution restructuring and control need to be taken up on priority together with water source development.

3.3.2 Supplied Amount per Capita

YWC supplied 71 MCM/year (or 195 thousand m^3/day on average) of water to a population of about 1,780 thousand in the northern governorates in 2012. The per capita supplied amount is calculated as 110 lpcd. Considering a leakage ratio of 20 to 30 %, about 80 to 90 lpcd has reached consumers. This value is almost equal to the basic value (say, winter demand) of 88 lpcd for rural area but is lower than the basic value of 116 lpcd for urban area recommended in the "Water Reallocation Strategy 2010."

The per capita water supply amount in Irbid Study Area is much lower than the average of the northern governorates. Supplied and consumed amounts per capita in 2012 are estimated as shown in Table 3.18. The YWC supplied 14.3 MCM/year (or 39 thousand m^3/day on average) of water to a population of 450 thousand in the Irbid Study Area in 2012. This is equivalent to a per capita supplied amount of 87 lpcd. Similarly, assuming 20 to 30 % leakage, the consumed amount is 60 to 70 lpcd in Irbid which is much below the recommended value of 116 lpcd. In addition, considering the number of Syrian refugees in Irbid city and assuming this number as an additional 20 % of the Jordanian population, the per capita consumed amount is further reduced to only 43 to 56 lpcd.

In the Ramtha area, 3.83 MCM/year (10,500 m^3/day) were supplied in 2012 to a population of 133 thousand. This is equivalent to a per capita supplied amount of 79 lpcd, which is lower than that of the Irbid Study Area. The estimated consumed amount is 55 to 63 lpcd.

Table 3.18 Estimated Supplied and Consumed Amounts per Capita in 2012

(Unit: lpcd)

Parameter	Northern Governorates	Irbid Study Area	Ramtha Study Area	Irbid Study Area plus Syrian Refugees	Basic Water Consumption*, Water Reallocation Strategy 2010
Per Capita Supplied Amount	110	87	79	70	-
Per Capita Net Consumed Amount (Estimated)	80 to 90	60 to 70	55 to 63	43 to 56	116 for urban area and 88 for rural area

Note: * includes additional 16 % of basic value (100) for urban area for commercial and other uses and 10 % of basic value (80) for rural area.

This low per capita net consumption further reduced by the influx of Syrian refugees, is severely affecting the daily life of the host communities.

3.3.3 Water Rationing

Water rationing is implemented to distribute water equitably because of the shortage of water at source and inadequate distribution network as described in section 3.2.2 (4) and section 3.2.3 (4).

(1) Irbid and its Suburbs

Irbid city is divided into several parts and water is supplied on different days to these areas as shown in Figure 3.19. The three largest zones are in central Irbid. YWC is supplying water rotationally one day per week to each divided area. In the Irbid central area, water is supplied through gravity on Wednesday (northern part), Monday (central part) and Saturday (southern part). Every consumer within the zones may receive water eventually in the 24-hours supply period.

(2) Ramtha and its Suburbs

In the Ramtha Study area, water is rationed in six supply zones: south Ramtha, north Ramtha, Torrah, Shajarah, Emrawah and Dnaibeh (see Figure 3.14 for zone names). Water is supplied one day per week by supply zone.

Water is directly supplied to this area from the eastern transmission line. The YWC controls water volume and supply hours through a valve at the inlet of Ramtha supply area and thereby controls the water supplied to Hofa.

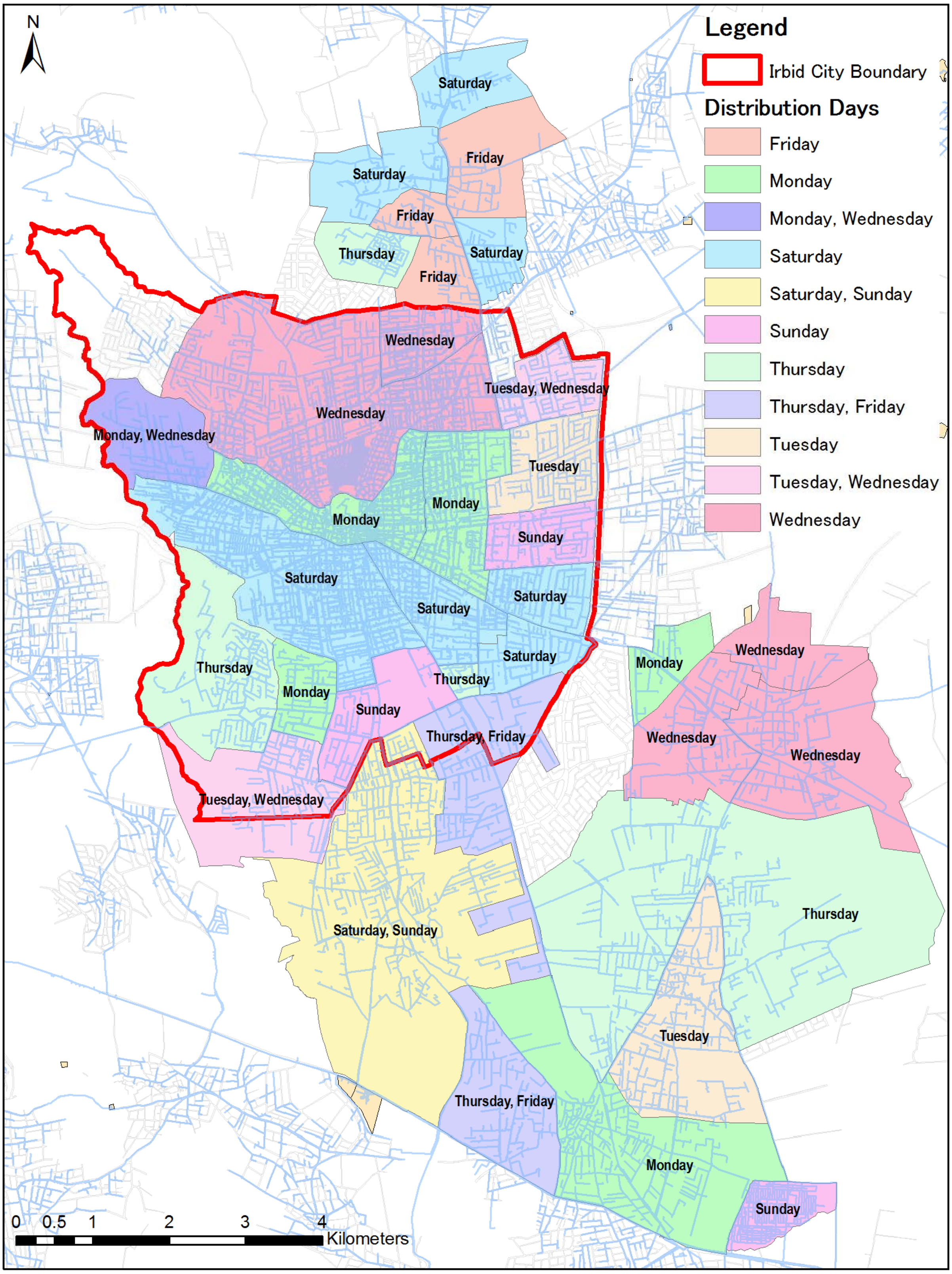


Figure 3.19 Rationing Schedule from the Zebdat and Hofa Systems (as of April 2014)

3.3.4 Water Pressure

(1) Irbid and its Suburbs

1) Gravity-supplied Area

The pressure at six locations in the gravity-supplied area is plotted in Figure 3.20 together with the flow from the Zebdat reservoir. On mornings of the supply day, the pressure remains low due to high consumption or storage in private tanks by users. The pressure at nights increases although the highest pressure is only 2.25 bars. The locations of YWC's pressure data loggers in Irbid and its suburbs are shown in Appendix 3F.

Water pressure at the start of supply is low because customers try to fill their tanks; the pressure increases gradually as tanks fill and flow reduces. When all customers in a zone have received water, the supply to that zone is stopped. This pressure pattern is true in almost all supply zones.

2) Pump-supplied Area

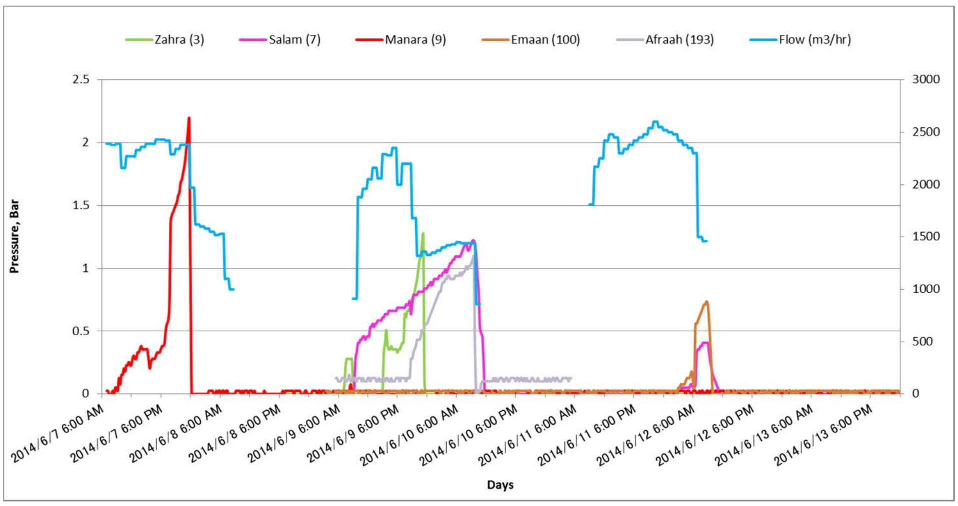
Water to the eastern part of Irbid is supplied from the Zebdat reservoir by pump. The water pressure in this area is shown in Figure 3.21. Pressure in Hakama, Werud, and Zahra, which are located at the head end, generally falls in the low pressure range of 0.5 to 1 bar on the day of supply. However, pressure at locations in Rouda and Bait Ras, which are located at the tail end, is above 1 bar and relatively high; it sometimes rises to 3.7 bars in Bait Ras.

These pressures are, however very low considering pump head of 20 bars in the Zebdat PS and differences in ground elevation between the pumping station and the measured point. The same can be said of the gravity-supplied area. This indicates that the carrying capacity of the distribution network is low due to the relatively small diameter of pipes.

