No.

THE HASHEMITE KINGDOM OF JORDAN
MINISTRY OF MUNICIPAL AND RURAL AFFAIRS
AND THE ENVIRONMENT

THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK-TAFILA DEVELOPMEHT REGION

VOLUME 4 SUPPORTING REPORTS

March 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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FINAL REPORT

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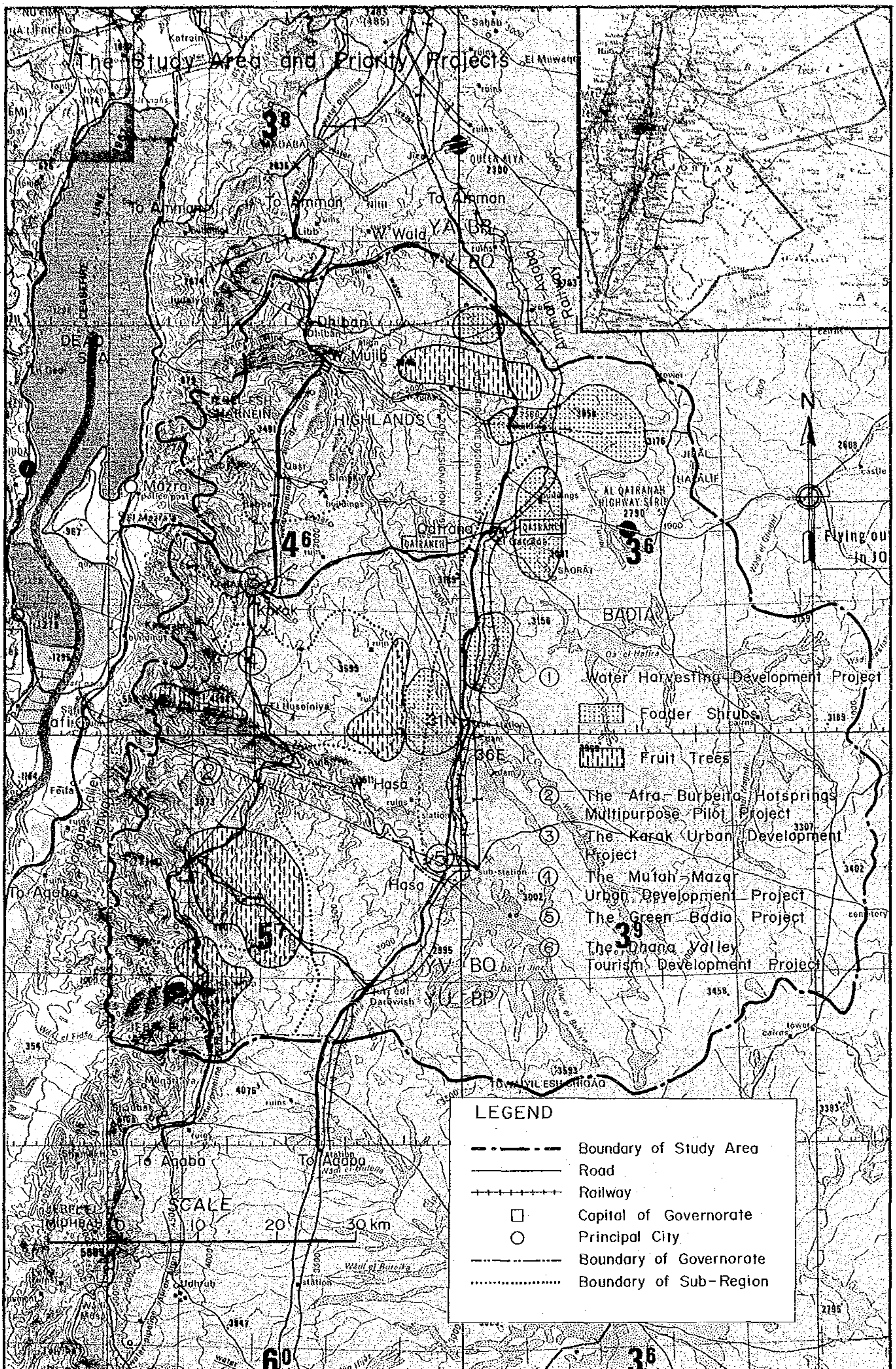
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LEGEND
Boundary of Study Area
Road
Railway
Capital of Governorate
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Boundary of Governorate
Boundary of Sub-Region
SCALE
10 20 30 km
DEAD SEA
HIGHLANDS
BADIA
Karak
Mazra
Qatrana
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ABBREVIATIONS

(1) International/Foreign Organizations

JICA	Japan International Cooperation Agency
UNRWA	United Nations Relief and Works Agency
USAID	United States Agency for International Development
WHO	World Health Organization

(2) Jordanian Governmental Organizations

MOA	Ministry of Agriculture
MOC	Ministry of Communications
MOE	Ministry of Education
MEMR	Ministry of Energy and Mineral Resources
MOHE	Ministry of Higher Education
MOIT	Ministry of Industry and Trade
MOL	Ministry of Labour
MOP	Ministry of Planning
MPW	Ministry of Public Works
MMRAE	Ministry of Municipal and Rural Affairs and the Environment
MOT	Ministry of Transport
MCTA	Ministry of Culture, Tourism and Antiquities
CBJ	Central Bank of Jordan
CVDB	Cities and Villages Development Bank
DOS	Department of Statistics
IDB	Industrial Development Bank
JEA	Jordan Electricity Authority
JIEC	Jordan Industrial Estate Corporation
JNGC	Jordan National Geographic Centre
JVA	Jordan Valley Authority
NPC	National Planning Council
NRA	Natural Resources Authority
RSS	Royal Scientific Society
WAJ	Water Authority of Jordan

(3) Other Public Organizations

ACC	Agricultural Credit Corporation
ALIA	Royal Jordanian Airline
APC	Arab Potash Company
ARC	Aqaba Railway Corporation
HC	Housing Corporation
HJR	Hejaz Jordan Railway
IDECO	Irbid District Electricity Company
JCFC	Jordan Cement Factories Company
JCO	Jordan Cooperative Organization
JETT	Jordan Express Tourist Transport
JPMC	Jordan Phosphate Mines Company
TCC	Telecommunications Corporation
UDD	Urban Development Department of MMRAE

(4) Technical Terms

AMSL	above mean sea level
SS	suspended solids
TDS	total dissolved solids
EC	electric conductivity

(5) Economic Terms

JD	Jordanian Dinars
GNP	Gross National Product
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product
ICOR	Incremental Capital Output Ratio

(6) Measurement

mm	millimetre	cm^2	square centimetre
cm	centimetre	m^2	square metre
m	metre	ha	hectare
km	kilometre	km^2	square kilometre
cm^3	cubic centimetre	mg	milligramme
l, lit	liter	g	gramme
m^3	cubic metre	kg	kilogramme
MCM	million cubic metre	ton	metric ton
bbl	barrel	t.o.e.	tons of oil equivalent
s, sec	second	^{o}	degree
min	minute	'	minute
h, hr	hour	"	second
y, yr	year	^oC	degree Celsius
V	Volt	m^3/s	cubic metre per second
A	Ampere	lcd	liter per capita per day
W	Watt		
kW	kiloWatt	kWh	kiloWatt-hour
MW	megaWatt	MWh	megaWatt-hour
GW	gigaWatt	GWh	gigaWatt-hour
10^3	thousand	10^6	million
ppm	parts per million	ppt	parts per thousand
ø	diameter in mm		

(7) Exchange rate
US$ 1.00 = JD 0.34 (the prevailing rate in mid 1987)

ANNEX-A WATER

THE STUDY ON
INTEGRATED DEVELOPMENT MASTER PLAN
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ANNEX-A WATER

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1. INTRODUCTION

This ANNEX-A -- WATER presents results of the water sector study which was undertaken as part of the Study on Integrated Regional Development Master Plan for the Karak-Tafila Development Region.

The water sector study was conducted in three stages as follows:

Stage 1: Analyses of present situation and identification of development potential of water resources (21/9/86-5/11/86)

Stage 2: Preparation of a preliminary water allocation plan and a sector development plan (20/1/87-16/3/87)

Stage 3: Preparatory study on priority projects, and modification and adjustment of the preliminary water allocation plan and the development plan (9/7/87-3/11/87)

Study results of Stage 1 were reported in a Progress Report in November 1986, and Stage 2 in an Interim Report in March 1987. This annex includes the study results presented in the Progress Report and Interim Report in addition to study results of Stage 3. An outline of the study results is presented in Volume 2; Part 1 of the Main Report. Results of the water sector study on priority projects are presented in Volume 3; Part 2 of the Main Report.

The water sector study was undertaken by a joint study team of JICA and MMRAE with cooperation from Water Sector Committee of the Government of Jordan and agencies concerned such as MOP, MOA, WAJ, JVA and so forth.

This report has been prepared taking into consideration the comments and recommendations of the Water Sector Committee on the Draft Final Report.

2. THE STUDY AREA

The general climate and topographic characteristics of the Study Area are briefed in Section 2.1 of Volume 2.

2.1 Meteorology

As shown in Table A-1 and Fig. A-2, there are 44 rainfall stations currently operated in the Study Area. Annual rainfall records of these stations are presented in Table A-3, and rainfall masscurves and isohyets are shown in Figs. A-3 to A-5. The Study Area was divided into 16 sub-basins for a hydrometeorologic study as shown in Fig. A-1. Mean annual basin rainfall of each sub-basin is obtained based on annual rainfall records by Thiessen polygon or as a arithmetic mean. As shown in Table A-6, the mean rainfall over the Study Area is 153 mm/yr equivalent to 1,242 MCM/yr. Of them, the Wala-Mujib basin shares 62 per cent, Hasa 23 per cent and others 15 percent.

2.2 Hydrology

The east bank of Jordan draining 89,206 km^2 has a mean annual rainfall of 6,000 MCM (million cubic meter) equivalent to a mean depth of 67 mm/yr over the east bank. The rain, about 1,100 MCM consisting of 880 MCM as surface flow and 220 MCM as groundwater are the annual water resources of the Kingdom. The surface flow consists of perennial base flow (originally spring discharge) and flushing storm runoff as broken down below for the Yarmouk River, an international river forming the northern boundary of the Kingdom and for the other domestic rivers:

SURFACE FLOW OF JORDAN

(MCM)

	Yarmouk River 1/	Other Rivers	Total
Base flow	220	320	540
Storm runoff	180	160	340
Total	400	480	880

Source: National Water Master Plan, 1977

1/ : Inclusive flow from Syrian part of the basin

By 1985, approximately 520 MCM of the water resources above have been developed; 111 MCM are used for municipal and industrial water, and 409 MCM for irrigation.

There are six stream gauging stations in and around the Study Area as shown in Table A-2 and Fig. A-2. The station at the Sultani dam is located at an upstream side of the dam being in the reservoir area and, therefore, only water level data are available. Annual runoff records at the other stations are listed in Table A-4.

Two stream gauging stations on Wadi Wala are located close to each other. Runoff records at a station called the Karak Road for a period from 1979/1980 to 1984/1985 seem to be overestimated in comparison of its previous records and those at the other stations called the Weir Site. Accordingly, mean annual runoff at the Karak Road was estimated as a mean for a period of 1963/1964 to 1978/1979. The mean annual runoff was calculated to be 14.8 MCM/yr at the Karak Road, and 16.3 MCM/yr at the Weir Site. In this study, the estimate of 16.3 MCM/yr at the Weir Site was adopted for assessment of the Wala flood flow potential.

Mean annual runoff and runoff coefficients are estimated as summarized in Table A-5. A relation between runoff coefficient and basin rainfall is shown in Fig. A-8. Runoff coefficients except for Siwaqa and Ghor Safi are as low as 3.0 to 4.5 per cent if rainfall over respective upstream desert basins is taken into account.

Mean runoff height of 6.0 mm/yr and runoff coefficient of 4.7 per cent are recorded at Siwaqa Station being higher than those at Tannour on Wadi Hasa and Karak Road on Wadi Mujib. The runoff records at Siwaqa are considered slightly overestimated in view of its relatively low basin rainfall and flat topography. On the other hand, the relatively high runoff height of 15.0 mm/yr and runoff coefficient of 13.3 per cent at Ghor Safi on Wadi Hasa is considered reasonable if the discharge from deep aquifer, which contributes to the perennial base flow of Wadi Hasa, is taken into consideration.

Mean runoff coefficient at these stations are shown, in Fig. A-7, against mean basin rainfall on the abscissa. As shown in this figure, runoff coefficients of Wala, Mujib and Hasa, all of which are located respectively near the King's Highway at elevations between 120 to 440 m AMSL, are almost in a straight line being linear to the annual basin rainfall. This fact also suggests the little overestimate of runoff at Siwaqa.

2.3 Geology

(1) Geology in the Study Area: The Study Area is underlain by the Pre-Cambrian, Paleozoic, Mesozoic and Cenozoic sedimentary rocks with some basic and acidic intrusives. The Mesozoic system, especially Cretaceous sedimentary rocks are most dominant in the Study Area.

The Cretaceous to Paleogene systems are divided into three groups; Kurnub, Ajlun and Belqa Groups in ascending order. The Wadi Sir Formation (A7) in the Ajlun Group, the Wadi Ghudran Formation (B1) and the Amman Formation (B2) in the Belqa Group of the middle to upper Cretaceous age constitute the most important aquifer system in the Study Area.

The middle to lower Cretaceous system and the Pre-Cretaceous sedimentary and intrusive rocks are found only in downstream areas of Wadi Wala, Wadi Mujib and Wadi Hasa, and in lower slopes of the Rift Escarpment.

The Pleistocene basalt flows associated with plugs, cones and vents are common in the western part of the Study Area.