(2) Ramtha and its Suburbs

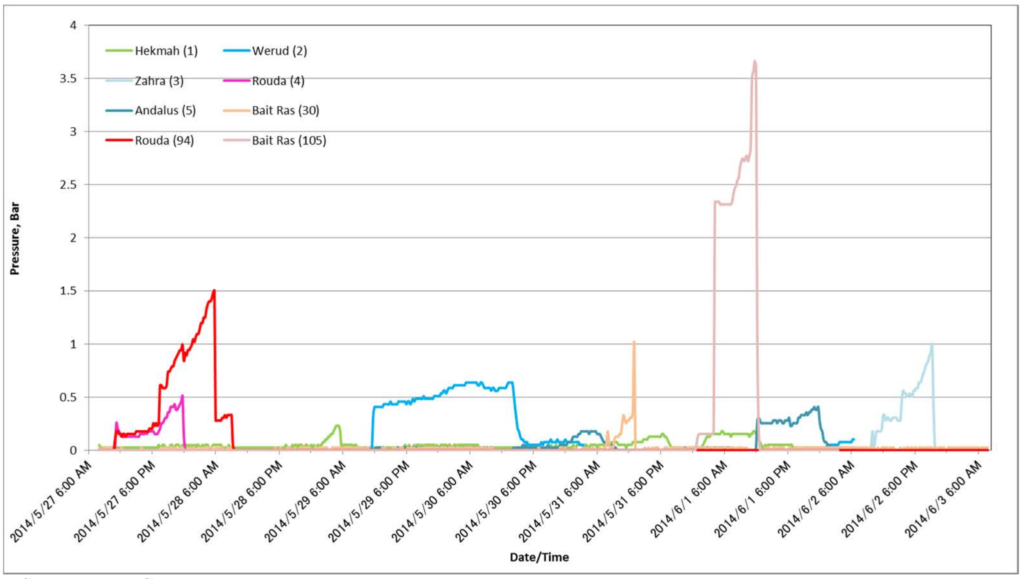
The locations of YWC's pressure data loggers in Ramtha and its suburbs are shown in Appendix 3F. Pressure data of four of the six supply zones are available, as shown in Figure 3.22. The pressure falls within a range of 0 to 3.5 bars with low pressure at the start of supply and high pressure at the end of supply.

The water pressure of the transmission line at the branching-off point is estimated at approximately 20 bars above the ground level of Ramtha city (600 m in elevation). This residual pressure at the transmission line is reduced to 3.5 bars maximum. This shows that the carrying capacity of the distribution network is low due to the relatively small diameter of pipes, as mentioned for the Irbid network as well.



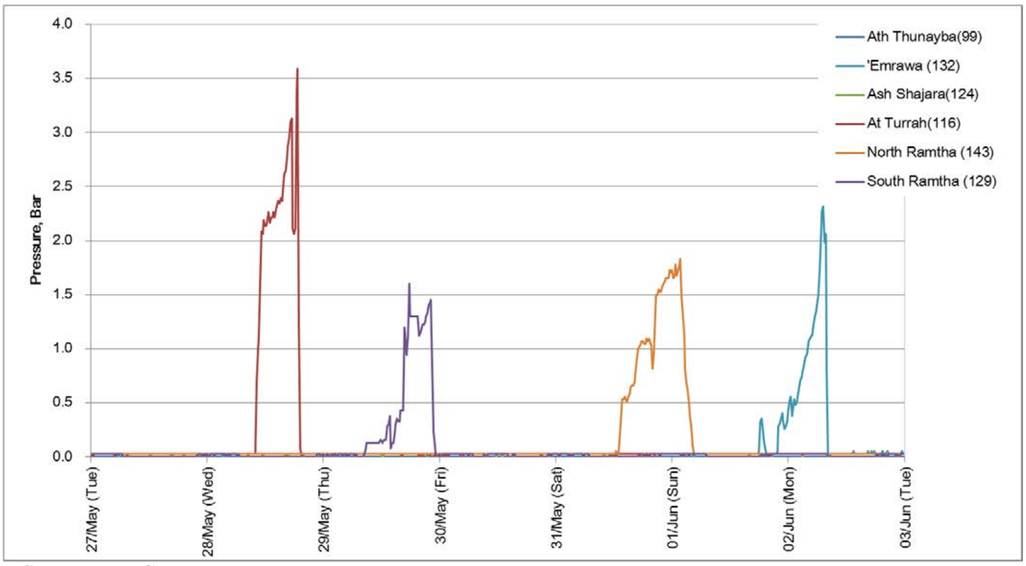
Source: YWC

Figure 3.20 Gravity Flow Rate and Pressure in Gravity-Supplied Area in Irbid



Source: YWC

Figure 3.21 Pressure in Pump-Supplied Area in Irbid



Source: YWC

Figure 3.22 Pressure in Study Area in Ramtha

3.3.5 Water Flow

Almost constant volume of 24,000 m^3 delivered in one day through the western transmission system is stored in the Zebdat reservoir (110,000 m^3). The stored water together with the delivered water is supplied to the supply areas the following day. Water is supplied three days per week to one zone; the supply area in the zone is divided into several sub zones. Therefore, consumers receive water only once a week.

The flow data of the Zebdat gravity-supplied system for one week each in January and June in 2013 and 2014 were obtained to understand the characteristics of diurnal fluctuation of water demand, and analyzed in Table 3.19. The water supply starts at around 8 AM and stops at about 8 AM the following day. The total supplied volume per week ranges from 153,000 to 180,000 m^3, which is equivalent to 22,000 to 26,000 cubic meters per day (8.0 to 9.4 MCM/year).

Table 3.19 Water Supply Amount from Zebdat Reservoir by Gravity

Unit		Week starting from				Average
		2013		2014		
		Jan-5	Jun-8	Jan-7	Jun-7	
Per Week: (Thousand m^3/week)	Wednesday for north	57	62	62	53	**58**
	Monday for center	52	54	54	44	**51**
	Saturday for south	51	63	64	56	**59**
	Total	161	179	180	153	**168**
Per Day:	Thousand m^3/day	23	26	26	22	**24**
Per Year:	MCM/year	8.4	9.4	9.4	8.0	**8.8**
Per Hour:	m^3/hour	961	1,067	1,071	909	**1,002**

Source: Compiled by the JICA Study Team based on YWC data.

Two types of diurnal demand or supply exist. One is constant flow for 24 hours as in the supply on Wednesday in the north (Zebdat Gravity North Wednesday in Figure 3.24). Even after 24 hours of water supply, the supply and demand amounts do not reduce in this case. This implies that the supply cannot meet the demand.

The other type of demand fluctuation can be seen from the supply on Saturday in the south and Monday in the city center. There are two constant flows during the day and at night (Zebdat Gravity South Saturday and Zebdat Gravity Center Monday in Figures 3.23 and 3.24). The central area shows a clear pattern; supply amount drops at around 8 pm to about half the daytime amount. Most private house tanks are probably filled during daytime. In the south area, the time of the supply amount to reduce is delayed more than that in the central area between 9 pm and 1 am the following day. Also, the decrease in supply amount is not abrupt but gradual.

The picture is clear in the central area with daytime flow of about 1.5 and 2 times the nighttime flow, except in June 2014, which was an abnormal case with drought.

Flow data for the Ramtha Study Area are not available.

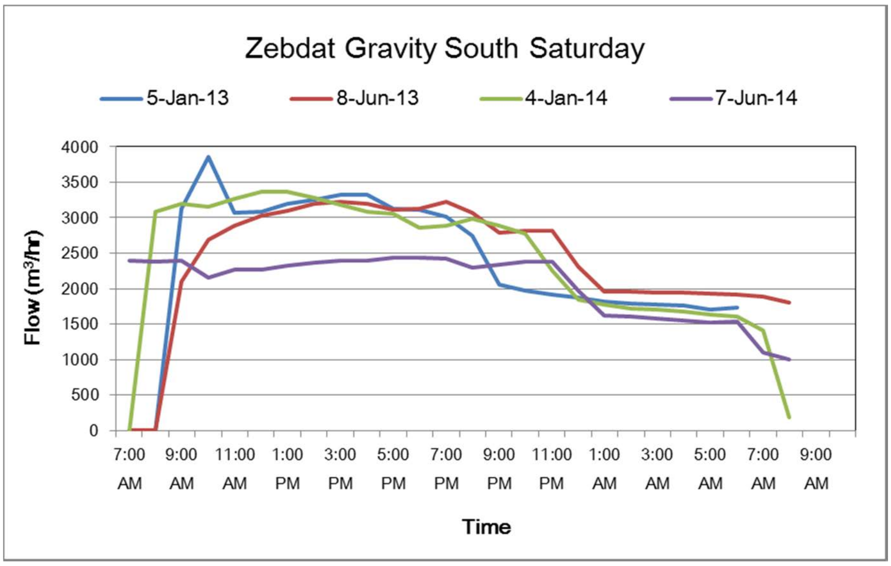
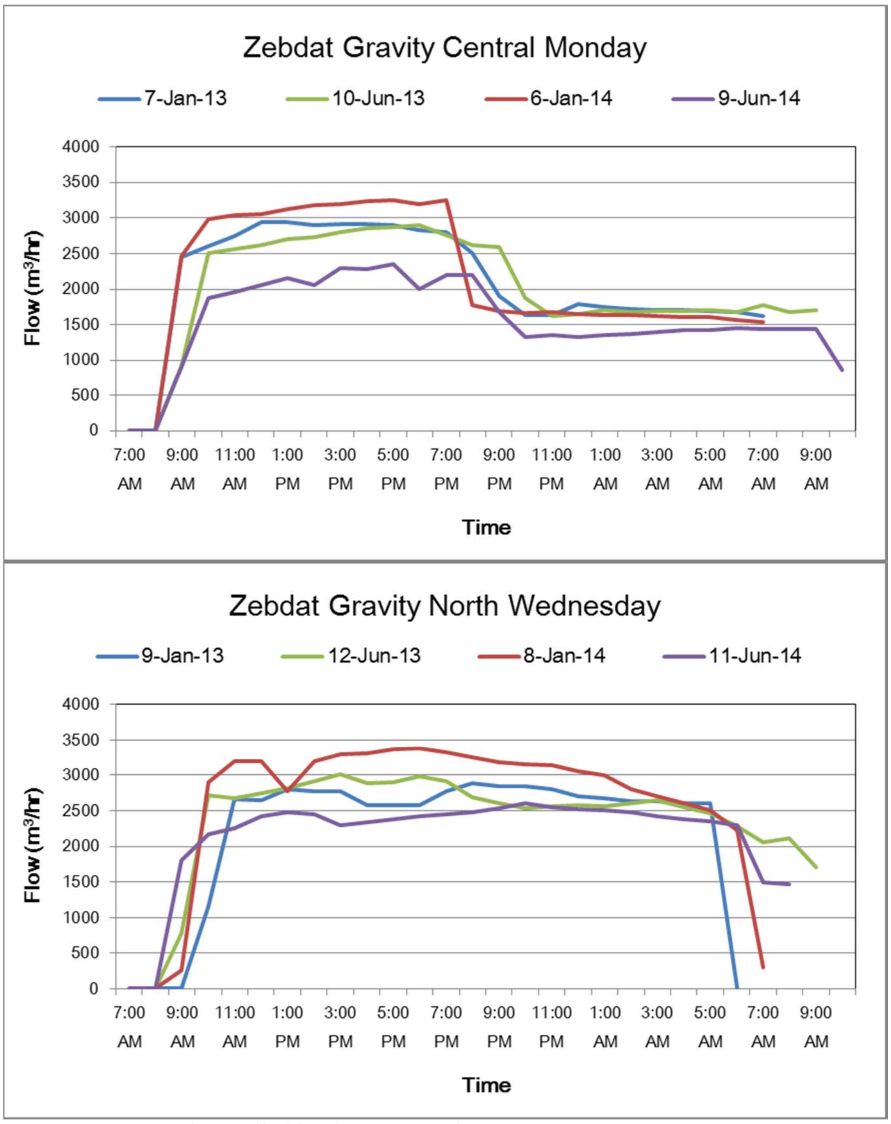