The Quaternary fluviatile deposits with poorly sorted, loose or weakly cemented pebbles and sand cover extensive areas in the desert and obscure the older formations. These deposits are normally thin. The pelitic sediments of mudflat have developed over extensive areas where drainage of rainwater is restricted. These sediments commonly accumulate saline materials. Extensive pavements of the regolithes or mantle rocks, which consist mainly of cherts, are present on the plateau.

The Paleozoic to Cenozoic sedimentary rocks in the Study Area generally have a structure of monoclinal flexures at a low angle, faults and joints. The dominant fault direction in the Study Area ranges from NW to SE and NNW to SSE. The two most remarkable faults in the Study Area, Siwaqa Fault and Hasa Fault run SW-NE to W-E and W-E to NW-SE respectively. Fault systems correlated to the Rift Valley also occur in the west of the Study Area. Fig. A-10 shows a summary of the geologic analysis in the form of fence diagram.

(2) Geology in the Southern Ghor: The Southern Ghor area is located in a graben of the Rift Valley. The strata of the Dead Sea area were, in general, grouped into the pre-graben and post-graben formations by Neer & Emery (1967) and Zak (1974).

With respect to the post-graben formations, they recognized five formations in descending order as follows:

Post-Lisan Superficial Deposits	Late Pleistocene to Recent
Lisan Formation	Late Pleistocene
Amora Formation	Early to Middle Pleistocene
Sedom Formation	Early to Middle Pleistocene
Unnamed Rock Salt	Late Pliocene to Middle Pleistocene

Unnamed rock salt: There is no outcrop of rock salt in the area. However, the nearest outcrop is located on the Dead Sea shore near the south of Jebel Usdum (West Bank). In this area rock salt forms a cliff of some 28m high, extending for several hundred meters and is pierced by a tunnel-like caves.

In the Lisan Peninsula, a huge salt body occurs at a minimum depth of 103 m from the surface and it was penetrated to depths of several thousand meters by exploration well. The results of geophysical survey in the Lisan Peninsula indicates the existence of salt body below the Lisan Formation. The salt deposit is an evaporite from the Old Lisan Salt Lake, which is the mother of the present Dead Sea.

Sedom Formation: This formation consists of alternating rock salt and shale units reaching a thickness of about 1,850 m.

Amora Formation: The formation is mainly composed of marl and chalk with arhydrite, gypsum, silt, sand, conglomerate and some rock salt. The thickness is over 400 m in the exposed uplifted section and much greater in exploration wells located in still subsiding parts of the Dead Sea basin.

Lisan Formation: The formation consists of marl, chalk, gypsum, silt, sand and conglomerate. The thickness ranges between 50 m and 15 m. The only out-cropping formation is the Lisan Marl Formation which is covered in some places by superficial deposits.

The Lisan Marl Formation is subdivided into two members: the Lower Member and the Upper Member.

(A) Lower Member: This member consists of alternating thick beds of soft greenish grey marl, white chalk and thin beds of medium hard gypsiferous marl and gypsum, 40 to 60 cm thick. This member covers the majority of the Lisan area, it can be clearly seen on both sides of the deeply incised wadis where it forms most of the cliff in the bad land areas. The lowermost portion of this member consists mainly of greenish wet marl, 10 to 15 m thick which covers most of the southern part of the Lisan Peninsula. Medium-sized modules of sulphur are irregularly dispersed within these beds.

(B) Upper Member: This member consists of laminated chalk and gypsiferous marl. Small nodules of sulphur, 2 to 4 cm in diameter occur throughout this member. The member is sporadically distributed in the Lisan Peninsula in the form of isolated hills or ridges. Also it covers most of the northern and western parts of the peninsula.

Both members are found to be covered with a cap rock, 20 to 60 cm thick, composed of small crystals of gypsum with a fringing cement of calcite.

Post-Lisan Superficial Deposits: The Late Pleistocene to Holocene superficial deposits are developed in the eastern part of the Lisan Peninsula, the eastern bank of south Dead Sea and the Ghor area, where they cover a considerable part of the lowland area. They are characterized by the occurrence of a grey to dark brown silty clay, fluviatile gravels of alluvial fans or talus gravels.

2.4 Hydrogeology

(1) Hydrogeology in the Study Area: The Mesozoic sedimentary rocks form a sequence of aquifers and aquitards. Four aquifer systems; B2/A7, A4, A2 and K have been recognized in the Study Area. Among them, B2/A7 aquifer system (Amman-Wadi Sir aquifer system) has regional and economic importance for groundwater development. The detailed study is concentrated on this B2/A7 aquifer system. The B2/A7 aquifer system has been considered to be a semiuniform aquifer unit with hydraulic connections, which are widespread in the entire Study Area with thickness of 100 to 300 m.

The B2 formation (Amman Formation) is mainly composed of silicified limestone and chert, and stratigraphically sub-divided into the lower silicified limestone unit (B2a) and the upper phosphorite unit with coquina (B2b). The silicified limestone unit (B2a) consists of the alternating chert, silicified limestone and marl or calcareous shale. The limestones and cherts of this unit are phosphatic in parts and intensively jointed and fractured. This unit is saturated with fresh groundwater. The phosphorite unit (B2b) is composed of the lower phosphorite beds, the coquina limestones and the upper phosphorite beds in ascending order. The lower phosphorite beds consist of chert, silicified limestone and shale, which is occasionally bituminous, and phosphate bed. The upper phosphorite beds are composed of thick phosphate bed with thin chert and limestone.

The B1 formation (Wadi Ghudran Formation) is intercalated between the B2 and A7 formations, and consists of chalk, marly or sandy limestone, chert and sandstone. This formation forms a poorly saturated aquifer and sometimes thins out in the Study Area.

The A7 formation (Wadi Sir Formation) is composed of three sub-units of (A) A7c of upper unit of alternating marly limestone and limestone, (B) A7b of middle unit of limestone or dolomitic limestone, and (C) A7a of lower unit of alternating marl, marly limestone and limestone. Among these sub-units, the A7b is fractured and contains numerous solution cavities. The groundwater fully saturates this unit.

Both the B2a unit in B2 formation and the A7b unit in A7 formation are important aquifers in the Study Area for their excellent permeability. The B2a unit is a phreatic aquifer being partly saturated. Where the A7b unit is artesian, it is confined by the B1 formation and/or A7c unit. The B1 formation and A7a/A7c unit in the A7 formation are aquitards or aquicludes with less permeability. The B3 formation (Muwaqqar Formation) which covers the B2 formation is mostly composed of poorly permeable chalky marls.

(2) <u>Hydrogeology in the Southern Ghor</u>: Thickness of sediments of alluvial fans is 50 m in maximum. Depth to the groundwater table is shallow in part, varying from 1 to 13 m. Transmissivities of two wells in the Wadi Hasa alluvial fan are estimated to be 44 and 126 m^2/day respectively.

The underlying Lisan Marl Formation might be unsuitable for groundwater development because of its poorly percolating lithofacies. The exploratory deep borehole records in the Lisan Peninsula indicate that the deep-seated strata under the Lisan Marl Formation are also unsuitable for groundwater development because of dominance of rock salt intercalating shaly and marly layers.

One exploratory water well of 230 m deep was drilled by WAJ on the downstream of Wadi Isal. This well penetrates into Zarqa and Disi Formations and the groundwater is self-flowing, however, the TDS value is high at 5,000 ppm. Pumping yield is not tested, but this drilling work indicates the existence of some potential water in the deep-seated sandstone aquifers.

3. PRESENT WATER USE AND SUPPLY SYSTEM

Most of the water presently exploited in the Study Area is groundwater and spring water. Groundwater is pumped up at well fields located along the Desert Highway; Siwaqa, Qatrana, Sultani and Hasa. Spring water is used mainly for agriculture on site of each spring.

Water uses in the Study Area are classified into the following three categories:

(1) Municipal demand including small-industrial, commercial and public demands

(2) Irrigation demand

(3) Mining and large-industrial demand

Water use of the South Cement Company was treated separately from the small-industrial use as it has its own supply system.

3.1 Municipal Water

As shown in Fig. A-9, most part of the western Highlands along the King's Highway are supplied water by 2 water networks; one covering the Karak Governorate, and the other Tafila Governorate. In 1986 groundwater of 5.5 MCM was pumped up in Karak and Tafila Governorates including Safi and Mazra in the Southern Ghor (Tables A-7 and A-8). Table A-10 shows monthly fluctuation of groundwater pumped up in Karak and Tafila Governorates. The total number of water tap connections in Karak and Tafila Governorates in 1986 was 22,500 (Table A-9).

(1) <u>Karak water network</u>: Annual municipal water supplied by the Karak water network was about 3.8 MCM in 1986 (Table A-8). Present sources of water is the Sultani well field along the Desert Highway and Ain Sara spring in Wadi Karak.

In 1981, Karak City was supplied with municipal water of 1,850 m^3/day corresponding to 154 lcd. While, the water consumption that was measured by individual meters was 900 m^3/day or 75 lcd. The difference between the water supplied and metered amounted as high as to 950 m^3/day equivalent to 51 per cent of the water supplied (Ref. A-7).

(2) Tafila water network: Annual municipal water supplied by the Tafila water network was about 1.7 MCM in 1986 (Table A-8). Present sources of water is the Nijil well field in Shaubak, Ma'an Governorate located approximately 44 km south of Tafila City. The second source is Bir el-Harrir springs yielding 28 m^3/hr in 1977.

In 1981, Tafila City was supplied with water of 1,000 m^3/day corresponding to 83 lcd. While the water consumption that was measured by individual meters was 867 m^3/day or 72 lcd. The difference between the water supplied and metered amounted to 133 m^3/day equivalent to 13 percent of the water supplied.

(3) Wastewater: Presently there is no sewerage system in the Study Area. Wastewater disposal is made by on-site methods using a septic tank, cesspit or holding tank. Groundwater of Karak and Tafila Cities is reportedly polluted by plugging of the soil-liquid interface, undersized cesspits, limited percolation areas, and interference from adjacent system (Refs. A-7 and A-8).

3.2 Mining and Industrial Water

There are 2 phosphate mines in the Study Area, one at Hasa and the other at Abiad. In addition there is one cement factory at Rashadiya. They have deep wells for self water supply.

(1) El Hassa Phosphate Mine has 10 deep wells for phosphate production, of which total pumping capacity amounts to 1,650 m^3/hr. Presently, 9 wells are in operation and the last is kept as standby. Annual water pumped up is 5.7 MCM in 1983, 5.9 MCM in 1984, and 6.9 MCM in 1985. The increase of 1.0 MCM in 1985 is considered because of a tentative demand for construction works of its housing project etc. since the phosphate production showed little increase.

Of 5.9 MCM used for normal production activities in 1984 and 1985, approximately 4.2 MCM are estimated to have been added to the recycling water for beneficiation of phosphate ore to reduce chloride concentration in the washing water. The international market criteria need the chloride concentration below 600 ppm in the products. Of the fresh water added, about 3.8 MCM/yr are discharged as slimes with solids of less than 20 per cent in weight. The slimes are presently discharged to the flood plain of Wadi Hasa and are left for natural evaporation and infiltration.

(2) El Abiad Phosphate Mine has 6 deep wells for phosphate production, of which total pumping capacity is about 730 m^3/hr. In 1985, groundwater of 2.8 MCM was pumped up, and 2.5 MCM were used for beneficiation of ore, discharging about 2.3 MCM of water as slimes.

(3) South Cement Company at Rashadiya has 2 deep wells for cement production. As a closed circuit water system is adopted, there is no specific water loss in the process of cement production except cooling water for air dust. The maximum cooling water required at full cement production is 56 m^3/hr but is needed only a few hours a day. At present, 166 living quarters are under construction for 603 employees. A wastewater treatment plant having a capacity of 150 m^3/day is also constructed. In September 1986, water of 36,700 m^3 (1,200 m^3/day) was pumped up and used for cement production, domestic and construction uses of the quarters. If this amount of water is pumped up through the year, annual water consumption would be 0.44 MCM.

3.3 Irrigation and Livestock Water

Sources of the irrigation water used in the Study Area are springs, deep wells and base flow of wadis. These water resources are also used as domestic water.

(1) Spring: Of 169 principal springs existing in the Study Area, about 140 springs are used for small scaled irrigation around each spring (Table A-25). Most of the springs are concentrated in western slopes of the Highlands between Wadi Karak and Wadi Feifa with some springs in the

Wadi Mujib basin (Fig. A-22). Spring water used for irrigation is estimated, on the basis of a mean yield of respective springs, to be around 7.5 MCM/yr irrigating farmlands in wadis of more than 2,000 ha.

(2) Well: There are 118 deep wells in the Study Area as shown in Table A-11, of which 25 in the Wadi Mujib basin and several in the Wadi Hasa basin are being used for irrigation. Total water supplied by wells is estimated at around 3 MCM/yr to irrigate farmlands of about 500 ha.

(3) Base flow: Since perennial base flow is available only at lower altitude areas, the irrigated land with base flow is limited to deep valleys like Wadi Wala near the King's Highway and Burbeita in the Hasa Valley.

3.4 Municipal Water for Greater Amman

Groundwater pumped up in the Mujib Basin is presently transferred to Greater Amman at a rate of about 15 MCM/yr(WAJ).

3.5 Water Use in the Southern Ghor

(1) Domestic water is supplied by WAJ with one well to the Feifa area, four wells to the Ghor Safi-Naqa area, and two wells to the Mazra-Haditha area. The water supply is increasing in accordance with the development of the Southern Ghor. The amount of water supply in 1985 was assumed at 0.60 MCM/yr (Table A-19).