Figure 3.23 Hourly Water Supply Volume from the Zebdat Reservoir by Gravity



Source: YWC and compiled by the JICA Study Team

Figure 3.24 Hourly Water Supply Volume from the Zebdat Reservoir by Gravity

3.3.6 Water Quality[5]

Treated water quality is not a major issue in the Study Area. The compliance rate of chemical samples in Irbid was 93.4 % (the number of analyses: 6,603/year, samples taken: 1,782/year on average), and the compliance rate of microbiological samples was 99.6 % (the number of analyses: 5,224/year, samples taken: 4,830/year on average) for 3.75 years during the period of 2009 to 3rd quarter of 2012.[6]

The water quality characteristics of major ROU are summarized in Table 3.20 based on the water quality data of water sources and water treatment facilities in 2013. After treatment, Nickel exceeds the standards in some cases, but other parameters comply with the standards in Irbid and Ramtha areas.

[5] See section 3.8(3) for Water Quality Management

[6] Feasibility Study for EBRD, November 2013

Table 3.20 Quality of Raw Water and Treated Water in Major ROUs

ROU	Raw water	Treated water
North Shouna	In some samples, boron, chlorine, fluorine, hardness, nickel, sodium, sulfate and TDS exceed the water quality standards of Jordan.	In some samples, nickel exceeds the standard, but other parameters comply with the standards.
Irbid (Incl. Bani Kinana)	In some cases, coliform exceeds the standard, but other parameters comply with the standards.	In some cases, nickel exceeds the standard, but other parameters comply with the standards.
Ramtha (Incl. Bani Obaid)	In some cases, turbidity, nickel and nitrate exceed the standards.	Comply with the standards
Ajloun (Incl. Al Koura)	Comply with the standards	Comply with the standards
Jerash	In some cases, coliform, fecal coliform, ammonia, boron, hardness, iron, nitrate, sulfate and radioactive material exceed the standards.	In some cases, coliform, fecal coliform, ammonia exceed the standards.
Mafraq	In some cases, coliform, fecal coliform, boron and hardness exceed the standards.	In some cases, aluminum and lead exceed the standards.

Source: Compiled by JICA Study Team based on the analysis results of WAJ and YWC

The number of customer complaints related to water quality is very small; 13 in 2014 and 10 in 2013 in Irbid, and 7 in 3 years in the Ramtha area, according to YWC data.

3.4 Non-Revenue Water

Non-revenue water (NRW) ratio is still high at about 40-70 % in the northern governorates (Table 3.21) although various efforts have been made to reduce it, such as by rehabilitating old pipes. High NRW ratio is due to several factors, such as poor water network condition, lack of isolated water supply zones, intermittent water supply, meter inaccuracy, use of water through illegal connection, and meter reading errors.

Table 3.21 NRW in Northern Governorates

Governorate	2011			2012		
	Amount of supplied water (MCM/year)	Amount of billed water (MCM/year)	NRW (%)	Amount of supplied water (MCM/year)	Amount of billed water (MCM/year)	NRW (%)
Irbid	41.0	26.1	36.4	40.2	22.1	45.1
Mafraq	20.0	8.4	57.9	22.1	6.8	69.4
Ajloun	3.6	2.5	31.9	4.3	2.2	48.3
Jerash	5.2	3.5	33.5	5.8	3.0	49.3
Total	69.9	40.4	42.1	72.5	37.4	48.4

Source: WAJ, YWC

Note: NRW ratio in Irbid in 2012 was 45.1 % according to WAJ but 36.8 % according to YWC. The Study Team has adopted the authorized WAJ figures in this table.

3.5 Leakage

The leakage ratio in Jordan is assumed from past experience to be half of the NRW ratio. Therefore, the estimated leakage ratios of the northern governorates and Irbid are 24.2 % and 22.6 %, respectively. These figures are still high for an extremely scarce water resource in this area.

The number of complaints of leakage by cause and material is tabulated in Table 3.22. GI is a corrosion prone material and steel is easily damaged. GI is weak and needs to be replaced with some other material.

Table 3.22 Complaints of Leakage by Cause and by Material (January 2011-July 2014)

(Number)

Cause	CI	DI	GI	PE	PVC	Steel	SS	Total	%
Corrosion	0	30	3,497	5	0	215	1	3,748	37.1
Damage, Vandalism, and Excavation	3	46	589	1,752	1	3,682	33	6,106	60.5
Improper Construction (Poor repair, substandard construction and welding)	0	0	23	16	1	53	0	93	0.9
Others (Excessive pressure, etc.)	0	0	16	42	1	89	2	150	1.5
Total	3	76	4,125	1,815	3	4,039	36	10,097	100
%	0.0	0.8	40.9	18.0	0.0	40.0	0.4	100	

Note: Corroded items can be repaired. Damaged items that need replacement include items that have suffered from meter explosion, explosion by freezing and natural factors, and pipes with expired lifetime.
Ductile Iron (DI), Galvanized Iron (GI), Polyethylene (PE), Polyvinyl Chloride (PVC), Cast Iron (CI), SS (Stainless Steel)

Source: Compiled by the JICA Study Team based on data in the ICT Directorate, YWC.

Table 3.23 gives the number of complaints of leakage due to corrosion by diameter and material. 90 % of the instances of corrosion occur in GI pipe and 95 % occur in pipes of diameter less than 50 mm.

Table 3.23 Complaints of Leakage Due to Corrosion by Diameter and Material (January 2011-July 2014)

(Number)

Diameter (mm)	CI	DI	GI	PE	PVC	Steel	SS	Total	%
15		8	857	1		53	1	920	24.5
20		15	1,283	2		66		1,366	36.4
25		3	492			21		516	13.8
32			3					3	0.1
50		4	705	2		54		765	20.4
63			3					3	0.1
75			9					9	0.2
100			103			14		117	3.1
150			16			1		17	0.5
200			14			3		17	0.5
300			6					6	0.2
400			5			3		8	0.2
500			1					1	0.0
Total	0	30	3,497	5		215	1	3,748	100
%	0.0	0.8	93.3	0.1	0.0	5.7	0.0	100	

Note: Ductile Iron (DI), Galvanized Iron (GI), Polyethylene (PE), Cast Iron (CI), Polyvinyl Chloride (PVC), SS (Stainless Steel)

Source: Compiled by the JICA Study Team based on data in the ICT Directorate, YWC.

Complaints of leakage have been received from all parts of the Study Area. Leakage is reportedly due to the following reasons:

- Corrosion due to aged galvanized iron (GI) pipes in the tertiary distribution network
- High water pressure
- Improper connection between pipes of different sizes
- Poor connection due to thread formed by old threading machine
- Pipe damaged by contractor

To reduce leakage, the following measures are required on priority:

- Replacement of GI pipe with pipe of another material
- Replacement of damaged steel pipe
- Reduction in water pressure

- Improvement of construction method or procedure
- Control of other constructions

3.6 Organization of YWC

3.6.1 Background

The "Yarmouk Water Company (YWC)" is the legal successor to the Northern Governorates Water Administration (NGWA), which is responsible for providing water supply and sewerage services in the Irbid, Jerash, Ajloun and Mafraq governorates. YWC is a limited liability company (LLC) registered in 1997. It is an independent government company fully owned by WAJ.

YWC provides water supply and sewerage services based on the assignment agreement between YWC and WAJ, by which the ownership of all assets was transferred from WAJ to YWC.

3.6.2 Management by Contractor

(1) Management Contract
PMU of WAJ and YWC employed a service provider for providing management, operation and maintenance services related to the water and wastewater infrastructure through open competition in September 2010. PMU assigned Veolia Water MENA/ Aqua Treat to this task for five years starting September 2011.

(2) Goals of the Management Contract
The major goals of the contract were as follows:

- To improve the water and wastewater services to customers in the northern governorates;
- To improve the financial position of YWC by realizing cost efficiency and by improving revenue management;
- To establish the foundation for sustainable operations, business effectiveness and efficiency for YWC; and
- To reduce the amount of water lost or unaccounted for by reducing leakage and unauthorized connections to the facilities.

The contract, however, was terminated in June 2013; hence the management provider was employed for less than 2 years.

3.6.3 Organization Structure of the YWC

Since the termination of management contract, the operation and management of the waterworks of YWC have been taken over by General Manager of YWC.

(1) Staffing
The total number of employees is 1,649 as of September 2014, according to the database of the cost center (see Table 3.24). This number shows downsizing of employees from 1,740 in 2012. The current level of staffing for water and wastewater per 1,000 connections (6.0) seems to be low (see Table 3.25), and is better than the average of the three available utilities in Jordan (8.7) and generally similar to that of other upper-middle income countries (5.2 - 6.2) from the IBNET database.

Forty-five (45) employees are directly hired by the YWC, and others are transferred from WAJ to YWC; they are entitled to government retirement benefits. Nearly one-fourth of the total staff members are engaged in customer service activities. Most of these staff members are operators at the Call Center and account for a relatively large part unlike the typical staff composition of a water and wastewater utility.