(2) The Southern Ghors Irrigation Project, Stage I has been implemented to irrigate land of 4,060 ha with the base flow (39.3 MCM/yr in total) of Wadi Hasa and other side wadis (Ref. A-12).

(3) Potash factory: The existing wells in the Southern Ghor area mainly extract phreatic water in fluviatile deposits of alluvial fans. Mazra pump station abstracts groundwater of 90 to 105 m^3/h by three boreholes in the Wadi Karak alluvial fan (Ghor el Mazra). Arab Potash Plant uses groundwater of 5.9 MCM/yr (674 m^3/h) by nine boreholes tapping the Wadi Hasa alluvial fan (Ghor es Safi) deposits, and surface water of 0.8 MCM/yr from the base flow of Wadi Hudeira (Wadi Numeira).

Safi domestic water is provided at 30 to 40 m^3/h by three boreholes sunk in the Wadi Hasa alluvial fan.

4. DEVELOPMENT POTENTIAL

4.1 Groundwater

(1) Groundwater flow: A regional pattern of groundwater movement in the B2/A7 aquifer system is shown as a groundwater level contour map in Fig. A-11. Most of the groundwater recharge enters into the aquifer system in the western Highlands of the Study Area, which have relatively high rainfall of 250 to 300 mm/yr.

A groundwater basin of the B2/A7 aquifer system in the Study Area is divided into three sub-basins by the Siwaqa Fault and Hasa Fault. The groundwater in the north of the Siwaqa Fault flows north-westwards along main reaches of Wadi Wala (often called Wadi Heidan). Groundwater of the middle basin between the Siwaqa Fault and Hasa Fault mostly flows northeastwards to main reaches of Wadi Mujib and northeastern deserts. Groundwater in the south of the Hasa Fault flows approximately north-eastward to main reaches of Wadi Hasa and northeastern deserts.

The Siwaqa Fault and Hasa Fault are believed to form a hydraulic barrier against groundwater in the B2/A7 aquifer system. As shown in Fig. A-12, a groundwater table in northern areas of the Siwaqa Fault is relatively deep at 150 m or more in its eastern Highlands compared to the south of the Fault. In a middle basin between the Siwaqa Fault and Hasa Fault, a groundwater table is relatively shallow at less than 130 m in its central Highlands along the Desert Highway. A groundwater table in the south of the Hasa Fault is further shallow at less than 50 m in its central desert area and at more than 50 m in the southwestern Highlands.

(2) Existing groundwater wells: Around 170 test and production wells have been drilled in the Study Area. Among them, 38 wells are privately owned and the remaining 132 wells are of the Government. The Water Resources Department of WAJ maintains an inventory of these wells.

Most of the private wells were drilled in the middle of the Wadi Wala basin. Some wells are located in the western Highlands. They are used for irrigation, domestic and livestock water. The Government wells, which are mainly located along the Desert Highway, are mostly used for municipal water supply to Greater Amman and Karak, washing water at the El Abiad and El Hassa Phosphate Mines, industrial water of the Rashadiya Cement Factory. WAJ drilled 15 test wells in downstream areas of Wadi Wala to examine the groundwater potential. NRA drilled 17 exploratory holes in the Lajjun area where oil shale mining is envisaged.

Pumping yields of existing production wells in the Study Area are estimated as shown in Table A-14.

(3) Groundwater quality in the B2/A7 aquifer system was measured for pumped water or was estimated on the basis of a field electric conductivity (EC) test. An iso-salinity map is prepared by total dissolved solids (TDS) values as shown in Fig. A-13. The map shows that areas of low TDS value occur in the western Highlands where rainfall is relatively high. This western Highlands are intake areas of regional groundwater within the B2/A7 aquifer system. Areas of high TDS value are found in Rabba-Dhiban area of the western Highlands and in the eastern desert to the east of Qatrana. Areas of relatively low TDS value also occur in productive well fields. These are believed to indicate a regional dilution by vertical recharge from the upper horizon within the B2/A7 aquifer system resulting from the past heavy abstraction of groundwater.

Fig. A-14 presents a diagram showing irrigation water classes made from chemical analysis data. It indicates that groundwater in the B2/A7 aquifer system is suitable for irrigation except a few wells. The water of more than 1,300 mg/litre in TDS is not attractive for uses to irrigation and domestic supply.

(4) Groundwater potential: Prospective groundwater well fields are shown in Fig. A-16 including those proposed by the JICA Mujib study.

A transmissivity of the B2/A7 aquifer system was estimated from pumping test data of each well. Fig. A-15 shows a distribution of transmissivities in the Study Area. Transmissivities widely change from well to well in a range from 3 to 30,000 m^2/day. This wide range of transmissivities mainly results from regional changes of permeability in the aquifer system. The very high transmissivity of some wells is due to development of joints and cavities in limestone. Higher transmissivities of more than 50 to 100 m^2/day, which are believed to be an economic aquifer, are mainly found in the middle basin of Wadi Wala and in a zone along the Desert Highway from the Wadi Mujib basin to the Wadi Hasa basin.

A groundwater level is relatively deep in the Wadi Wala basin compared to the Wadi Mujib and Hasa basins, ranging from 50 to 250 m from the ground surface. Groundwater depth in this area approximately ranges from 140 to 200 m. A relatively shallow groundwater table of less than 100 m deep is found at middle to lower reaches of Wadi Wala.

In the Wadi Mujib basin a groundwater level is 60 to 160 m deep, which is generally shallower than that of the Wadi Wala basin. A shallow groundwater table of around 100 m in depth is mainly located in a zone along the Desert Highway from Siwaqa to Hasa.

A groundwater level in the south of the Hasa Fault is shallower than that in northern areas of the Fault. It ranges from less than 30 m to 150 m in depth. As shown in Fig. A-12, a shallow groundwater table of less than 50 m deep occurs in middle reaches of the Wadi Hasa basin.

Three new well fields were identified and proposed by another JICA study team for Hydrogeological and Water Use Study of the Mujib Watershed (the JICA Mujib study) in the Wadi Wala and Wadi Mujib basins. Besides, there exists another potential well field at Lajjun. A sustained yield of these four well fields, which would not give an adverse effect to base flows of wadis, is estimated by them at 27.9 MCM/yr on top of the present extraction. They are the Siwaqa-Qatrana (potential 9.6 MCM/yr), new Sultani (6.3 MCM/yr), Rumeil (7.0 MCM/yr) and Lajjun

(5.0 MCM/yr) potential well fields (Source: JICA Mujib study).

Potential well fields in the Wadi Hasa basin are selected taking account of a transmissivity, groundwater depth and water quality. Two well fields were chosen for the potential study.

In the vicinity of the new Sultani well field, there are two existing well fields; one the Sultani well field supplying water to Karak, and the other Abiad well field for El Abiad Phosphate Mine. Both of the well fields have pumping capacity beyond the respective present production levels as shown below:

(MCM/yr)

Well Field	Production	Yield	Allowance
- Sultani	1.4	3.0	1.6
- Abiad	2.8	3.5	0.7
Total	4.2	6.5	2.3

The Sultani and Abiad well fields have production capacity of 6.5 MCM/yr in total, and are able to increase their production by 2.3 MCM/yr. And a demand for this 6.5 MCM/yr exists. It is, therefore, assumed that the development potential of the new Sultani well field should be the remaining potential in this area. Then the new development potential of the proposed Sultani well field is modified to be 4.0 MCM/yr, by deducting 2.3 MCM/yr from 6.3 MCM/yr.

Two new well fields, Hasa and Darawish are proposed in the Hasa basin. Their groundwater potentials are assessed, in a master plan study level, by a mean throughflow in each segment of flow nets, which is estimated by the Darcy's equation.

$$Q = T \times i \times W$$

where, Q : throughflow in m^3/day

T : average transmissivity from pump tests in m^2/day except larger figures in existing well fields

i : hydraulic gradient from groundwater contours

W : width of aquifer parallel to groundwater contours in m

Exploitable groundwater without mining is assumed to be 70 per cent of the throughflow above. Potential yields of the two well fields are then estimated as shown below:

GROUNDWATER POTENTIALS OF HASA BASIN

Well Field	Section	Width of Aquifer W(m)	Ave. Hyd. Gradient i	Ave. Trans-missivity (m^2/day)	Throughflow Q Qd m^3/day	Qy MCM/yr	Qy x 70% MCM/yr
Hasa	A-B	14,000	0.007	260	25,480	9.3	6.5
Darawish	C-D	16,000	0.013	130	27,040	9.9	6.9
Total	-	30,000	-	-	52,520	19.2	13.4

In the Hasa well field, around 6.9 MCM/yr of groundwater was pumped up in 1985 for the El Hassa Phosphate Mine. This pumping rate is slightly over the potential yield above. The geological profile of this well field is shown in Fig. A-17.

In the Darawish potential well field, about 0.5 MCM/yr is used for an irrigation project, of which a well yield is around 0.8 MCM/yr. And around 0.44 MCM/yr is abstracted by a cement factory at Rashadiya, of which well yield is 0.6 MCM/yr. New development potential of the groundwater in this well field is then obtained to be 5.5 MCM/yr by deducting the existing well yield of 1.4 MCM/yr from the potential of 6.9 MCM/yr. The geological profile of this well field is shown in Fig. A-18.

(5) Groundwater potential in the Southern Ghor: The information on groundwater in the deep-seated sandstone aquifer is still insufficient. These potentials are subject to recharge by base flow of wadis on the alluvial fans which are, however, limited. The order of potential groundwater resources in each alluvial fan is preliminarily estimated by WAJ and the Study Team at 11.5 MCM/yr in total, as broken down below (refer to Fig. A-19):

No.	Alluvial Fan	Place	Potential (MCM/yr)
(A)	Wadi Hasa	Ghor es Safi	5.5
(B)	Wadi Hudeira	Ghor en Numeira	1.0
(C)	Wadi Isal	Ghor Isal	1.0
(D)	Wadi Karak	Ghor el Mazra	1.5
(E)	Wadi Ibn Hammad	Ghor el Haditha	0.5
(F)	Wadi Feifa-Khanzeira		2.0
	Total		11.5

The above figures require future examination through a detailed potential study on the alluvial fans.

4.2 Surface Flow

Estimated runoff at representative places on principal wadis in the Study Area is compared with estimates of National Water Master Plan (Ref. A-2), and the JICA Mujib Study (Ref. A-4) as shown in Table A-12. Estimates of this study are slightly lower than the others in general since the estimate in this master plan study was made to be in conservative side whenever there was uncertainty in data. It is then judged that the estimates of this study can be a basis for development planning of surface water resources. Estimated runoff at representative places and existing damsites is summarized in Table A-13.

Mean annual rainfall over the Study Area is 1,242 MCM/yr or 153 mm/yr. Of the rainfall, 80 MCM/yr or 9.9 mm/yr become surface runoff. An overall runoff coefficient is estimated to be 6.4 per cent. Most of the runoff in the Study Area are flood flow (86 per cent at Tannour).

(1) Base flow: Perennial base flow is observed on downstream reaches from the King's Highway except where springs exist in higher altitudes like Ain Sara Spring on Wadi Karak. These base flow is derived from springs located at faults or basalt cones/vents existing along downstream reaches of each major river course. The base flow generally shows an intermittent increase towards downstream. A main source of spring water is the A7 Formation in Wadi Wala, the A2 Formation and/or Kurnub and Disi Formations in Wadi Mujib, and the A7 and/or A4/A2

Formation and Kurnub Formation in Wadi Hasa. An annual fluctuation of base flow in the Ghor is generally less than 20 per cent (9 per cent at Ghor Safi on Wadi Hasa).

Annual base flow of Wadi Hasa is estimated at 26 MCM/yr at Ghor Safi as shown in Table A-4. That of Wadi Wala is estimated by the JICA Mujib study to be 23 MCM/yr, and Wadi Mujib 12 MCM/yr.

(2) Flood flow: As shown in Table A-4, mean annual flood flow is calculated to be 13.5 MCM on Wadi Wala, 19.5 MCM on Wadi Mujib, and 5.7 MCM on Wadi Hasa at respective sites of stream gauging stations located near the King's Highway. Since the base flow presented in the table for Wadi Mujib at Karak Road and Hasa at Tannour is not perennial but available in the rainy season, this was treated in this study as part of the flood flow. Mean annual flood flow was then estimated to be 13.5 MCM on Wadi Wala at the Weir Site, 24.1 MCM on Wadi Mujib at the Karak Road, and 6.6 MCM on Wadi Hasa at Tannour (44.2 MCM in total).

Flood flow is usually available in the period from November to April. However, it does not continue through the rainy season but flushes in a few days after each rainstorm. Number of floods is usually 2 to 8 times/yr, and coefficient of variance of annual flood flow volume is as high as 90 to 160 per cent. These characteristics of flood flow are main development constraints as they require a large reservoir capacity to catch and store such rare but voluminous flood water.

Development of flood runoff in deep wadis for irrigation use on the Highlands which have elevation of 800 to 1,000 m is not realistic in view of its high pumping head required.

On the other hand, a riverbed elevation of these wadis rises to 760 to 820 m at crossing points with the Desert Highway being similar to an elevation of surrounding areas (Fig. A-6). Annual rainfall of basins spreading to the east of the Desert Highway was estimated: in a normal year there is an annual rainfall of 142 MCM in total in the desert basins of 3,243 km^2 wide, equivalent to a mean depth of 44 mm/yr.

However, there is presently no data basis to assess the runoff coefficient of these desert basins as there have been no stream gauging stations in the basins except those newly installed in 1986 under the JICA Mujib study.

4.3 Municipal and Industrial Wastewater

(1) Mining slimes: According to water quality tests made on the slimes, TDS is 1,800 to 3,600 ppm (refer to Table 3-3 of Volume 3). The wastewater could not be directly used for irrigation purpose. The main constraints to reuse the slimes are high salinity, desilting of its fine (less than 0.05 mm in diameter) and voluminous solid contents and its proper disposal.