Table 3.24 Staff Composition of YWC by Cost Center

Governorate	ROU or Area	Total	Water	Wastewater	Support Service	Customer Service
Irbid	Head Office	253			224	29
	Irbid	318	110	92	23	93
	Bani Obaid	93	21	25	11	36
	Bani Kinana	70	36		10	24
	Al Koura	55	26		11	16
	North Shouna	122	78		20	24
	Ramtha	101	28	32	19	22
	Wadi Shalala*	10		10		
	Za'atary*	15	15			
Ajloun	Ajloun	158	74	19	20	45
Jerash	Jerash	163	43	26	49	45
Mafraq	Mafraq	204	97	20	39	48
	North Badia	87	59		12	16
Total		1,649	587	224	438	398

Note: * They are not ROU but facility office.
Source: YWC

Table 3.25 Staff Numbers and Staffing Productivity per Connection (2006-2014)

	2006	2007	2008	2012	2013	2014
Total staff	1,761	1,801	1,673	1,740	1,671	1,649
Staff number Water &Wastewater/ W&WW 1,000 conn.	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 from 2009-2011 are not available
Source: JICA Study Team

(2) Organization Chart

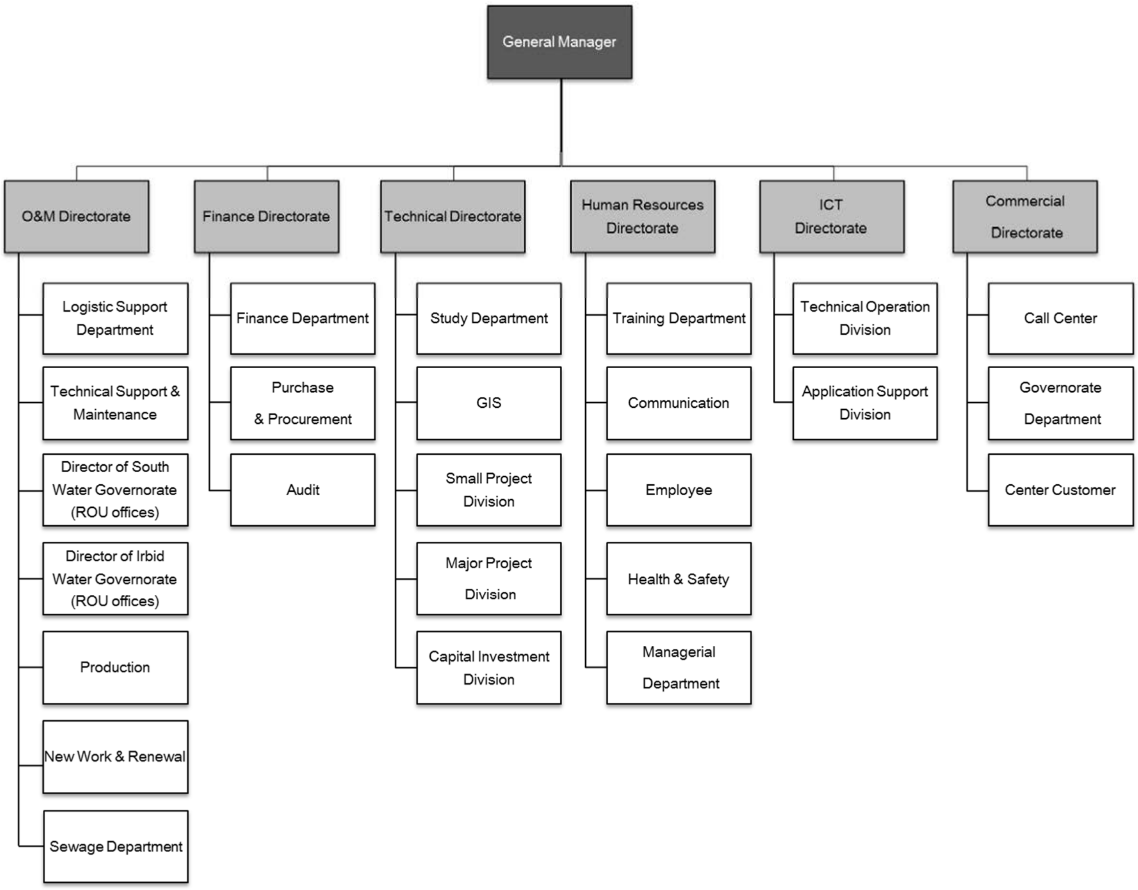
After the Management Contractor left, the organization structure was reviewed by the General Manager. The new organization structure, however, has not yet been finalized as of September 2014, presumably due to the sensitive labor issues. Hence, the current organization structure was envisaged by the JICA Study Team through interviews and observations, as shown in Figure 3.25 It should be noted that this organization structure is different from the aforementioned classification by the Cost Center, which aims for cost control.

(3) Sensitive Nature for Organizational Restructuring

Organizational restructuring by the Veolia Water MENA/ Aqua Treat (the Management Contractor) during the time of the Management Contract was deadlocked presumably due to sensitive labor relations, influence of the clan system, requests for early retirement, deposition and transfer, and strong labor union. Hence, organizational restructuring has become sensitive although the current organizational restructuring by the General Manager has made gradual progress.

(4) Directorate and its Functions

The YWC encompasses six directorates: O&M, Finance, Technical, Human Resources, Information Communication Technology (ICT), and Commercial. The major functions of the various directorates of YWC are summarized in Table 3.26.



Source: JICA Study Team

Figure 3.25 Organization Chart (YWC)

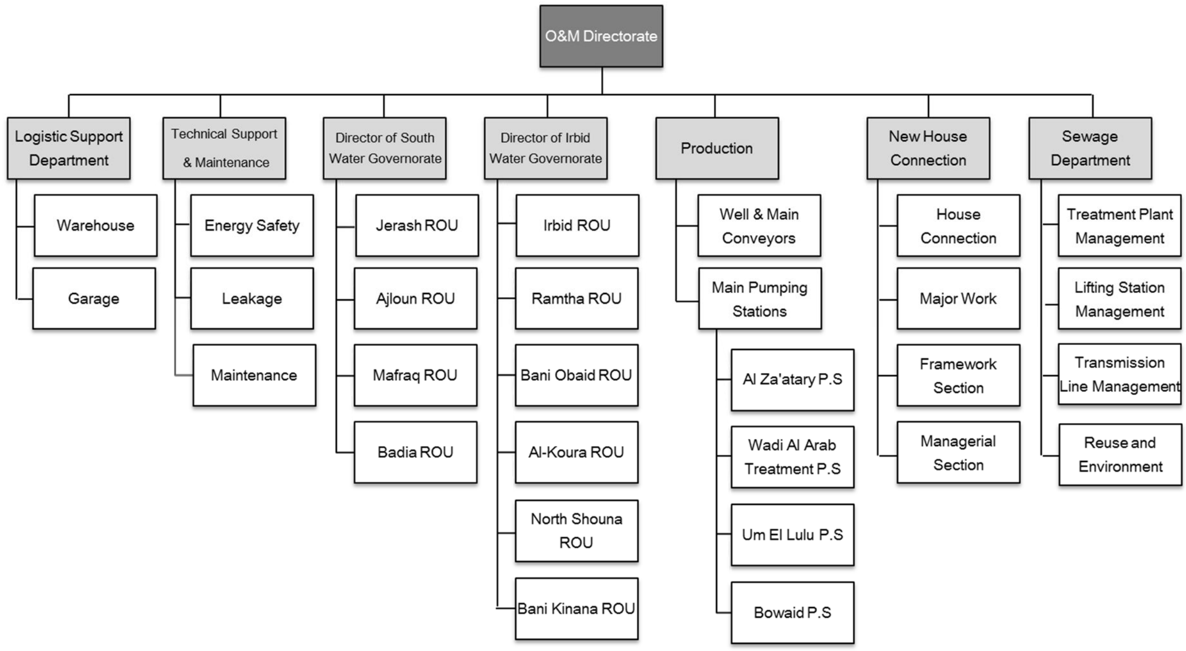
Table 3.26 Activities of Directorates of the YWC

Directorate	Major activity
O&M	• O&M of plant, network pipeline, pumping station and other water and wastewater facilities ➢ Water production ➢ New connection ➢ Technical support service ➢ Logistic support and stock management
Finance	• Overall financial management (budget, income, expense, tax, salary, audit, etc.) • Planning and implementing cost reduction measures
Technical	• GIS database cleansing and updating • Management of capital investment • Preparation of contract and specification • Project planning and management
Human Resource	• Optimal human resource management • Management of payroll, staff allocation, personnel information, recruitment • Planning and implementing staff training
ICT	• Introduction and maintenance of ICT including both software and hardware
Commercial	• Billing and revenue collection management • Meter reading • Handling customer inquiries and complaints through the Call Center

Source: YWC

(5) O&M Directorate

The O&M Directorate is one of the six directorates directly managed by the General Manager. It is a key directorate responsible for the daily operation and maintenance of water and wastewater facilities, such as intake wells, pumping station, water treatment plant, house connection, wastewater treatment plant, pumping station, pipeline and sewer networks, etc. Network operation and maintenance are under the responsibility of ROUs located in the ten regional areas of the northern governorates. The organization chart of O&M directorate is shown in Figure 3.26.



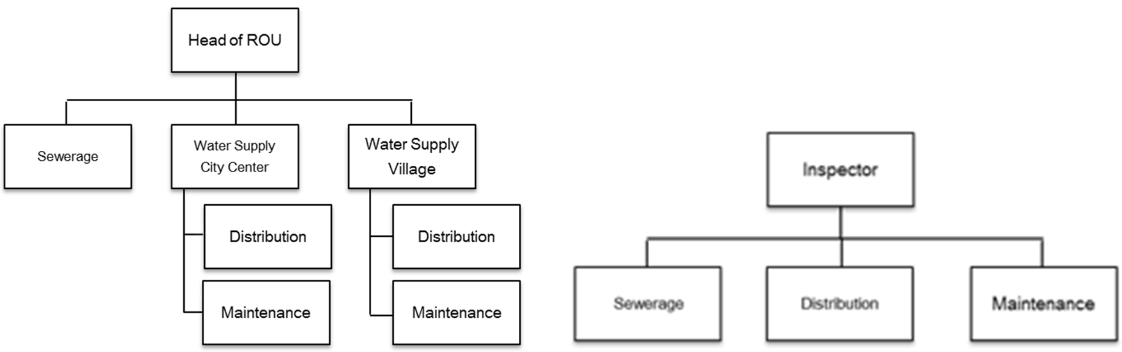
Source: JICA Study Team

Figure 3.26 Organization Chart (O&M Directorate)

(6) Regional Operation Units (ROUs)

ROUs belong to the O&M Directorate, and are geographically divided into 2 groups: Irbid Water Governorate and South Water Governorates. The Irbid Water Governorate covers the central and the surrounding areas of the Irbid Governorate, and the South Water Governorates covers the remaining governorates of Jerash, Ajloun and Mafraq.