One of conceivable ways to reuse the slimes is to guide it into a large reservoir, and to take the desilted water from the other side of the reservoir. After certain period of operation, the reservoir will be full of sediments to be abandoned, and another reservoir will be needed. With this idea, if a reservoir having an enough capacity for one year operation is to be constructed, an order of the required reservoir capacity and available water would be as follows:

		El Abiad	El Hassa	Total
(1)	Slimes: (10^6 t/yr)	2.9	4.7	7.6
	- water (MCM/yr)	2.3	3.8	6.1
	- solid (10^6 t/yr)	0.6	0.9	1.5
(2)	Reservoir:			
	- surface area (ha)	15.0	25.0	40.0
	- depth for sediments (m)	2.7	2.4	-
	- storage for sediments (MCM) 1/	0.4	0.6	1.0
(3)	Evaporation loss (MCM/yr) 2/	0.2	0.3	0.5
(4)	Infiltration loss (MCM/yr) 3/	0.1	0.2	0.3
(5)	Residual water in deposits	0.8	1.1	1.9
(6)	Available water	1.2	2.1	3.3

1/: A unit weight of 1.5 t/m^3 is assumed.

2/: An annual evaporation rate of 2,000 mm is assumed.

3/: An infiltration rate of 2.5 mm/day is assumed.

If the reservoirs above are constructed, the desilted water of about 3.3 MCM/yr would be available.

(2) Municipal wastewater: Under the Third Five-Year Plan, two sewerage systems are under construction in Karak and Tafila Cities. Also El Hassa Phosphate Mine and the South Cement Company are constructing respective sewerage systems for their own quarters. Design capacity of the wastewater treatment plant for the Karak and Tafila cities is 3,000 m^3/day each in 1995, and 6,000 m^3/day each in 2005.

At present there is no specific wastewater available as treated water. However in the year 2005, the wastewater is estimated to increase to about 5.77 MCM/yr as shown below:

TREATED WASTEWATER IN 2005

	Water Supply	Actual Use 1/	After Treated 2/
(1) Municipal wastewater			
- Karak	1.79	1.43	1.14
- Mu'tah-Mazar	1.16	0.93	0.74
- Tafila	1.82	1.46	1.17
- Hasa	1.40	1.12	0.90
Sub-total	6.17	4.94	3.95
(2) Industrial wastewater			
- Mu'tah	0.83	0.66	0.53
- Karak	0.11	0.09	0.07
- Tafila	0.43	0.34	0.27
- Hasa	0.99	0.79	0.63
- Others	0.50	0.40	0.32
Sub-total	2.86	2.28	1.82
Total	9.03	7.22	5.77

1/: Obtained deducting distribution losses of 20 per cent

2/: Obtained as 0.8 times of actual use taking account of miscellaneous losses and consumptive uses

(3) <u>Cement factory</u>: There is no specific discharge of wastewater except that from quarters where 603 employees are living.

4.4 Development Potential in the Mujib-Hasa Basin

Water resources in the Mujib-Hasa basin is assessed at a master plan level as summarized in Table A-20, and their development potential (after deduction of spill out from dams, etc.) in Table A-21. Potential of the Wadi Hasa basin was estimated by the Study Team, while those of the Wadi Wala and Wadi Mujib basins were estimated on the basis of the data provided by WAJ and the JICA Mujib study (Ref. A-4) with some modifications. Water resources development potential in the Southern Ghor area are quoted from a report for the Southern Ghor Irrigation Project (Refs. A-11 and A-12), the Study on Water Conveyance System for South Jordan, Study Report (Ref. A-5) and the data provided by WAJ. These estimates are compared in Table A-15.

As shown in Table A-21, the water resources potential in the Mujib-Hasa Basin is assessed to be 184.9 MCM/yr, consisting of base flow of 78.9 MCM/yr, flood flow of 33.2 MCM/yr, and groundwater of 72.8 MCM/yr.

Although the annual yield of the proposed Wala Dam was estimated by the JICA Mujib study to be 16.9 MCM/yr, it was herein assumed to be 80 per cent of the average runoff (13.5 MCM/yr) at the Weir Site gauging station on Wadi Wala, or 10.8 MCM/yr to keep consistency in runoff estimates of this study at a master plan level. Also the yield of Nukheila Dam was estimated by the JICA Mujib study to be 5.3 MCM/yr out of the mean inflow of 26.15 MCM/yr because of the geologic conditions of the damsite. In this study, the total potential yield of the Nukheila dam and the proposed Dabba Dam etc. on the upstream reaches was assumed to be 11.7 MCM/yr, or 80 per cent of the mean runoff (19.5 MCM/yr) less extraction by the upstream Siwaqa, Khabra and Karak Highlands dams.

In addition to the potential given in Table A-21, about 3.3 MCM/yr of water could be recovered from the slimes of El Abiad and El Hassa Phosphate Mines if the proposed tailing dams are constructed.

In the year 2005, municipal and industrial wastewater of about 5.8 MCM/yr would be available; 2.8 MCM/yr in the Karak-Mu'tah-Mazar Corridor, 1.5 MCM/yr in the Tafila area, and 1.5 MCM/yr in the Hasa area, provided that sewerage systems should be constructed for these towns.

5. WATER DEMAND

Water demand in the Study Area was projected for an intermediate year 1995 yields and a target year 2005 of this master plan study in accordance with the selected development Scenario 3, to see the future supply and demand balance and the water resources development need.

5.1 Municipal Water Demand

Municipal water demand in the Study Area was projected based on the unit municipal water demand at a supply end presented in Table A-16 and on a population framework presented in the Main Report-Part 1. As shown in the table, this unit demand is principally quoted from Ref. A-5 but with some modification. The unit municipal water demand includes commercial and small-industrial demands (assumed at 10 per cent of the domestic demand) and distribution losses (assumed at 20 per cent of the water supplied).

The unit demand was assumed at 160 lcd in the year 2005 for large cities that are provided with sewerage systems taking account of water use for water closet, washing machines, shower, gardening and so forth. A solar heater system for supplying hot water in each household, which is planned by the Government to be spread to 50 per cent of the households by the year 1990, will also be an increasing factor of the unit demand. It is also required to raise living standards in the strategic urban centres in the Study Area as one of measures to counter the out-migration trend towards Greater Amman.

The unit water demand in the target year 2005 was accordingly set at 160 lcd although it is high compared to past trend projections which were made without this Regional Development Master Plan.

Regarding the unit water demand for the secondary urban centres and new villages proposed in the Master Plan, water for the proposed Home Garden Project, which was estimated at 20 lcd, was added to the estimate of Ref. A-5.

Projected municipal water demands are presented in Table A-17, and may be summarized as belows:

PROJECTED MUNICIPAL DEMAND

Area	1985		1995		2005	
	(MCM)	(lcd)	(MCM)	(lcd)	(MCM)	(lcd)
Karak Governorate	2.70 1/	77	3.87	86	7.36	119
Tafila Governorate	1.16 1/	85	1.77	101	4.36	140
Dhiban area	0.20 1/	60	0.33	79	0.58	107
Total	4.06	78	5.97	90	12.30	125

1/: Data given in the Water Sector Committee's comments on the Progress Report. One of the Karak network was obtained as: Karak Governorate (3.3) - Ghor Safi (0.6) = 2.7 MCM/yr.

5.2 Industrial Water Demand

Water demand of the two phosphate mines was estimated at around 11 MCM/yr at a full production level, and the cement factory at 0.6 MCM/yr. That of the Lajjun oil shale project was estimated at 0.8 MCM/yr in 1995 for a pilot plant having a capacity of 5,000 bbl/day. A unit water requirement was assumed at 3 m^3 per ton of oil produced. Its demand in the year 2005 was assumed at 5.0 MCM/yr. The demand of the Sultani oil shale power generation project was assumed at about 2.0 MCM/yr (Source: NRA).

Water demand of the manufacturing sector in the year 2005 was projected to be 2.9 MCM/yr in accordance with the industrial development plan (Refer to Table A-18 and Annex-D for details).

5.3 Irrigation and Livestock Water Demand

The new irrigation water required to promote Highlands agriculture was estimated at around 5.0 MCM/yr taking account of the water shortage in the Study Area. Water demand of livestock farming for one million goats and sheep was estimated at 1.8 MCM/yr with unit demand of 5 litre/day/head.

5.4 Environmental Water Demand

As part of the proposed strategic development of the Badia, water and green parks, greenbelts, a golf course and so forth have been proposed in the Master Plan. Water demand of these plans was preliminarily estimated as shown below:

(1) Greenbelt: Water demand for maintaining greenbelts which would be provided along the Desert Highway was estimated at about 0.6 MCM/yr as follows:

(A) Numbers of trees per km of road 2,000
(200 nos./km/row x 5 rows x both sides)
(B) Length of roads to be provided with greenbelts .... 85 km
(C) Total number of trees 170,000
(D) Unit water requirement per tree .... 0.01 m^3/day
(E) Water demand .... 0.6 MCM/yr

(2) Water and productive green parks: Fresh water of about 2.4 MCM/yr would be required in addition to the desilted water from the phosphate slimes, to maintain the proposed productive green park and forests.

A pond of 15 ha (equivalent to 300 m by 500 m for example) and 1.0 m deep impounds water of 0.15 MCM. An evaporation loss will be around 0.3 to 0.6 MCM/yr. Water in the pond needs circulation for refreshment of its water quality. If the water circulation is made at a rate of once in two weeks, the water of 3.9 MCM would be required. Infiltration losses through the bottom of the pond was assumed to be nil as it could be almost stopped by waterproof sheets. The total water which should pass through the water pond will then be around 4.5 MCM/yr, which may be supplied with the desilted saline water from the phosphate slimes mixed with the flood flow of Wadi Hasa. The discharge of the pond will be utilized to maintain the greenery.

(3) Golf course: For maintaining a course of 100 ha with a unit water supply of 2,000 mm/yr, the water demand was roughly estimated at about 2 MCM/yr. However, this water could be mainly supplied by the discharge from the water pond. In addition, fresh water of about 0.6 MCM/yr would

be required for special plantation, and could be supplied by the flood water to be developed by the proposed Hasa Dam.

5.5 Municipal Water Demand of Greater Amman

Annual water supplied to Greater Amman in 1985 was 61.5 MCM having been in short to meet the estimated demand of 70 MCM/yr. To cope with the current water shortage and growing municipal demand of Greater Amman, the following national water development strategy was envisaged by the Government of Jordan:

(1) Growing municipal water demand of Greater Amman should be met by groundwater at Disi and Mukhebah and base flow of Wadi Wala.

(2) Of the groundwater of 36 MCM available at Mukhebah well field, 26 MCM should be diverted to Greater Amman by WAJ, and the remaining 10 MCM to the East Ghor Canal by JVA.

(3) Of the base flow of 35 MCM available in the whole Mujib basin, 15 MCM of Wadi Wala should be diverted to Greater Amman by WAJ, and the remaining 20 MCM for the Southern Ghors Irrigation Project - Stage II by JVA.

(4) Allocation of groundwater resources of the Disi well fields should be decided after completion of an ongoing survey of its development potential.

In early September 1987, an agreement was signed between the Government of Jordan and the Government of Syria on development of Al Wahdah Dam on Yarmouk River which had a reservoir capacity of around 222 MCM, although it is subject to a further study.

According to the JICA Mujib study, municipal water demand of Greater Amman will be 192 MCM by the year 2005 including local demand in the Mujib basin. To meet this demand, water supply capacity of Greater Amman should be augmented by the Mukhebah (26 MCM) and Wadi Wala (15 MCM) schemes, but still 78 MCM will be in short requiring early development of the remaining potential water in the Wala-Mujib basin preceding Al Wahdah Dam.

The potential municipal demand of Greater Amman was then assumed at 36.0 MCM/yr as the possible maximum sum of sustainable yields of candidate well fields and of surface flow as shown below:

Qastal well field (existing)	2.0 MCM/yr
Siwaqa-Qatrana well field (existing + proposed).....	15.0
New Sultani well field (proposed)	4.0
Base flow of Wadi Wala	15.0
Total	36.0 MCM/yr

5.6 Water Demand in the Southern Ghor

(1) The Southern Ghors Irrigation Project is planned in 2 stages, of which water demands are as follows:

Stage I :	39.3 MCM/yr for land of 4,060 ha	(Ref. A-12)
Stage II :	23.5 MCM/yr for land of 3,780 ha	(Ref. A-13)
Total	62.8 MCM/yr	7,840 ha (= 800 mm)

Stage I has been implemented by JVA, and Stage II is planned to be implemented under the Third Five-Year Plan.

(2) The Potash Project: According to the Arab Potash Company, its water demand of the potash plant in Ghor Safi will increase to 12.5 MCM/yr, including 0.5 MCM/yr for domestic, by the year 2000 along with a production increase from 1.2 million t/yr at present to 2.5 million t/yr by 2000. The present unit water requirement is about 5.0 m^3 per ton of potash produced. However, about 70 per cent of the water requirement can be brackish water with a TDS concentration of up to about 20,000 ppm provided that a sulphate concentration is low.

(3) *The Dead Sea Chemical Complex: In addition to the above production* expansion of potash by APC, there is a plan to construct by-product plants such as Potassium Sulphate, Soda Ash, Magnesium Oxide and Bromine, of which the water requirement was estimated by APC to be 1.5 MCM/yr after 1991 and 2.25 MCM/yr after 1995 (APC estimate as of March 1987).