The organization structure of the ROU office can be categorized into two types: large scale and small scale. A large city such as Irbid city or Mafraq city has two separate sections for water supply: city center and village. There is no sewerage section if a sewerage system is not established in the area, such as Bani Kinana. The typical organization chart is shown in Figure 3.27.



Source: JICA Study Team based on the information from YWC

Figure 3.27 Typical Organization Chart (ROU) – Large Scale (Left), Small Scale (Right)

(7) Management by Performance Measurement

Based upon an assignment agreement between YWC and WAJ, the responsibility of operation and management for water and wastewater services is delegated to YWC. YWC submits a report quarterly to WAJ regarding the activities and the key performance indicators. This information is likely utilized for monitoring of WAJ, however not sufficiently for proactive improvement of the service by YWC. It can be said that the systematic function to prepare high level policies, plans and strategies and to support the decision of General Manager is weak. The key performance indicators need to be reviewed and be effectively fed back to its proactive improvement practice.

(8) Customer Service

A Call Center in the head office have received customer's phone call on 24 hour basis. Then, these customer complaints and inquiries are handled by each ROUs. Monitoring, tracking and resolution of customer complaints are not sufficiently done. A more functional system and an overall organizational capacity leading to substantial resolution are required.

Meanwhile, it is pointed out that a proactive approach of promoting Information, Education and Communication (IEC) activities for the residents is weak. IEC activities to promote water saving and leakage reduction by immediate reporting is very limited without a strategic program. Since water demands has increased particularly by the inflow of Syrian refugees, people's awareness-raising needs to be strengthened through IEC activities.

3.7 Human Resource Development of YWC

3.7.1 Directorate of Human Resource Development (HRD)

Directorate of HRD was upgraded from one section to the directorate after Veolia Water Company commenced their operation based upon the management contract for YWC with WAJ in 2012. The director was newly recruited from outside YWC, so it is assumed that a dramatic change was expected.

3.7.2 Human Resource Management

After upgrading of the directorate, it can be mentioned that some areas of human resource management such as attendance management, and personnel management by cost center and payroll is improved. Meanwhile, a systematic performance evaluation system and an effective incentive mechanism are not yet formulated in order to increase staff's motivation. Job description and standard operation procedures (SOPs) are hardly or not developed yet. Also the invisible influence of clan-based working style is remained, hence this could be a constraint for appropriate human resource allocation and management.

3.7.3 Training Policy

Training policy was established in April 2012 and it states its objectives and training management process which include strategy, training plan, training implementation, evaluation, reporting and so on. Transportation provision and internal trainer's bonus according to their working years are also mentioned. The following training objectives are defined in the policy.

- Developing staff competencies
- Improving staff performance in accordance with the Training Needs Assessment as defined by each line manager
- Developing staff attitude as required by each job, and in parallel with the Corporate Culture of the company

3.7.4 Training Budget

The training budget amounted 189,000 JD in 2012, however it has been reducing since 2012. The allocated budget for 2014 is 50,000 JD as less than one-third of the peak and the downward trend has remarkably appeared after the completion of donor funding by USAID and leaving of the Management Contractor.

3.7.5 Training Achievements

Based upon the needs assessment initiated by directorate of HRD, the training areas were divided into the following six: Technical, Safety, Management, ICT, Customer Service and Miscellaneous.

The main types of trainings in YWC are internal session and workshop, while outside course organized by external training institutions are very limited. The number of trainees and the training hours in 2012 was doubled in comparison to the past yearly achievement during 2009-2011. In the aspect of training hours, internal sessions share most of training hours as 93 %. This training achievement is expected to dramatically decline in 2014 according to the manager of training division. The number of persons trained and the training hours in the past 5 years are shown below.

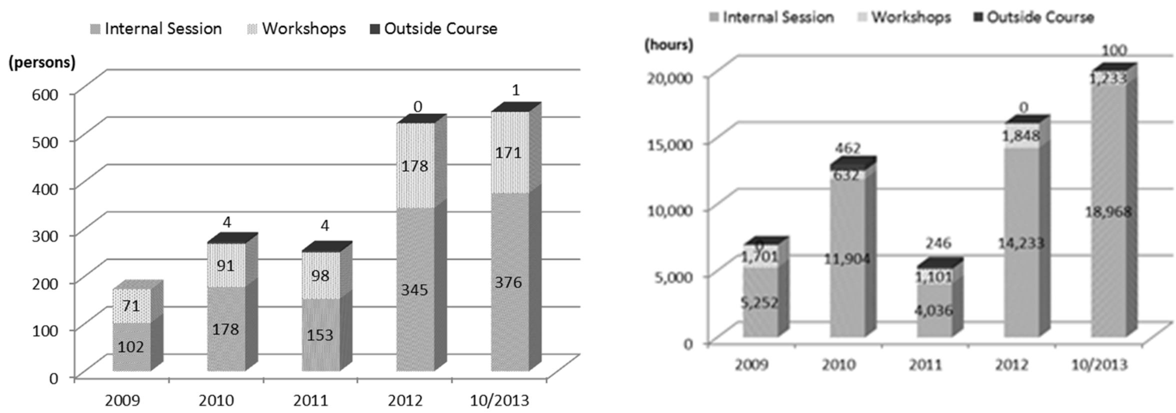


Figure 3.28 Number of Persons Trained (Left) and Training Hours (Right)

3.7.6 Competence of Staff Members

Some key staffs of management classes were recruited from outside and brought new knowledge and management style. There are also some resource persons at the field level such as engineer and technician. However, the competence of staff members in the technical and the management areas are not sufficiently high in the whole. This likely attributes not only to a lack of training in the past but also to an embedded bureaucratic cultural issue. The sense of duty as a water utility and the awareness on business and customer focus are weak except for some members.

3.7.7 Training Institutions

Most of the aforementioned training courses have been implemented by external service providers, even in the internal training case according to Training Department. The lecturers are mostly asked and dispatched from external service providers arranged by directorate of HRD.

Meanwhile, 2 rooms of Wadi Arab (Daugara) WWTP are allocated as a Daugara training center. The training equipment such as projector, chairs and desk etc. and stationaries are provided by donor assistance from French government. Due to the limited budget, the training in Daugara training center has not been launched. The JICA study team observed that this location is a bit far from the city center of Irbid and it might not be convenient for the stronghold in the long-term. Thus, it could be useful for the tentative training space in the short-term.

	
Training Room 1 (Large)	Training Room 2 (Small)

Figure 3.29 Training Room of Daugara Training Center

3.8 Operation and Maintenance of YWC

The major operation and maintenance activities of YWC are as follows:

- Rationing operation
- Well maintenance
- Leakage repair and detection

(1) Rationing Operation

Water supply service is rationed in the Study Area. Rationing requires hydraulic separation of each area; water is rationed in 35 areas in total in Irbid. Only a few valve operators open and close about 100 valves three days per week in Irbid city. This is a time-consuming work, and sometimes operators forget to open or close valves. This operation is not based on hydraulic analysis but on experience and trial and error. Such manual tasks in complicated networks in Irbid are one of the causes of inequitable rationing and "No Water" complaints.

(2) Well Maintenance

191 well pumps were repaired in YWC in 2012 (Table 3.27). Rehabilitation and repair of water source wells were carried out by the YWC mechanical group, WAJ drilling team, or by a private company. Due to aging and raw water quality deterioration, some of the wells especially in Jerash, North Badia and Mafraq are not being used. The YWC has only just ensured the required amount of water by installing new wells near the old wells. The yield per well is reduced but YWC maintains the total production by developing new wells. The number of wells managed by YWC is increasing and so are repairs. The YWC is performing maintenance work of wells satisfactorily.

(3) Leakage Repairs and Detection

The Leakage Division and Maintenance Team of ROU carry out leakage repairs. Upon receiving information on leakage complaints from the Call Center, the staff member of the Leakage Division detects the leakage location and delivers the relevant information to ROU for repair work. These two divisions (Leakage Division and Call Center) are under different directorates but communicate smoothly because of the well-organized office automation system.

Leakage Division is equipped with tools and instruments for leakage detection such as pipe locator, listening stick, ground microphone, etc.

Table 3.27 Number of Wells Repaired in 2012

ROU	Number of Operating Wells		Number of Repairs.		Number of Yield Measurements
	YWC well	Contracted private well	Repaired*1	Not repaired	
Wadi AL Arab*2	21	0	31	0	14
Ramtha	14	0	34	3	9
Irbid	19	0	5	0	0
Bani-Kinana	8	0	7	0	6
Bani-Obaid	5	0	4	0	0
Al Koura	7	0	7	0	7
North Shouna	8	0	7	0	0
Ajloun	11	0	5	0	5
Jerash	21	4	7	1	4
North Badia	22	0	16	2	0
Mafraq	40	9	32	8	0
Za'atary*2	39	0	36	7	17
Total	209	13	191	21	62

Note: *1 It shows the number of items repaired by the YWC. There are cases where multiple repairs are recorded in the same well.
*2 they are not ROUs but well fields.

Source: Compiled by the JICA Study Team based on YWC Well Division Annual Report 2012 data and Withdrawal data of ICT Directorate

The ROU is responsible for repairs to pipelines. The Irbid ROU consists of three divisions: Irbid center, village and sewerage divisions. The maintenance sub-division of the Irbid center consists of four teams, which carry out work according to the program. Each team has a truck with tools and pipe materials for pipe repairs, and a special team with a truck loaded with compressor, etc., which is on standby for cases beyond the control of ordinary maintenance teams.

Tools are too old to carry out the pipe repair work adequately. For instance, threading of GI pipes is difficult with the existing threading machine. Furthermore, maintenance teams cannot repair HDPE pipes satisfactorily because they do not have tools for HDPE welding. Under such working conditions, repairs are temporary, and leaks occur repeatedly at the same location.

It was observed that leakage was left unattended in the center of Irbid city, especially in the southern area of Irbid city. The YWC is not notified probably because people living in the highly populated area assume that someone else will notify the leakage. If leakage is neither reported by residents nor observed by ROU staff-members, it is often unattended and no measures are taken. The ROU does not have adequate employees for regular patrols although it is responsible for resolving all problems in the service area. The ROU implements measures for leakage observed during field visits or regular inspections.