In July 1987, the Jordanian Industrial Consortium Engineering Company (JICECO) prepared a plan to construct the Dead Sea Chemical Complex as Stage II of the Potash Project (Ref. 14). JICECO estimated the water requirement of the Complex at 40 MCM/yr, of which breakdown is given in Table A-26.

While the Water Sector Committee provided the Study Team, in the comments on the Draft Final Report, with another estimate of the water requirement at 13-15 MCM/yr. The breakdown and source of the estimate are not known.

The water demand of the Dead Sea Chemical Complex was then assumed in this study at 14 MCM/yr in accordance with the figure provided by the Committee.

(4) Tomato factory: There is a tomato processing factory, of which the water demand is about 0.6 MCM/yr (WAJ).

5.7 Overall Water Demand to Mujib-Hasa Basin

Present and projected water demands for the years 1995 and 2005 are shown in Table A-19. The total water demand in the year 2005 would amount to 203.4 MCM/yr although the Highlands irrigation projects are limited in view of severe water shortage expected. The total demand exceeds the potential (184.9 MCM/yr) by 18.5 MCM/yr.

Water uses in Jordan are usually classified in three categories. In this study, however, the fourth group of environmental use is proposed. As one of measures required for achieving socioeconomic development of the Badia, rehabilitation and improvement of environment in terms of green will have an important role. For creating attractive environment for human settlement and wildlife conservation, this environmental water will be used.

6. ALTERNATIVE WATER ALLOCATION PLANS

The Study Area does not include the north bank of Wadi Wala and the Southern Ghor which is lower than 500 m AMSL in elevation. However, for a planning purpose of a possible water allocation in the Study Area, it is inevitably required to take account of runoff from the north bank of Wadi Wala, water resources in the Southern Ghor as well as the water demand in these areas. Accordingly, this water allocation study was made for an expanded area, herein named as the Mujib-Hasa basin.

6.1 Water Allocation Policy

Comments of the Water Sector Committee given on the Progress Report presents the water allocation policy as summarized below:

In view of projected severe water shortage in the Mujib-Hasa basin in the year 2005, the water allocation is to be made with the following priority ranking order:

(1) Domestic water supply from the Study Area to meet national priorities

(2) The Highlands agriculture projects

(3) The Southern Ghors irrigation projects

Careful consideration is to be given to the following projects:

(1) Highlands agriculture projects in the Study Area

(2) Southern Ghors irrigation project, Stage II

6.2 Balance between Local Demand and External Demand

In view of limited amount of water resources and increasing demand for drinking water in large urban centres like Greater Amman which often conflicts with local water demand for irrigation, establishment of a Watershed Development Fund is proposed as described below.

Water Policy: In spite of the Government's effort for decentralization, an intensive reinforcement of the drinking water supply to Greater Amman will obviously be required. In line with the water allocation policy which gives top priority to drinking water supply (domestic) over irrigation and industrial water, a necessary amount of water should be allocated to domestic use both inside the Study Area and outside including Greater Amman.

Groundwater resources would be allocated to drinking purpose with priority in view of its favourable quality and dependability of supply even in dry years. On the other hand, flood flow could mainly be allocated to agriculture, which can cope with drought by reducing areas of cultivating land. Flood flow could also be developed for certain large scale industries like oil shale development at Lajjun if shortage of water supply in dry years can be covered by groundwater.

Water for Highlands Agriculture: If certain amount of groundwater in the Study Area is allocated to Greater Amman for drinking purpose, the local agriculture will lose a chance to develop groundwater which, in general, is more economical than flood flow. Other water resources which can be developed for the Highlands are rainwater, flood flow in small catchments, spring flow and wastewater. Most of the spring flows have been fully utilized though some need rehabilitation works. For promotion of the Highlands agriculture, development of rainwater and flood flow is prerequisite although these are costly.

National Needs for Rainwater and Flood Flow Development: Since water resources are limited in the Kingdom, rainwater and flood flow, which are renewable and indigenous resources of the Kingdom but have been less exploited, should be developed to the maximum possible extent from a national point of view. As they are costly compared to development of groundwater and base flow (but much cheaper than desalinization and long-transmission of sea water), a financing system would be required to promote development of rainwater and flood flow.

Meanwhile, the Water Harvesting Development Project proposed in the Master Plan consists of two schemes: the Winter Irrigation Scheme to develop flood flow; and other the Water Harvesting Scheme which aims at an efficient utilization of rainwater. Both of the two schemes have many components of small scale, and need to be implemented year by year towards the 21st century to promote Highlands agriculture.

Need of Financial Assistance in Construction: The Winter Irrigation Scheme would become feasible if financial assistance is made in construction of dams, diversion weirs, terrace farmlands and other major structures. Once these infrastructure are constructed, Highlands agriculture could manage itself without yearly subsidy from the Government. The persisting subsidy has been made in many countries to cause serious national budgetary problems and it is not a recommendable way. To promote Highlands agriculture, the financial assistance in the initial investment is prerequisite.

Extra Water Fee: With principle of *Give and Take*, it would be acceptable to people, who are living in large urban centres like Greater Amman and enjoying comfortable urban life with water transmitted from the under-developed regions like the Study Area, to assist rural farmers in developing flood flow and rainwater for promotion of Highlands agriculture. One of conceivable ways of this assistance is to pay extra fee for drinking water in urban centres. This fee would be deposited as the proposed Watershed Development Fund and would be used for development of rainwater and flood flow for Highlands agriculture as well as for irrigated agriculture in the Ghor.

Higher Water Tariff in Urban Centres: With the extra fee above, the water tariff will be high in large urban centres, while the tariff in rural areas will remain at lower levels. High living expense in large urban centres would assist the Government policy of decentralization.

6.3 Alternative Water Allocation Plans

Quantity allocation plan: Within the water allocation policy described above, four cases of preliminary alternative water allocation plans have been prepared: Case 1--Highlands oriented; Case 2--Amman oriented; Case 3--Ghor oriented; and Case 4--Dead Sea Chemical Complex (Stage II of the Potash Project) oriented. These four cases are presented in Table A-22.

The latest estimate of the water requirement of the Dead Sea Chemical Complex amounting to 14 MCM/yr could not be fully met except in Case 4. Also the water demand of Highlands agriculture projects as presented in the Progress Report (24 to 37 MCM/yr) could not be supplied.

New extensive water users would have to bear the projected water deficit of 18.5 MCM/yr in 2005 as shown below for each case of water allocation:

WATER DEFICIT IN 2005

(MCM/yr)

Water Use	Case 1 Highland	Case 2 Amman	Case 3 Ghor	Case 4 Potash
1. Municipal of Amman	7.0	-	12.0	19.0
2. S. Ghor Stage II	-	7.0	-	-
3. Dead Sea Chemical Comp.	11.75	11.75	7.0	-
Total	18.75	18.75	19.0	19.0

Case 1 would satisfy all the demands except for Greater Amman and the Dead Sea Chemical Complex. Greater Amman would have, however, 14 MCM/yr of additional allocation on top of the present supply (15 MCM/yr). The Dead Sea Chemical Complex would be allocated only 2.25 MCM/yr, which is the original estimate of Arab Potash Company (APC).

Case 2 would provide an extreme water allocation to Greater Amman and, therefore, would have an adverse effect on the Southern Ghors Irrigation Project - Stage II.

In Case 3, the water requirement of Southern Ghors Irrigation Project would be fully met, but that of the Dead Sea Chemical Complex would be only half met. Greater Amman would have 9 MCM/yr of additional allocation as compared to now.

Case 4 is an reverse case of Case 2; all the water demands other than the municipal demand of Greater Amman would be satisfied, but

Greater Amman would have only 2 MCM/yr of additional water allocation on top of the present supply (15 MCM/yr).

If Greater Amman could manage its municipal water supply without significant additional supply from the Study Area (for example by construction of Al Wahdah Dam planned on Yarmouk River), Case 4 would be the most preferable from the viewpoint of regional development as well as national water allocation.

However, implementation of such a large scale project may take time and smaller scale projects would be needed to meet the growing demand in Greater Amman in the short-term. In the present circumstances, therefore, Case 1 may represent one of the most realistic and practical allocations.

Since the Dead Sea Chemical Complex was planned without reference to these water allocation studies, plans for the Complex need to be re-examined keeping in mind the need for a balance of water supply and demand.

Allocation plan by source of water: A preliminary water allocation plan by source of water was prepared only for Case 1 of the Alternative Water Allocation Plans to ensure that the above quantitative water allocation plans were practically possible.

In general, groundwater resources have been allocated to municipal and industrial water supply which needs high stability and dependability, while flood flow sources have been mainly allocated to new irrigation projects in the Highlands.

Table A-23 shows that Case 1 of the Alternative Water Allocation Plans is physically possible.

Water quality and extra cost: Regarding the allocation by source of water, there exist the following practical matters to be considered:

(A) The Mujib base flow is marginal in salinity (about 1,270 ppm in TDS) in view of irrigation use. As shown in Fig. A-20, the present salinity of about 1,060 ppm in TDS concentration at the confluence of Wadi Wala and Wadi Mujib would become higher to about 1,470 ppm if the base flow of Wadi Wala is abstracted at a rate of 15 MCM/yr at around the King's Highway. In these cases of water allocation, it would be necessary to mix the base flow of Wadi Mujib with less saline flood flow to reduce the salinity suitable for irrigation in the Southern Ghor.

(B) In the case of water source allocation presented in Table A-23, the water quality for the Southern Ghor would not be affected by the abstraction of the fresh base flow of Upper Wadi Wala, because the fresh flood flow of about 10 MCM/yr and the fresh groundwater of about 10 MCM/yr in the Ghor alluvial fans would be mixed to the base flow.

(C) In general, flood flow development costs much higher than the base flow or groundwater development as it requires large reservoirs. Therefore, in addition to the water allocation, cost allocation should also be examined in the same concept with the proposed Watershed Development Fund. In other words, the construction cost of dams for the flood flow development should be shared not only by the beneficiaries of the dams but also by beneficiaries of the groundwater development. Otherwise, nobody wants to develop the costly and unstable flood flow, but everybody want to have an allocation of the cheaper and more dependable groundwater and base flow, in spite of the national need of the flood flow development.

<u>Provision for drought</u>: When flood flow is allocated to industries (the Lajjun Oil Shale Project for example), a standby water supply system with a groundwater or base flow will be required to secure the supply even in drought years. Some mining of the groundwater would be required exceeding the allocation in these drought years, but could, in general, be compensated by less abstraction of it during rich water years.

Brackish water to potash: Upon development of the base flow of Wadi Mujib and Wadi Wala which has a TDS concentration of more than 1,000 ppm (Fig. A-20), there will be a possibility of exchanging the base flow with the fresh groundwater, which are being used for the potash processing, to supply water of the better quality to the Southern Ghors Irrigation Project.

7. WATER RESOURCES DEVELOPMENT PLAN

7.1 Existing Development Plans

Of water-related projects planned in the Third Five-Year Plan, the followings are concerned with the Study Area or its water resources:

(1) Irrigation projects

(A) Southern Ghors Irrigation Project, Stage II: To irrigate by diverting base flow of Wadi Mujib with a cost of JD 36 million

(B) Water resources development of Wadi Ibn Hammad: To divert base flow of about 4 MCM from Wadi Ibn Hammad to land of about 400 ha in the Southern Ghor with a cost of JD 1.55 million

(2) Flood water development projects

(A) Desert dams: Comprehensive dam planning for development of all the desert regions in the Kingdom for irrigation and groundwater recharge with a cost of JD 4.5 million

(B) Tannour dam on Wadi Hasa: To divert flood flow of Wadi Hasa for the irrigation project (1)-(A) above with a cost of JD 12.15 million

(C) Rumeil dam on Wadi Wala: To develop flood flow of Wadi Wala for irrigation and domestic water supply with a cost of JD 3.23 million

(D) Nukheila dam on Wadi Mujib: To develop flood flow of Wadi Mujib for irrigation with a cost of JD 2.75 million

(3) Water network projects

(A) Water networks for Karak and Tafila Cities

(B) Replacing and upgrading of existing water networks in Karak and Tafila Cities

(4) Sewerage network projects

(A) Sewerage networks for Karak Governorate covering Southern Mazar, Mu'tah and Adaniyyah

(B) Karak sewerage networks and treatment plant: First phase is being implemented in Karak City with a cost of JD 2.3 million, and is expected to be completed by 1988.

(C) Tafila sewerage networks and treatment plant, First phase is being implemented in Tafila City with an estimated cost of JD 1.7 million, and is expected to be completed by 1987.

(D) Southern cities sewerage networks will be provided to the east and west of Tafila by 1988 with a cost of 2.38 million.

(E) A station for reuse of treated wastewater for irrigation in Karak and Tafila Cities will be constructed by 1990.

7.2 Development Strategy

(1) National strategy: The Third Five-Year Plan presents an estimation of national water demand for the year 2000 as shown below:

NATIONAL WATER DEMAND BY THIRD FIVE-YEAR PLAN

(MCM)

Demand	1985	1990	1995	2000
Domestic & Industrial	111	152	196	247
Irrigation	409	553	624	687
- Ghor and Wadi Araba	(309)	(453)	(524)	(587)
- Other areas	(100)	(100)	(100)	(100)
Total	520	705	820	934

The Plan aims, with top priority, to supply domestic water almost to every households in the Kingdom through water networks. The unit water consumption rate is 88 liters per capita per day (lcd) in 1985, and the projected one in the year 2000 is 120 lcd.

(2) Regional development strategy: A development plan of water resources in the Study Area is prepared in accordance with the following basic strategy:

(A) Groundwater in the B2/A7 aquifer system should be developed on the basis of a sustainable yield with some mining (consumptive use). Groundwater in other deep aquifer systems needs a further exploration and, therefore, should be reserved for future development.

(B) The existing water use on the downstream reaches should not be affected by the water development in upstream basins.

(C) To develop flood flow for use on the Highlands to the maximum possible extent, construction of many small dams and weirs in the western Highlands would have a key role. These would contribute to development of flood flow on the Highlands, groundwater recharge, and reduction of sediment transport to downstream reaches.

(D) Reuse of municipal and industrial wastewater should be made as far as technically possible and economically viable. For example, the reuse of brackish water withdrawn from the potash processing should be considered.

(E) An effective use should be investigated for the flowing water in alluvial fans in the Southern Ghor by an infiltration gallery, induce well, etc. An exploitation of the groundwater in sandstone aquifers should be required for future industrial water demand. In addition, groundwater recharge with abundant base flow during the winter season should be examined through a detailed study so as to reuse it in the spring to early-summer seasons when the irrigation water demand increases.

7.3 Development Plan of Groundwater

(1) <u>Groundwater development plan in Hasa basin</u>: One potential well field is proposed in the Darawish area. A standard well is assumed to be 300 mm in diameter, 60 m^3/hour in pumping ratio, and 16 hour/day in pumping hour. A pumping drawdown of this standard well is estimated by Theis's non-equilibrium formula to be 8.75 m. Taking account of the drawdown and groundwater depth, the depth of standard well is assumed at 150 m.

A radius of influence of the standard well is estimated by the non-equilibrium formula to be about 220 m, and a well spacing at 440 m respectively. However, this well spacing of the standard well may be set at not less than 1.0 km following the practice of WAJ from a practical point of view. A standard pumping yield of one well is estimated at 960 m^3/day or 0.32 MCM/yr. Total number of production wells will exceed 18.

To distribute the pumped water from the proposed Darawish and Lajjun well fields, the following pipeline projects will be needed although these are depending on the final water allocation to be made by the Government:

(A) Darawish-Tafila Pipeline Project for supplying municipal water of about 1.22 MCM/yr including a demand of the proposed small scale industries (0.4 MCM/yr) from Darawish to the Tafila Water Network

(B) Lajjun-Karak Pipeline Project for supplying municipal water of about 4.36 MCM/yr including a demand of the proposed small scale industries (1.5 MCM/yr) from Lajjun to the Karak Water Network

(C) Darawish-Hasa Pipeline Project for supplying municipal water of 3.24 MCM/yr including a demand of the proposed Hasa Industrial Estate (1.0 MCM/yr) and an environmental demand (0.8 MCM/yr) from Darawish to Hasa

(2) Groundwater development plan in the Mujib basin: Three new well fields and two pipeline projects are proposed in the whole Wadi Mujib basin by the JICA Mujib study (Ref. A-4).

7.4 Development Plan of Spring Flow

The existing 169 springs are of small scale, having mean discharge of 0.7 to 1.2 litre/s. These may be summarized as follows:

YIELD OF SPRINGS IN THE STUDY AREA

Class of Spring Yield	Number	Total Flow (m^3/min)			Average Flow (M^3/min)		
		Max.	*Min.*	*Mean*	*Max.*	*Min.*	*Mean*
1. Large	13	58.4	9.3	33.9	4.49	0.72	2.61
2. Medium	20	10.5	2.6	6.6	0.53	0.13	0.51
3. Small	136	9.7	5.9	7.8	0.07	0.04	0.06
Total	169	78.6	17.8	48.3			
(MCM/yr)		41.5	9.4	25.4			

The spring water above is used for domestic or irrigation water supply by small pipeline or ditch systems. The existing system need rehabilitation as proposed in Figs. A-22 and A-23 and below:

(1) Improvement of intake facilities

- to install a distributing and regulating sump. The sump should be provided at the end or halfway of each pipeline to prevent water from spilling out.
- to repair damaged intake facilities

(2) Improvement of water conveyance facilities

- to replace open canals with pipelines to reduce water conveyance losses
- Damaged joints of existing pipelines should be repaired to prevent water from leaking.
- RC (reinforced concrete) pipes should be applied to new pipelines for saving costs.

(3) Improvement of irrigation: A wider area can be irrigated in a short time by an introduction of the proposed regulating sump. Irrigation should be made during night time to reduce evaporation losses.

7.5 Development Plan of Flood Flow

Since proposed dams on main wadis like Wala, Nukheila and Tannour are located at altitudes lower than 500 m, development of these flood flow for use on the Highlands will inevitably require a high pumping head of about 300 to 800 m. Therefore, this study was focused on small scale dams and weirs in upstream basins on the Highlands.

(1) Flood flow development plan in Mujib basin: Five new dams were studied and proposed in the JICA Mujib study for flood flow development in the whole Mujib basin.

(2) Qatrana Dam: An expansion plan of this dam has been proposed by the JICA Mujib study (Ref. A-4). The Qatrana Dam is located near the existing Qatrana well field. Flood flow retained in the reservoir is planned by them to be used for reinforcement of the existing well field and part of the proposed well field. By providing a desilting basin and three wells for injection and production, water of 1.8 MCM/yr can be

injected in the rainy season and 1.4 MCM can be recovered by pumping in the succeeding dry season. Such injection will also contribute to curing of existing wells.

<u>Qa El Hafira</u>: On the upper reaches of Wadi Hafira, there is flat land with swampy topography. This area will turn to a swamp after heavy rainfall. It is estimated by the JICA Mujib study that the outflow of Wadi Hafira will increase by about 2.2 MCM by improving drainage in Qa El Hafira. Of the increase, water of 1.8 MCM/yr will be recovered by pumping in the dry season if four new wells are provided and if the required flood storage capacity is added to the Qatrana Dam.

<u>Rehabilitation of the Qatrana Dam</u>: The present reservoir capacity is measured by WAJ in 1987 at 1.85 MCM, which was initially 2.0 MCM. It is proposed by the JICA Mujib study that the crest of the dam be raised by 3 m, and the spillway be extended to 136 m in its overflow crest length and be raised by 1.25 m in its crest elevation. In addition, dykes of 2 km long will be required to protect the Desert Highway from occasional floodings due to the raising of the design flood water level.

(3) <u>Sultani Dam</u> is located near the existing Sultani well field. The Sultani reservoir has been filled of its 72 per cent of the initial reservoir capacity (1.2 MCM) with slimes from El Abiad Phosphate Mine located upstream. It is proposed by the JICA Mujib study to remove the deposits of 0.9 MCM in volume to recover the original reservoir capacity. Combined with construction of tailings dams proposed in this study, water of 0.6 MCM/yr would be made available by digging two additional wells, although it will be costly.

(4) <u>Flood flow development in the upstream Hasa basin</u>: As shown in Table A-6, mean basin rainfall of this basin is as low as 89 mm/yr, and runoff has not been measured at all. According to a villager of Old Hasa, the old road bridge on Wadi Hasa was once almost reached by flood flow. Mean runoff of the upper Hasa basin is preliminarily estimated at around 1.6 MCM/yr on an average (Table A-6). Annual runoff records at Tannour (Table A-4) suggest that there may have been certain amount of

flow in such rich water years as 1970/71, 1971/72, 1974/75, 1979/80 to 1981/82, or simply six years out of 16 years (approximately every three years on an average).

Due to high evaporation and probable infiltration losses, it is not realistic to regulate these occasional and small amount of flood flow to constant flow through the year. Therefore, The flood flow of the upper Hasa basin could be utilized for groundwater recharge and watering for grazing livestock, or for environmental use being supported by groundwater in normal to dry years.

As a prospective damsite on the main river course from topographic and hydrologic viewpoints, a place on the main reaches at about 10 km downstream from the railway bridge was proposed by the Study Team. The riverbed elevation at this site is about 780 m AMSL. The drainage area is 1,588 km^2. The expected mean flood flow at this site is around 2.29 MCM/yr, and the expected yield at 1.8 MCM/yr (refer to Section 6 of Part 2 of the Main Report for details).

Drainage improvement works in Qa El Hasa: The catchment area of the whole Qa El Hasa is 1,019 km^2 and a mean basin rainfall is 89 mm/yr. According to a villager of Old Hasa, Qa El Hasa will impound water with a wide open water surface after heavy rainfall. As proposed for Qa El Hafira (1,310 km^2) by the JICA Mujib study, drainage improvement works would yield a considerable amount of water to downstream reaches. If the same runoff height with that of Qa El Hafira (1.7 mm/yr) is assumed, Qa El Hasa would yield about 1.7 MCM/yr. This water can be stored in the proposed Hasa Dam, and will compensate the decrease (1.8 MCM/yr) of the inflow to the Nukheila Dam due to construction of the Hasa Dam on the upper reaches.

(5) Flood flow development at Tannour on Wadi Hasa: Mean runoff at the Tannour damsite is estimated at 6.6 MCM/yr, and its coefficient of variance is 90 per cent. Mean annual effective yield of the Tannour dam was estimated at 2.1 MCM/yr (Ref. A-12).

(6) Karak Highlands Dam Project: The upper Wadi Karak basin has a high rainfall of about 360 mm/yr on an average. Since it has a mountainous topography, a high runoff coefficient is expected. But presently there is no data. The basin has a drainage area of 88 km^2 at Ain Sara Spring, and 41 km^2 at the Kaminna damsite near El Ifranji. The mean flood flow at this damsite is estimated at 1.06 MCM/yr.

In the upper Wadi Khabra basin of Wadi Mujib river system, small dam projects were proposed in this study for use of Highlands agriculture and groundwater recharge at altitudes of higher than 850 m AMSL as well as for reduction of sediment transport. The drainage area of the upper Khabra basin is 144 km^2 in total. Mean flood flow is preliminarily estimated to be 0.63 MCM/yr at Midden, and 0.76 MCM/yr at Lajjun damsites. The Midden Dam would decrease the inflow of the Khabra Dam by about 0.5 MCM/yr. The Lajjun Dam would decrease the inflow of the Nukheila Dam by about 0.6 MCM/yr (refer to Section 2 of Part 2 of the Main Report for details).

(7) East Tafila Highlands Dam Project: To the east of Tafila, there are a great number of places suitable for small dams or diversion weirs having drainages areas of 10 to 40 km^2 and a hilly topography (a good factor for higher runoff coefficient). Most of these are located in Wadi El La'ban (115 km^2 in drainage area), Wadi Zabda (115 km^2) and Wadi Ahmar (117 km^2) basins with some in adjacent basins. Total drainage area of the three sub-basins is 347 km^2. (refer to Section 2 of Part 2 of the Main Report for details).

Since there is no dam planned on the downstream reaches (the Tannour Dam has been proposed at an upstream point from the confluence of Wadi El La'ban with Wadi Hasa), this project will not affect the water use on the downstream reaches.

7.6 Development Plan of Phosphate Slimes

Slimes of the phosphate mines in the Study Area are discharge from a thickener, a kind of sediment settling basin for recycling use of phosphate washing water as illustrated in Fig. A-21. The slimes contain fine suspended particles of less than 0.05 mm in diameter. An ordinary type of settling basin could not be applied as it requires very low flow speed to settle such fine particles and periodical disposal of desilted solids that amount to around 1.5×10^6 t/yr in total.

An optimization study on the economic size of slimes reservoirs was made to have a conclusion that yearly construction of a pond with a surface area of 25 ha is the cheapest solution for El Hassa Phosphate Mine, and 15 ha for El Abiad (refer to Section 6 of Part 2 of the Main Report for details).

If the present production level of El Abiad and El Hassa Mines will be lowered in the future, these wastewater will also decrease along with the production decrease of groundwater for the Mines. Future users of the wastewater (a productive green park for example) will not suffer from water shortage, instead they can pump up fresh groundwater by themselves at a lower cost than the reuse of this wastewater.

7.7 Reuse of Municipal Wastewater

For utilizing municipal wastewater of about 5.8 MCM/yr by the year 2005, a sewerage system with treatment plants are to be provided for the strategic urban centres which have been proposed in the Master Plan. A draft allocation plan of these wastewater is presented in Table A-24.

7.8 Prospective Projects

Among the water resources development projects discussed in the preceding sections, the following are directly related with socioeconomic development of the Study Area:

(1) <u>Groundwater development and distribution projects</u>

- (A) Darawish Groundwater Development Project
- (B) Lajjun Groundwater Development Project
- (C) Lajjun-Karak Water Pipeline Project
- (D) Darawish-Tafila Water Pipeline Project
- (E) Darawish-Hasa Water Pipeline Project

(2) Flood flow development projects

(A) Karak Highlands Dam Project

(B) East Tafila Highlands Dam Project

(C) Desert Dam Development Project (Siwaqa, Dabba and Hasa)

(D) Drainage Improvement Project (Qa El Hafila and Qa El Hasa)

(3) Phosphate slimes reuse project (Hasa and Abiad)

7.9 Priority Projects

All of the water projects should be implemented by the year 2005 to meet the projected water demand as much as possible, although a water shortage of about 18.5 MCM/yr would still arise in the year 2005.

Priority projects in the water sector are selected with criteria that these should directly contribute to the region's development and be completed before 2000. The others are priority projects for the Southern Ghor and Greater Amman, or the long-term projects for the region. The priority projects are selected as follows:

(1) Karak and East Tafila Highlands Dam Projects as part of the Water Harvesting Development Project (see Section 2 of Part 2 of the Main Report)

(2) Lajjun-Karak Pipeline Project as part of the Karak Urban Development Project (see Section 4 of Part 2 of the Main Report)

(3) The following project as part of the Green Badia Project (see Section 6 of Part 2 of the Main Report):

- Darawish Groundwater Development Project
- Darawish-Hasa Water Pipeline Project
- Darawish-Tafila Water Pipeline Project
- Phosphate Slimes Reuse Project
- Hasa and Siwaqa Desert Dam Development Project

8. CONCLUSIONS AND RECOMMENDATIONS

(1) Conclusions: Most of the water demands in the Study Area by the year 2005 can be secured except that in the Southern Ghor. Owing to the minimized development of irrigated agriculture in the Highlands, the municipal water of about 29 MCM/yr could be allocated to Greater Amman Case 1 of the Alternative Water Allocation Plans. In this case, however, the Dead Sea Chemical Complex will have only the minor allocation of 2.25 MCM/yr.