Customer Service exists, but their activity is limited and it is very inactive because of the limited budget for them. Customer Service carries out awareness activities related to saving water in elementary schools and through radio; it uses the brochure prepared by the WAJ.

(4) Maintenance

Veolia Water MENA/ Aqua Treat installed the computerized maintenance management system in the technical support and maintenance section, O&M Directorate, during the Management Contract period. The corrective and preventive maintenance works by the section were recorded in the database during the period from October 2012 to April 2013. However, the recording seems to have stopped at present. This practice should be restarted for ensuring efficient and systematic maintenance activities.

Preventive maintenance was carried out during the above-mentioned period and 342 working orders were recorded. This practice, however, seems to have stopped according to the interviews of the section staff. The main reason is attributed to downsizing of the work force of the section after the termination of the Contractor. Preventive maintenance should be re-launched and strengthened to maximize the lifetime of equipment and facilities.

Distribution pipeline maintenance is inadequate and this causes leakage problem repeatedly. More than 4,000 customer complaints per year on "leakage" were received in 2013. Leakage is attributed to inappropriate connection skills of ROU staff, limited tools and equipment for repair work, GI pipe corrosion due to aging, and no proper replacement. Therefore, proper training on improving and enhancing maintenance skills and adequate tools and equipment need to be ensured.

Preventive measure against physical losses and a plan to reduce losses are yet to be developed. Therefore, current leakage management is very limited and passive. Repair methods are ineffective at present, so leakage occurs again and again. In order to reduce large number of leakage, the leakage section was created in 2013 during the pilot project of this Study, and the preventive activities have been enhanced through training and provision of detection equipment. Such activities need to be continuously supported until getting on the track.

(5) Water Quality Management

The YWC central laboratory and the WAJ central laboratory analyze water quality in the YWC area. The water quality analyses are shared by these institutions (YWC water quality analysis sharing plan in 2014). The Ministry of Health also conducts water quality analysis separately.

1) YWC laboratory

Water quality (of water sources, treatment facilities and water supply network in part) in Irbid and Ajloun is analyzed by the YWC laboratory with following parameters.

- Chromaticity, Odor, Taste, Turbidity, Temperature, pH, TDS, Hardness, MBAS (Methyl alkyl benzene sulfonate), NH_4, Al, Fe, Zn, Na, Cl, SO_4, NO_3, NO_2, As, Pb, CN, Cd, Cr, Ba, Ag, Ni, Sb, F, Cu, Mn, Mo: 1-2 times a year
- Residual chlorine and Escherichia coli (E coli): 1-8 times a month

2) WAJ laboratory

Water quality in Jerash and Mafraq is analyzed by WAJ laboratory. Analysis parameters are the same as the YWC laboratory and following parameters are added.

- Pathogenic bacteria and protozoa parameters in Irbid and Ajloun, sharing of cryptosporidium and giardia items with the YWC laboratory (1-2 times a year in Rahoub Spring, Tabaqat Fahel PS and Wadi Arab PS)

Organic, pesticides and radioactive substances for all YWC areas are analyzed by WAJ Laboratory with following specifications.

- Mercury: once a year
- Organic substances, herbicides and pesticides: 1-2 times a year
- Volatile organic compounds, trihalomethanes (THM), radioactive substances: once a year

3) Water Treatment Facilities

The main water treatment facilities subject to water quality management in YWC are shown in Table 3.28.

4) Water Quality Analysis

General items, coliform items (coliforms, fecal coliforms), inorganics, organics, pesticides, pathogenic bacteria and protozoa items are analyzed in major water sources and treatment facilities. Water quality analysis makes use of only data analysis that has been carried out collectively and frequently at the specific locations.

The analysis is carried out according to the Jordanian Drinking Water Standard JS 286/1977 (Refer Appendix 7A) and the WHO Guideline for Drinking Water Quality 4th Edition.

Table 3.28 Major Water Treatment Facilities

ROU	Major treatment facility	Treatment method	Treatment amount	
			Design (m^3/h)	Actual (m^3/h)
Irbid	Hakama / well 9	Packed column - Aeration * + filtration	50	50
	Wadi Arab Treatment	Pre-Chlorination, Aeration Basin, Flocculation, Coagulation, Filtration, Post Chlorination ,	2,400	2,400
	As'ara	Packed column – Aeration* + filtration	50	50
	Kraymeh	Fixed RO	125	100
Ramtha	Al-Mahasi / well 5	NO3 Ion Exchange + Chlorination	90 / 45	45
	Al-Hodod	Aeration Tower + Chlorination	120	120
	Abu Al Bassal	Packed column – Aeration* + filtration	120	120
	Al-Tura	Aeration Tower + Chlorination	-	-
Ajloun	Zguig 3	Packed column – Aeration* + filtration	50	50
	Zguig 1	RO	50	35-40
Jerash	Al-Qyrawan*	UV + 2µm Micro. Filtration + Chlorination	150 / 70-130	70-130
	Al-Deek	UV + 2µm Micro. Filtration + Chlorination	150 / 70-150	70-150
	Al- Qantara	UV + 2µm Micro. Filtration + Chlorination	150 / 40-150	40-150
	Mashtal	Fixed RO	240	220-220
	Al- Shawahed	UV + Multi Media Sand Filters + Chlorination	120	120
	Souf Al-Qarbi	Settling & Coagulation + Sand Filters + Chlorination	30	30
Mafraq	Al- Rewashed	Fixed RO	100 / 85	55-60
	Al- Zanaieh	Sand Filters +Mobile RO - (5* 2) Vessels + Mixing	55 / 53	42
	Al-Safawi	Fixed RO	70 / 60	42-48
	Harfoushieh	Packed column – Aeration* + filtration	200	200
	Jaber	NH_4 /As Removal	40	40
	Dabban	Packed column – Aeration* + filtration	40	40
North Badia	Al- Rewashed	Aeration Tower + Sand Filters+ RO- (6*4) Vessels	-	-
	Al-Safawi	Sand Filters+ RO (5*3)+ Ion Exchange + Lime Filters	-	-

Note: * Packed column – Aeration: Aeration by packed tower aerator
Source: YWC Laboratory data

3.9 Financial Conditions

Water and wastewater services providers in Jordan were not financially independent organizations because of its public objective. However, the corporatization and privatization of the providers in recent years compelled them to adopt the corporate accounting system that conforms to international financial reporting standards. As a result, financial statements are now prepared by the providers, the so called "Water Company."

3.9.1 Water Tariff

The tariff structure is described in Tables 3.29 and 3.30. Billing is quarterly, that is, four times a year.

Table 3.29 Residential Tariff Structure

Consumption Block (m^3)	Water rate (JD)	Sewerage rate (JD)	Additional fixed charge (JD)
0-18	2.13 (fixed)	0.6 (fixed)	2.43
- 36	0.145/m^3	0.040/m^3	1.65
- 54	0.500/m^3	0.250/m^3	1.65
- 72	0.935/m^3	0.495/m^3	0.00
- 90	1.150/m^3	0.690/m^3	0.00
- 126	1.610/m^3	0.805/m^3	0.00
Above 126	1.920/m^3	0.960/m^3	0.00

Table 3.30 Non-Residential Tariff Structure

Water rate (JD)	Sewerage rate (JD)	Additional fixed charge (JD)
1.00/m^3	0.50/m^3	2.00

3.9.2 WAJ's Financial Status

The WAJ prepares consolidated financial statements[7], which are consolidated statements of these four affiliated water companies. The consolidated financial statements of the WAJ indicate the severe financial situation of the WAJ.

(1) Profit and Loss Statement
Table 3.31 shows the consolidated profit and loss statement of the WAJ in 2011 and 2012. The operating revenues increased by 5 %, but could not cover the total operating expenses. A huge loss was recorded because of the high non-operating expenses mostly composed of interest expenses for the loans. The operating expenses were 1.5 times more than the operating revenues; personnel expenses (20 %), electricity expenses (28 %) and depreciation expenses (31 %) are the three major expenses and constitute 80 % of the total expenses[8].

Table 3.31 Consolidated Profit and Loss Statement of WAJ

(JD in thousands)

Account Items			2011	2012	2011-12	
					Average	Constitution
Operating	Revenues	Water	112,618	115,177	113,898	66 %
		Sewerage and Drainage	39,134	43,678	41,406	24 %
		Other Revenues	18,005	18,579	18,292	10 %
		Total	169,757	177,434	173,596	100 %
	Expenses	Procurement of Water	15,572	20,422	17,998	7 %
		Personnel	49,238	55,143	52,191	20 %
		Electricity	62,293	81,800	72,047	28 %
		Depreciation	78,663	80,013	79,338	31 %
		Write-off of receivables	5,598	3,819	4,709	2 %
		Other Expenses	29,001	29,767	29,385	11 %
		Total	240,365	270,964	255,668	100 %
	Operating Profit and Loss (-)		-70,608	-93,530	-82,072	-
Non-operating	Revenues	Foreign Exchange Gains	4,881	-	-	-
		Other Revenues	9,638	6,547	-	-
		Total	14,519	6,547	-	-
	Expenses	Financial Expenses	30,480	35,559	-	-
		Foreign Exchange Loss	-	3,527	-	-
		Other Expenses	3,622	8,092	-	-
		Total	34,102	47,178	-	-
	Non-operating Profit and Loss (-)		-19,583	-40,631	-	-
Profit and Loss (-) of the Year before Tax			-90,191	-134,161	-	-
Tax			318	186	-	-
Net Profit and Loss (1) of the Year			-90,509	-134,347	-	-

(2) Assets, Liabilities and Equities
Table 3.32 presents the consolidated balance sheet of the WAJ. The total capital used in the year 2012 was 1.7 billion JD. The current ratio (current assets/current liabilities) was only 32 %, which is extremely low, and indicates the tight short-term finances of the WAJ. On the other hand, the fixed assets ratio (fixed assets/net worth) was 230 %, which reveals that the procurement of fixed assets

7 Companies to be consolidated: Jordan Water Company – Miyahuna (JWCM), Aqaba Water Company (AWC), Yarmouk Water Company (YWC), Red Sea Water Company (RSWC).

8 Water expenses in Japan ：personnel 4.5 %, electricity 3.3 %, depreciation 9.4 % (Japan Water Works Association: Water Statistics Handbook, 2011)

largely depended on external finances such as foreign loans.

Most of the account receivables for the year 2012 were outstanding unpaid amounts of subscribers (70 million JD), which represents the amount after the write-off of long-term doubtful receivables (50 million JD).

The account payables turnover period is 155 days, which is too long a period compared to 90 days regarded as a sound period in general. Most of the account payables consisted of unpaid expenses, which soared in 2012.

The financial position of the WAJ is propped up by loans from international donors (8 donors, 14 to 40 years of loan period, 0.2 % to 5.78 % of interest rate), issue of corporate bonds (amortization in 2015, 4 to 8 % of coupon rate) and MOF (Ministry of Finance) financial support.

Table 3.32 Consolidated Balance Sheet of WAJ

(JD in thousands)

Account Items			2011	2012
Assets	Current Assets	Cash and the Equivalent	17,557	13,976
		Account Receivables	74,872	90,259
		Other Current Assets	68,879	51,556
		Total	161,308	155,791
	Net Fixed Assets		1,506,217	1,556,359
	Total		1,667,525	1,712,150
Liabilities	Current Liabilities	Account Payables	38,551	64,753
		Ministry of Finance Advancing Support	-	129,942
		External Loans (Due within 1 year)	19,934	21,196
		Corporate Bonds (Due within 1 year)	138,500	248,980
		Bank Overdraft Account	41,356	70,114
		Other Current Liabilities	52,198	34,804
		Total	290,539	569,798
	Fixed Liabilities	External Loans	213,718	233,984
		Corporate Bonds	392,980	220,000
		Other Fixed Liabilities	47,703	47,216
		Total	654,401	501,200
	Total		844,940	1,070,998
Equities	Own Equity	Paid-in Capital	2,004,697	2,056,936
		Reserves	5,495	6,139
		Accumulated Profit & Loss(-)	-1,293,360	-1,427,895
		Total	716,832	635,180
	Minority Shareholders' Interests		5,753	6,026
	Total		722,585	641,206
Total of Liabilities and Equities			1,667,525	1,712,204

Source of both Tables: Summarized by the JICA Study Team based on the Statements of WAJ

(3) Cash Flow

Table 3.33 shows the cash flow (CF) statement of the WAJ. The statement clearly reveals that the capital investment of the WAJ is not covered by the operating net CF but with the financial net CF such as paid-in capital, loans and MOF support. CF at the end of 2012 was 35 million JD, which was only 6 % of the current liabilities. A company is generally regarded to be solvent if this percentage is greater than 100. In this sense, the solvency of the WAJ is considered extremely low.

Table 3.33 Consolidated Cash Flow (CF) Statement of WAJ

(JD in thousands)

CF Items		2011	2012
CF from Operating Activities	Net Profit	-90,071	-133,745
	Depreciation	78,663	80,013
	Others	-6,202	-608
	Net CF	-17,610	-54,340
CF from Investment Activities	Additional Assets	142,579	129,927
	Additional Investment to DWCP	5,084	2,558
	Net CF	147,663	132,485
CF from Financial Activities	Paid-in Capital	29,019	52,228
	MOF Advancing Support	-	129,942
	External Loans	5,278	18,001
	Corporate Bonds	95,500	-62,500
	Bank Overdraft Account, etc.	9,158	27,679
	Net CF	138,955	165,350
Net CF Changes of the year		-26,318	-21,475
CF at the beginning of the Year		83,039	56,721
CF at the end of the Year		56,721	35,245

Source: Summarized by the JICA Study Team based on the Statements of WAJ

3.9.3 YWC's Financial Status

The financial statements of the YWC also show the severe financial situation of the company.

(1) Profit and Loss Statement

Table 3.34 presents the profit and loss statement of the YWC. The table shows that the operating revenues could not cover the operating expenses, and the YWC as well as the WAJ, recorded losses for three consecutive years. Therefore, adequate tariff setting and reduction in operating expenses are to be studied and analyzed. The operating expenses were 1.6 times more than the operating revenues; personnel expenses (26 %), electricity expenses (33 %) and depreciation expenses (10 %) were the three major expenses and constituted 70 % of total expenses. The unit cost of supplied water[9] is estimated as lying between 0.9 and 1.0 JD/m^3 in 2012, including indirect costs such as administrative and other miscellaneous costs.

(2) Assets, Liabilities and Equities

Table 3.35 shows the balance sheet of the YWC. The current ratio (current assets/current liabilities) was 110 %, higher than 32 % of the WAJ, but still lower than 200 % which is generally regarded as a sound level. On the other hand, the ratio of fixed assets to long-term capital (fixed assets / (net worth + fixed liabilities)) was 97 %, which is generally sound because fixed assets were appropriated mostly with long-term finances.

The account receivables in 2012 were 16 million JD as shown in Table 3.35. However, the total unpaid amount before the write-off was 29 million JD (amount unpaid over the half year was 20 million JD), which exceeded the operating revenue of 28 million JD in 2012. This stagnant amount of sales receivables compelled the YWC to raise loans of 10 million JD from the Housing Bank (5 years, 8.5 % of interest) for securing working capital. The account payables turnover period was 205 days, which is greater than 155 days for the WAJ.

[9] Water actually billed to the customers by the YWC.

Table 3.34 Profit and Loss Statement of YWC

(JD in thousands)

Account Items		2010	2011	2012	2010-12 Average	2010-12 Percentage
Revenues	Water Sales	13,127	19,745	20,284	17,719	73 %
	Sewerage & Drainage Fees	1,196	2,170	2,213	1,860	8 %
	Other Revenues	3,490	5,022	5,547	4,686	19 %
	Total	17,813	26,937	28,044	24,265	100 %
Expenses	Salary & Wages	7,773	9,882	11,766	9,807	26 %
	Electricity	10,204	12,428	15,582	12,738	33 %
	Fuels	1,424	1,407	1,210	1,347	4 %
	Repair & maintenance	2,452	2,556	1,658	2,222	6 %
	Water Purchase from Private Wells	1,476	2,961	3,408	2,615	6 %
	Chemicals	227	312	252	264	1 %
	Administration	675	762	704	714	2 %
	Management Contract	-	909	1,451	787	2 %
	Depreciation	3,288	3,392	4,842	3,841	10 %
	Provision of Doubtful Receivables	-	2,228	2,820	1,683	4 %
	Other Expenses	1,947	2,012	2,832	2,264	6 %
	Total	29,466	38,849	46,525	38,282	100 %
Profit & Loss (-) of the Year		-11,653	-11,912	-18,481	-	-

Source: Summarized by the JICA Study Team based on the Statements of YWC

Table 3.35 Balance Sheet of YWC

(JD in thousands)

Account Items			2010	2011	2012
Assets	Current Assets	Cash and the equivalent	3,776	1,126	3,984
		Account Receivables	10,767	14,156	16,337
		Inventories	2,215	3,087	3,083
		Total	16,758	18,369	23,404
	Fixed Assets	Net Fixed Assets	37,644	64,172	65,407
		Under Construction	33,244	17,534	18,224
		Total	70,888	81,706	83,631
	Total of Assets		87,646	100,075	107,035
Liabilities	Current Liabilities	Account Payables	4,546	17,906	19,443
		Short-term Loans	-		1,666
		Total	4,546	17,906	21,109
	Fixed Liabilities	WAJ Credit	145,591	156,547	95,594
		Long-term Loans	-	-	8,334
		Total	145,591	156,547	103,928
	Total of Liabilities		150,137	174,453	125,037
Equities	Paid-in Capital		0	25	25
	Accumulated Profit		-62,491	-74,403	-18,027
	Total of Equities		-62,491	-74,378	-18,002
Total of Liabilities and Equities			87,646	100,075	107,035

Source: Summarized by the JICA Study Team based on the Statements of YWC

(3) Cash Flow

Table 3.35 shows the cash flow of the YWC. The negative net operating CF as well as the capital investment was appropriated with bank loan and the WAJ credit for paid-in capital.

The CF at the end of 2012 was 3.9 million JD, which was only 20 % of the current liabilities. In this sense, the solvency capacity of YWC as well as WAJ is considered extremely low.

Table 3.36 Cash Flow (CF) Statement of YWC

(JD in thousands)

CF Items		2010	2011	2012
CF from Operating Activities	Net Profit	-11,653	-11,912	-18,481
	Depreciation	3,288	3,392	4,842
	Others	-7,620	9,101	681
	Net CF	-15,985	581	-12,958
CF from Investment Activities	Additional Assets	8,064	7,939	5,128
	Additional Assets under Construction	5,772	6,273	2,507
	Net CF	13,836	14,212	7,635
CF from Financial Activities	Paid-in Capital	-	25	-
	WAJ Credit	31,949	10,956	13,451
	Loans	-	-	10,000
	Net CF	31,949	10,981	23,451
Net CF Changes of the year		2,128	-2,650	2,858
CF at the beginning of the Year		1,649	3,776	1,126
CF at the end of the Year		3,776	1,126	3,984

Source: Summarized by the JICA Study Team based on the Statements of YWC

3.10 Summary of Water Supply Problems in the Study Area

3.10.1 Water Supply Services

(1) Insufficient per capita water consumption

The estimated per capita consumption (55 to 71 lpcd) in the Study Area is well below the country average for planning purpose (116 lpcd for urban) and less than that of the northern governorates (80 to 90 lpcd).

(2) Insufficient pressure and no water

Insufficient water supply and inadequate capacity of water supply facilities have caused insufficient water supply pressure. Water pressures measured by installed data loggers are very low at only 2 bars maximum and generally below 1 bar in Irbid city. These pressures have also created “No Water” areas, which form the maximum number of complaints from the customers. These claims have come from almost every part of the Study Area.

(3) Intermittent supply

Insufficient water supply has forced YWC to abandon continuous water supply and resort to rationing water. The average water supply hours in rationing zones in Irbid and Ramtha are 6 to 24 hours per week; but the actual water supply hours to individual customers are less. Intermittent supply is not a good practice since it accelerates internal corrosion in pipes, causes frequent intrusions of wastewater from holes or loose joints, and makes leakage detection difficult.

3.10.2 Main Problems

Issues and problems related to water supply in the Study Area are summarized in the Figure 3.30. The main problem for the citizens to be resolved in the water supply sector is “No Water.” Major complaints of the customers are “No Water,” followed by “Leakage.” Other complaints are much lesser than these two complaints. Although leakage does not directly affect a citizen’s life but has an indirect effect because water amount supplied to consumers is reduced. The result is the “No Water” complaint. Therefore, “No Water” is the main problem to be resolved.

Six main causes of “No Water” are summarized below.