The water resources potential in the region is assessed at 184.9 MCM/yr in total, while the water demand in the Mujib-Hasa basin is projected at 167.4 MCM/yr in the year 2005, including 14.0 MCM/yr for the Dead Sea Chemical Complex. In view of the limited water resources, the planning of the new irrigated agriculture is limited to the minimum. If the municipal demand of Greater Amman, which is simply assumed at 36 MCM/yr as the maximum possible sum of the sustainable yield of the candidate well fields and base flow, is included, the total demand will amount to 203.4 MCM/yr, and will exceed the potential by 18.5 MCM/yr.

(2) Recommendations: On the basis of the general concept that the domestic water should be supplied with the top priority as one of the basic human needs, the Study Team suggests to share a reasonable amount of the water resources to urban residents in Greater Amman.

For promoting the flood flow development for the Highlands agriculture, the Study Team proposes the establishment of a Watershed Development Fund. The Fund would be contributed, through extra fee for the drinking water, by the urban residents in Greater Amman who are getting less costly groundwater from the less developed region.

Under the same concept, it is also suggested to study the establishment of such a financial system for promoting the nationwide development of the flood flow resources that construction costs of dams be shared not only by beneficiaries of the dams but also by beneficiaries of the groundwater and base flow development.

It is recommended that all the water related projects be studied in detail for their implementation to reduce, as much as possible, the projected water shortage of 18.5 MCM/yr in the year 2005. In addition to these water resources development projects, efforts should be continued for promoting water saving measures and reuse of saline and brackish wastewater.

It is recommended that WAJ carry out, at the earliest stage, a detailed potential study to examine the development potential of the proposed well fields at Darawish and Lajjun, as well as to prepare basic and detailed designs for their development. Another study is required to clarify the possibility of recharging groundwater in the alluvial fans in the Southern Ghor with an excess base flow in the winter season. The efficient abstraction of the groundwater in these alluvial fans should also be sought through introduction of an infiltration gallery, an induce well and so forth.

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TABLES

Table A-1 LIST OF RAINFALL STATIONS (1/2)

Station Name	Station No.	Location Lat.(N)	Location Long.(E)	Location Alt.(ELm)	Equip-ment	Authority	Date of Establishment
Wadi Mujib Basin							
Sahab	CD1	31°52'	36°00'	830	M	School	10/1957
Muwaqqar	CD3	31°49'	36°05'	910	M	Police Post	2/1940
Beir Et-Tuneib	CD4	31°48'	35°56'	795	M	Irr.Expt.St.	10/1938
Jiza	CD5	31°42'	35°58'	705	M,T,R	Police Post	1/1938
Wadi Wala	CD6	31°33'	35°47'	350	M,R	Agr. St.	10/1954
Dhiban	CD7	31°30'	35°47'	745	M,R	School	1/1938
Hemud	CD9	31°18'	35°48'	890	M,T	School	10/1934
Rabba	CD10	31°16'	35°45'	970	M	Agr. St.	10/1951
Qatrana Police Post	CD11	31°15'	36°02'	770	M,T,R	Police Post	1/1938
Mazar	CD13	31°04'	35°42'	1,140	M,T,R	School	10/1934
Dhab'a Nursery	CD15	31°36'	36°03'	750	M,R	Forestry	11/1962
Judayda	CD16	31°32'	35°39'	725	M,T	School	11/1962
Um El-Risas	CD17	31°30'	35°55'	750	M	School	10/1962
Khan Ez-Zabeeb	CD18	31°28'	36°06'	775	M	Railway St.	11/1962
Jad'a	CD19	31°23'	35°45'	900	M	School	11/1962
Siwaqa Evap. St.	CD20	31°22'	36°06'	775	M,T,R	N.R.A.	11/1962
Qasr Evap. St.	CD23	31°19'	35°45'	900	M,T,R	Private Farm	5/1963
Yaduda Fahid Abu Jaber	CD24	31°51'	35°54'	850	M	School	10/1963
Um Al-Amad	CD25	31°47'	35°53'	800	M	N.R.A.	10/1963
Zeituna Evap. St.	CD26	31°45'	35°54'	765	M,T,R	N.R.A.	10/1968
Muleih	CD28	31°36'	35°49'	630	M	School	10/1967
Sirfa	CD29	31°20'	35°40'	900	M	School	10/1967
Jabel Abu Hallufa	CD30	31°21'	36°17'	950	T	N.R.A	
Wadi El-Jinz	CD31	31°04'	36°18'	825	T	N.R.A	
Um Al-Kindom	CD32	31°50'	35°53'	895	M	Private Farm	12/1968
Jabel Sakhriyat	CD33	30°49'	36°17'	910	T	N.R.A	
Qatrana Evap. St.	CD34	31°15'	36°03'	730	M,T,R	N.R.A	3/1970
D.S. Small Sub-Drainage Areas East Side							
Khanzira	CA2	31°03'	35°36'	1,000	M	School	9/1945
Aiy	CA4	31°08'	35°39'	900	M,R	School	5/1963
Al-Aina	CA5	30°58'	35°46'	775	M	Post Office	10/1967
Muhai	CA6	30°59'	35°51'	1,000	M	School	10/1967

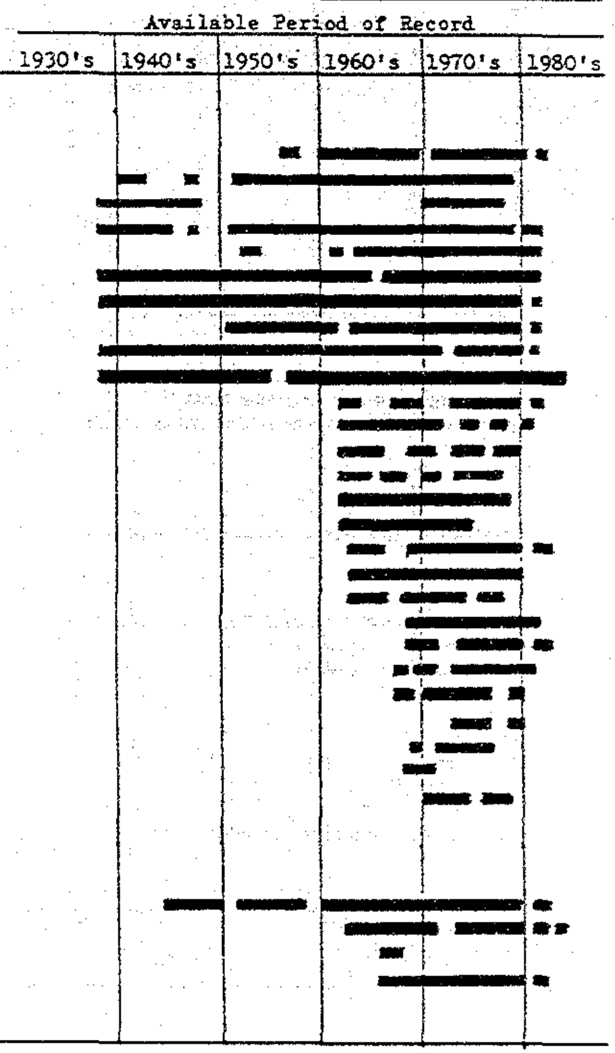

Table A-1 LIST OF RAINFALL STATIONS (2/2)

Station Name	Station No.	Location Lat.(N)	Location Long.(E)	Location Alt.(ELm)	Equip-ment	Authority	Date of Establishment	Available Period of Record 1930's	1940's	1950's	1960's	1970's	1980's
Wadi Hasa Basin													
Jurf Ed-Darawish	CF3	30°42'	35°52'	940	M,T,R	Railway Sta.	1/1938						
Hasa Police Post	CF5	30°49'	35°58'	825	M,T	Railway Sta.	11/1962						
Hasa Evap. Sta.	CF7	30°52'	35°59'	900	M,T,R	N.R.A	10/1967						
Hasa Gauging Sta.	CF8	30°58'	35°44'	380	M,R	N.R.A	10/1966						
Wadi Karak Basin													
Rakin	CE1	31°14'	35°42'	1,050	M	School	10/1958						
Ain Bisas	CE2	31°12'	35°40'	700	M,R	Forestry	10/1951						
Karak	CE4	31°11'	35°42'	1,000	M,R	School	1/1938						
Wadi Feefa Basin													
Tafila	DB1	30°50'	35°36'	1,000	M,T,R	School	1/1938						
Prince Hasan Nursery	DB2	30°48'	35°42'	1,220	M	Agr. Sta.	10/1967						
Wadi Khuneizeer Basin													
Buseira	DC1	30°45'	35°36'	1,100	M,R	School	12/1934						
Rashadiya	DC2	30°42'	35°38'	1,500	T,M,R	Police Post	10/1945						
Wadi Feedan Basin													
Dhana	DE1	30°41'	35°36'	1,230	M,R	School	9/1945						
Southeast Desert Basin													
Bayir Evap. Sta.	J1	30°46'	36°41'	902	M,R	N.R.A	10/1947						

Table A-2 LIST OF STREAM GAUGING STATIONS

St. No.	Station Name	River	Drain. Area (km^2)	El. (m)	Available Period of Data	Remarks
CD1	Karak road	Wadi Mujib	4,380	120	1963-1986	with control section
CD4	Karak road	Wadi Wala	1,800	440	1963-1986	at culvert bridge
	Weir site	Wadi Wala			1971-1986	with concrete weir
CD9	Siwaqa	Wadi Siwaqa	450	740	1963-1986	at bridge
CD8	Sultani dam	Wadi Sultani	990	820	-	in the reservoir
CF1	Tannour	Wadi Hasa	2,052[1/]	360	1968-1985	with concrete weir
CF2	Ghor Safi[2/]	Wadi Hasa	2,520	-300	1963-1983	

1/: 2,160 km^2 by Ref. A-12 Source: WAJ
2/: outside the study area

Table A-3 ANNUAL RAINFALL RECORDS (1/2)

Hydro Year	Jurf CF3	Rakin CE1	Bisas CE2	Karak CE4	Tafila DB1	Buse DC1	Rash. DC2	Dhana DE1	Bayir J1	Mean
37/38	102			408	354	408			23	
38/39	82			424	325	328			82	
39/40	-			522	327	358			48	
40/41	-			398	209	230			-	
41/42	-			541	306	401			-	
42/43	61			447	323	340			-	
43/44	90			403	346	327			-	
44/45	103			524	464	416			-	
45/46	53			358	324	274	264	344	-	
46/47	26			123	131	149	168	179	-	
47/48	-			293	267	249	244	263	5	
48/49	41			464	268	269	127	230	2	
49/50	142			280	380	358	352	360	38	
50/51	109			215	269	270	277	323	-	
51/52	57		455	500	304	293	263	402	223	
52/53	57		207	215	106	132	-	101	61	
53/54	36		290	360	301	311	288	310	53	
54/55	48		308	130	150	260	240	221	70	

Table A-3 ANNUAL RAINFALL RECORDS (2/2)

Hydro Year	Jurf CF3	Rakin CE1	Bisas CE2	Karak CE4	Tafila DB1	Buse DC1	Rash. DC2	Dhana DE1	Bayir J1	Mean
55/56	88		486	452	215	282	295	258	28	
56/57	116		-	414	263	346	339	282	34	
57/58	34		164	156	89	98	163	60	16	
58/59	43	239	283	282	84	264	286	281	16	198
59/60	48	85	147	145	87	161	136	126	8	105
60/61	32	251	333	273	204	237	244	188	42	200
61/62	79	221	225	210	136	217	211	133	58	166
62/63	51	99	115	102	84	84	93	56	77	85
63/64	55	490	498	496	617	577	638	580	32	443
64/65	99	557	643	661	751	730	485	520	41	499
65/66	67	257	275	321	167	162	-	163	67	185
66/67	59	386	372	438	343	336	350	277	82	294
67/68	64	364	357	387	282	315	100	283	33	243
68/69	49	309	336	359	295	214	150	302	21	226
69/70	43	267	232	291	132	125	103	121	17	148
70/71	46	376	314	357	257	253	252	269	-	266
71/72	75	532	588	606	439	-	215	-	-	409
72/73	11	150	166	187	82	124	150	102	-	122
73/74	57	-	509	509	403	285	302	357	67	311
74/75	65	316	337	364	339	285	311	313	78	268
75/76	30	207	180	202	139	125	-	135	50	134
76/77	30	217	202	256	244	226	224	-	22	178
77/78	53	271	243	302	169	156	180	187	24	176
78/79	37	274	232	326	189	253	197	271	23	200
79/80	89	486	478	619	367	424	241	360	78	349
S. Size	39	21	28	43	43	42	32	33	32	
Mean	62	303	321	359	268	277	246	253	47	237
S.D.	28	129	136	137	138	123	110	119	40	

Source: WAJ

Table A-4 ANNUAL RUNOFF RECORDS (1/2)