1. Limited water resource or deficit in the water supply amount
2. Insufficient transmission facilities

3. Increased demand due to the rapid influx of Syrian refugees
4. Inadequate arrangement of the distribution network
5. Low distribution management capacity
6. Leakage due to inferior pipes (old pipes and GI pipes) and inadequate maintenance

3.10.3 Causes of Problems

(1) Limited Water Resources
Water supply services in the northern governorates have always been in a poor state for a long period. The main reason is the lack of water resources and export of developed water resources to Amman. The WAJ and YWC have done their best to develop and rehabilitate wells and other water resources. The development of additional wells has eased the gap between demand and supply to some extent, but the amount of available water has never been able to meet the water demand fully. This situation exists not only in the northern governorates but also all over Jordan. The current annual deficit in the Study Area is estimated at approximately 10 MCM/y, with an average demand of 27.9 MCM/y and available water supply of 17.9 MCM/y in 2012. For details of water demand estimation, see Chapter 5.

(2) Insufficient transmission facilities
The transmission facilities from the sources such as strengthening of pipelines between Za'atary and Hofa and construction of pipeline between Hofa reservoir and Bait Ras, have already commissioned or under tendering/ construction. All these facilities are planned to start operation in 2017. So required water can be transferred to the Study Area in 2017. Furthermore, development of additional water sources and transmission facilities from the western transmission lines is under planning. The details are explained in the section 3.1.2. Therefore, limited water sources mentioned above and insufficient transmission facilities will be mitigated in future.

(3) Increased demand due to the rapid influx of Syrian refugees
Syrian refugees in large numbers have started settling in the host communities in the Study Area and in the northern governorates since 2011. The current population of Syrian refugees is approximately 240,000 compared to the Jordanian population of 1,137,000 in the Irbid Governorate. This has further aggravated poor water services including lower water consumption in the Study Area.

(4) Inadequate distribution network arrangement
Although water supply has been rationed for equitable supply, "No Water" complaints are still the largest type of complaint received and these complaints have increased in recent years, especially after the influx of Syrian refugees. Water pressure to the customers is very low and "No Water" complaints are many, although water is supplied by high lift pumps or from locations at elevations high enough to supply water to areas at lower elevation by gravity. The causes are as follows:

- Low distribution capacity or smaller pipe diameter than required
- Obsolete network unable to cope with the increased water demand
- Unorganized water distribution network of trunk mains, mains, sub-mains, and service pipes
- Supply zones not clearly defined considering difference in elevation
- Low distribution management capacity

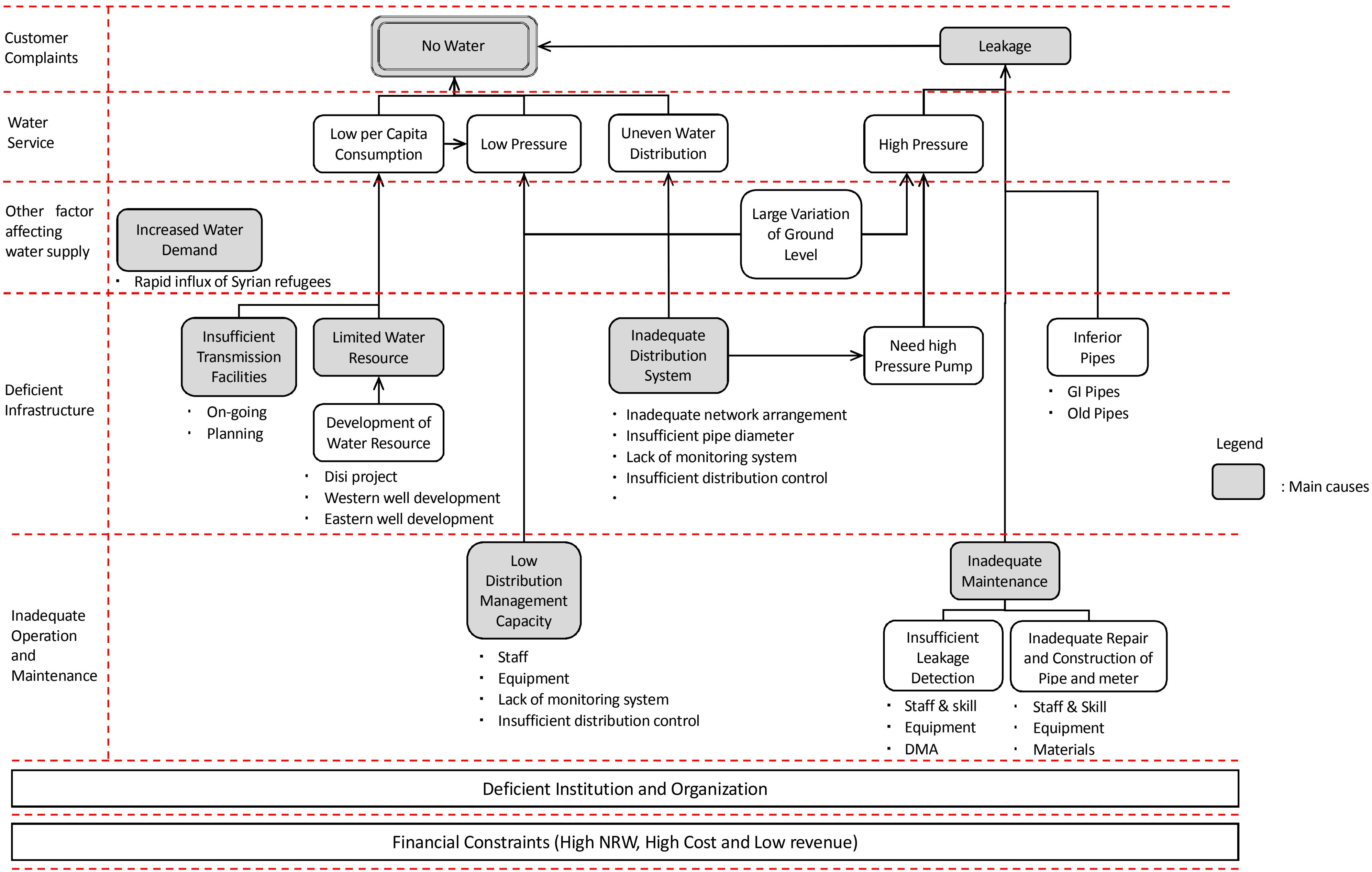


Figure 3.30 Problems and Causes Analysis

(5) Low distribution management capacity

Water distribution management, or rationing supply, is carried out by valve operators through manually opening and closing valves at about 100 locations daily. The rationing activities are conducted based on experience of workers which sometimes causes problems such that they forget closing and opening valves. These are one of the reasons for increased number of complaint of "No Water." The current rationing practice may not be rational and have a room to improve for more equitable supply of water in water distribution management in the area of extremely scarce water. There is a need for more advanced water distribution management to supply limited and scarce water evenly, equitably, and rationally based on the hydraulic modeling and analysis and by grasping the accurate water distribution conditions

(6) Leakage due to inferior pipes (old pipes and GI pipes) and inadequate maintenance

Complaints of leakage are from all parts of the Study Area. Leakage is due to the following reasons:

- Corrosion due to aged galvanized iron (GI) pipes in the tertiary distribution network
- Damaged steel pipes
- Improper and poor pipe connections
- Inadequate leakage repairs
- Pipe damaged by other contractors
- High water pressure near high head pumping stations or at low elevation areas

To reduce leakage, the following priority measures are required:

1. Replacement of GI pipe with pipe of another material
2. Replacement of damaged steel pipe
3. Improvement in the construction method or procedure
4. Control of other constructions
5. Reduction in water pressure

3.10.4 Issues in Organization and Institution

(1) Insufficient awareness on water utility's mission

The awareness on water utility's mission is weak on the whole except for some management members. Water utility has the responsibility to provide safe, reliable and potable water to the residents. Instead of the sufficient quality of water service, the utility is eligible for receiving an appropriate tariff rates from the beneficial residents. This awareness seems to be not sufficiently shared by all employees. It should be nurtured through training, and an orientation of customer focus by YWC needs to be strengthened.

(2) Lack of business awareness as a service provider

Typical bureaucratic behavior can be seen generally in the employees. The private service provider is required to have business awareness and work to realize an independent and financially sustainable utility. The first step is to initiate a change in the employee's thinking and awareness at the individual level.

(3) Lack of mechanism for the effective use of human resources

A comprehensive human resource management system has not been established for efficiently using human resources and allocating them properly. Incentive mechanism, promotion system and performance-based salary system should be adopted. Job description should be created in all the sections.

(4) Incompetence of staff members

In general, the level of technical and business competence of most employees is low. This may be due to the low awareness for improvement on the part of the employees, limited training, disregard for the importance of training, and limited financial budget for training. A strategic training plan with prioritization should be prepared and implemented to substantially improve staff competence considering current urgent needs of management improvement of YWC.

(5) Fragile training system

The training budget largely depends on external funding, mostly from development agencies, and presently there is lack of funding. Most training courses rely on outside providers; therefore, the training costs are high, which in turn impedes training. To save the training costs and establish sustainable training system, training of trainers (ToT) and OJT need to be enhanced by effectively using internal resource persons.

3.10.5 Issues in Finance

(1) Low revenue, high cost and increased financial deficit

The water supply cost is high, but water tariff is maintained at a low level because of the government policy to treat water as a basic human need. Water tariff does not cover the water supply cost, which includes high electricity cost.

(2) Increasing unpaid amount of customers

The unpaid amount of the customers has been increasing and presently accumulated to a bigger amount than annual revenues derived from water and sewerage sales, which are described as "an account receivable" in the financial statement of YWC. It is caused mostly by the unfavorable behavior and attitude of customers particularly in Mafraq, Badia and Ramtha. To make the customers aware of it, a step-by-step and tough efforts and activities such as public meetings, handouts and media should be schemed and implemented.

(3) High NRW

Non-revenue water (NRW) in the Irbid governorate is 45.1 %, which is still at a very high level. Therefore, there is adequate room for improving the financial conditions of YWC by reducing the NRW.

(4) Low Level of Investment and High O&M (electricity) Cost

Investments for restructuring distribution facilities have been relatively small because high capital investment is necessary. One example can be seen in the distribution system of Irbid city. Pump area has been expanding even to areas where water can be distributed by gravity by installing adequate size of pipes. Pump installation is cheaper than pipe installation so pump installation is YWC's preferred option to overcome the water shortage quickly in the affected areas. However, it is important to note that a pumping system incurs higher operation and maintenance costs in the long run.