Year	Hasa at Tannour			Hasa at Safi			Wala at Karak R.		
	Base	Flood	Total	Base	Flood	Total	Base	Flood	Total
38/39				24	-				
39/40				26	-				
40/41				24	-				
62/63				25	4.7	29.7			
63/64				29.8	17.1	46.9	2.7*	9.8*	12.5*
64/65				26.2	-	26.2*	3.5	10.5*	14.0*
65/66				25.1	2.6	27.7	1.8	4.5	6.3
66/67				38.4	40.3	78.7	5.3	19.7	25.0
67/68				42.6	34.2	76.8	3.8	1.8	5.6
68/69	0.21	2.13	2.34	-	-	-	13.9*	20.5*	34.4*
69/70	0.26	0.22	0.48	-	-	-	1.2	1.3	2.5
70/71	0.98	12.16	13.14	-	-	-	4.0	48.1	52.1
71/72	2.33	7.00	9.33	-	-	-	3.5	23.1	26.6
72/73	0.57	1.56	2.13	26.4	1.7	28.1	2.1*	0*	2.1*
73/74	1.78	5.17	6.95	25.6	5.7	31.3	3.4	18.4	21.8
74/75	0.80	9.58	10.38	28.4	11.5	39.9	2.0	0	2.0
75/76	-	-	-	-	-	-	1.2	7.1	8.3
76/77	0.49	0.24	0.73	20.0	0.9	20.9	3.1	2.4	5.5
77/78	0.76	0.49	1.25	24.2	1.0	25.2	5.1	8.2	13.3
78/79	0.21	1.72	1.93	24.8	0.5	25.3	2.7	2.3	5.0
79/80	0.81	19.83	20.64	27.3	20.0	47.3	3.4	60.7	64.1
80/81	0.76	13.85	14.61	27.1	4.6	31.7	35.3*	50.2*	85.5*
81/82	2.22	10.56	12.78	30.0	6.9	36.9	27.3	33.2	60.5
82/83	1.24	3.58	4.82	28.9	3.0	31.9	16.5	22.4	38.9
83/84	0.47	0.21	0.68	-	-	-	25.5	2.6	28.1
84/85	0.86	2.98	3.84	-	-	-	10.2*	60.1*	70.3*
S.Size	16	16	16	17 1/	15	16	16	16	16 2/
Mean	0.92	5.71	6.63	26.0	10.3	37.8	3.7	11.1	14.8
S.D.	0.64	5.72	5.97	2.4	12.0	16.7	2.9	12.2	13.5
C.V.(%)	69	100	90	9	117	44	78	110	91

1/: Obtained excluding data of 66/67 and 67/68 to be conservative.
2/: Mean, standard deviation, etc. of Wala at Karak road are obtained based on the data from 63/64 to 78/79 to be conservative.

Table A-4 ANNUAL RUNOFF RECORDS (2/2)

Year	Wala at Weir Site			Mujib at Mujib			Siwaqa at Siwaqa		
	Base	Flood	Total	Base	Flood	Total	Base	Flood	Total
63/64							0	3.82	3.82
64/65							0	7.27	7.27
65/66				4.0*	1.6*	5.6*	0	0.69	0.69
66/67				8.3	32.6	40.9	0	4.45	4.45
67/68				7.0	10.5	17.5	0	3.23	3.23
68/69				4.7*	15.5*	20.2*	0	2.00	2.00
69/70				3.3	8.5	11.8	0	1.61	1.61
70/71				6.3	136.8	143.1	0	4.00	4.00
71/72	2.5*	23.5	26.0*	6.0*	29.3*	35.3*	0	3.42	3.42
72/73	2.6*	0.0	2.6*	4.9*	7.6*	12.5*	0	0.05	0.05
73/74	3.4	18.9	22.3	-	-	-	0	3.80	3.80
74/75	-	-	-	2.2*	22.1*	24.3*	0	1.23	1.23
75/76	1.2	7.1	8.3	-	-	-	0	1.75	1.75
76/77	0.6*	2.3*	2.9*	-	-	-	0	0	0
77/78	6.5	5.5	12.0	4.0	9.0	13.0	0	0.82	0.82
78/79	0.1	1.5	1.6	3.5*	0.5	4.0*	-	-	-
79/80	-	-	-	2.9*	16.5*	19.4*	0	10.01	10.01
80/81	0.3	41.8	42.1	2.1*	17.9*	20.0*	-	0.84	0.84*
81/82	3.0*	6.1*	9.1*	1.0	18.9	19.9	0*	0.85*	0.85*
82/83	4.7	33.8	38.5	2.9	0.7	3.6	0*	35.72*	35.72*
83/84	4.8	1.8	6.6	5.7*	0.0	5.7*	0	0	0
84/85	3.3*	20.2*	23.5*	9.5*	2.8*	12.3*	0	4.24	4.24
S.Size	12	12	12	17	17	17	20	20 1/	20
Mean	2.8	13.5	16.3	4.6	19.5	24.1	0	2.70	2.70
S.D.	1.9	13.3	13.4	2.2	30.9	31.4	0	2.51	2.51
C.V. (%)	69	99	82	48	159	130	-	93	93

1/: Data in 1982/1983 is excluded in estimating the long-term average.
Source: WAJ

Table A-5 RECORDED MEAN RUNOFF AT STREAM GAUGING STATIONS IN AND AROUND THE STUDY AREA

St. No.	Station Name	Drainage Area (km^2)	Mean Rainfall (mm/yr)	Mean Rainfall (MCM/yr)	Mean Base Flow (MCM/yr)	Mean Flood Flow (MCM/yr)	Total (MCM/yr)	Total (mm/yr)	Mean Runoff Coefficient (%)
CD1	Mujib at Karak road	4,380	149	651	4.6	19.5	24.1 (28.8)	5.5	3.7
CD4	Wala at Karak road	1,800	202	364	3.7	11.1	14.8 (21.2)	8.2	4.1
	Wala at weir site	1,800 1/	202	364	2.8	13.5	16.3	(9.1)	4.5
CD9	Siwaqa	450	130	58	0	2.7	2.7 (1.8)	6.0 2/	4.7 2/
CF1	Tannour on Hasa	2,052 3/	106	218	0.9	5.7	6.6 (7.0)	3.2	3.0
CF2	Ghor Safi 4/ on Hasa	2,520	119	284	27.6	10.3	37.8 5/ (41.2)	15.0 5/	13.3

Note: Figures in parentheses are estimates by NWMP.
1/: Assumed to be equal to one at CD4
2/: Considered to be slightly overestimated in comparison with other stations. In this study, it is estimated to be 2.0 MCM/yr or 4.4 mm/yr, resulting in runoff coefficient of 3.4 percent.

3/: 2,160 km^2 by Ref. A-12
4/: outside the study area
5/: inclusive discharge from deep aquifer
Source: Compiled by the Study Team based on the data of WAJ

Table A-6 PRELIMINARY ESTIMATES OF RAINFALL AND RUNOFF BY SUB-BASINS IN THE STUDY AREA

Sub-basin	Drain. Area (km^2)	Mean Rainfall (mm/yr)	Mean Rainfall (MCM/yr)	Mean Runoff (mm/yr)	Mean Runoff (MCM/yr)	Mean Runoff Coefficient (%)
Hasa Basin						
Upper Hasa	1,019	89	90	1.6	1.6	1.8 1/
Qallat	416	85	35	1.4	0.6 2/	1.8 1/
Tannour	617	151	93	7.1	4.4 2/	4.7
Sub-total at Tannour damsite	2,052	106	218	3.2	6.6 3/	3.0
Lower Tannour	329	201	66	94.8	31.2 2/	47.3
Sub-total at Safi on Hasa	2,381	119	284	15.0	37.8 4/	13.3
Wala-Mujib Basin						
Sultani	914	118	108	2.1	1.9 2/	1.8
Qatrana	1,525	85	129	1.5	2.3 2/	1.8
Khabra	290	237	69	12.1	3.5	5.1 5/
Nukheila	782	251	196	13.3	10.4	5.3 5/
Sub-total at Nukheila damsite	3,511	143	502	5.2	18.1	3.6 5/
Upper Siwaqa	450	130	58	4.4	2.0 2/	3.4 5/
Lower Siwaqa	419	169	71	9.5	4.0	5.6
Sub-total at K.R. on Mujib	4,380	144	631	5.5	24.1 3/	3.8
Lower Mujib	260	292	76	17.3	4.5 2/	5.9 5/
Rumeil	284	126	36	4.2	1.2	3.3 5/
Wala	83	216	18	9.6	0.8	4.7
Sub-total	627	207	130	10.4	6.5	5.0
Other Basins						
Jarra	112	191	21	8.0	0.9	4.3 5/
Karak and Hudeira	174	340	59	23.0	4.0	6.7 5/
Tafila	426	275	117	15.7	6.7	5.7 5/
Sub-total	712	277	197	16.3	11.6	5.9
Total/Mean	8,100	153	1,242	9.9	80.0	6.4

1/: After an estimate for the Qatrana basin
2/: Obtained as the balance
3/: Recorded value at gauging station
4/: Recorded value at Ghor Safi, including discharge from deep aquifer but neglecting discharge from sub-basin in the Ghor
5/: Read on Fig. A-5 with mean basin rainfall
Source: The Study Team

Table A-7 YEARLY MUNICIPAL WATER SUPPLY IN JORDAN

(MCM)

Governorate	Annual Water Supply		Growth Rate 1985-1986
	1985	1986	(%)
Capital & Zarqa	67.0	71.3	6.4
Irbid & Mafraq	26.9	37.1	28.4
Balqa	6.4	8.2	28.1
Karak & Tafila	4.4	5.5	25.0
Ma'an	9.1	12.5	37.4
Total	110.8	134.6	16.2

Source: WAJ

Table A-8 MONTHLY MUNICIPAL WATER SUPPLY IN JORDAN IN 1986

(MCM)

Month	Governorate								Total
	Amman	Zarqa	Irbid	Mafraq	Balqa	Karak	Tafila	Ma'an	
Jan	4.032	0.925	1.521	0.849	0.661	0.278	0.130	0.732	9.128
Feb	3.558	0.768	1.384	0.918	0.634	0.256	0.120	0.733	8.371
Mar	4.348	0.937	1.702	1.116	0.647	0.301	0.135	0.907	10.093
Apr	4.946	0.968	1.655	1.124	0.656	0.330	0.136	1.028	10.843
May	5.422	0.965	2.217	1.070	0.654	0.270	0.146	1.147	11.891
Jun	5.321	1.014	2.021	1.052	0.628	0.358	0.166	1.188	11.748
Jul	5.703	0.981	2.208	1.474	0.675	0.367	0.166	1.292	12.866
Aug	5.736	0.994	2.140	1.693	0.705	0.408	0.157	1.234	13.067
Sep	5.851	1.128	2.317	1.625	0.735	0.401	0.154	1.264	13.475
Oct	5.364	1.163	2.221	1.451	0.792	0.347	0.142	1.129	12.609
Nov	4.685	1.009	1.987	1.006	0.745	0.282	0.121	0.916	10.751
Dec	4.419	1.030	1.783	0.583	0.698	0.263	0.107	0.878	9.761
Total	59.385	11.882	23.156	13.961	8.230	3.861	1.680	12.448	134.60

Source: WAJ

Table A-9 NUMBER OF WATER TAP CONNECTIONS IN JORDAN

(1,000)

Governorate	Population in 1986	No. of Connections 1985	No. of Connections 1986	Growth Rate 1985-1986 (%)
Amman	1155.0	143.5	160.4	11.7
Zarqa	404.5	46.6	49.9	7.1
Irbid	680.2	72.2	80.7	11.8
Mafraq	98.6	14.1	15.1	7.1
Balqa	193.8	16.2	18.1	11.7
Karak	120.1	15.1	16.1	7.0
Tafila	41.4	6.2	6.4	3.2
Ma'an	97.5	18.2	18.4	1.1
Total	2791.1	332.1	365.4	10.0

Source: WAJ

Table A-10 GROUNDWATER PUMPED UP IN KARAK AND TAFILA GOVERNORATES IN 1985

(1,000 m^3)

Month	Water	Month	Water
January	309	July	428
February	249	August	470
March	290	September	437
April	306	October	400
May	383	November	361
June	420	December	320
		Total	4,373

Source: Annual Report, 1985, WAJ

Table A-11 DEEP WELLS IN THE STUDY AREA

Basin	Well Field	Nos. of Deep Well	Yield (m^3/hr)
Mujib	Siwaqa	19	1,302.0
	Wadi Wala	15	841.8
	Qatrana	16	1,352.3
	Abiad	9	604.5
	Other private	25	1,419.0
Sub-Total		84	5,519.6
Hasa		34	3,375.6
Total in the study area		118	8,895.2

Source: WAJ

Table A-12 COMPARISON OF ESTIMATED RUNOFF

Sub-basin	Drainage Area (km^2)	Estimated Runoff (MCM/yr)		
		Water Master Plan	Mujib Study	This Study
Wala Basin				
1. Wala	1,770	21.20	21.52	16.0 1/
Mujib Basin				
2. Siwaqa	440	1.84	1.32	2.0
3. Qatrana	1,640	0.42	2.28	2.3
4. Sultani	950	3.45	3.19	1.9
Sub-total	3,030	5.71	6.79	6.2
5. Khabra	290	4.82 2/	9.01	3.5
6. Nukheila	3,560	20.81 3/	26.15	18.1
Hasa Basin				
7. Hasa	1,019	-	-	1.6
8. Qallat	416	-	-	0.6
9. Tannour	2,052	7.0	-	6.6
Other Basins				
10. Jarra	112	2.3 4/	-	0.9
11. Karak & Hudeira	174	11.0 5/	-	4.0
12. Tafila	426	11.0 6/	-	6.7

1/: Estimated based on the G.S. at weir site on Wala as follows:

16.3 MCM/yr x (1,770 km^2 / 1,800 km^2) = 16.0 MCM/yr

2/: Not given. Simply estimated by drainage area ratio only for reference based on the data of sub-basin CD11 as follows:

23.08 MCM/yr x (290 km^2 / 1,390 km^2) = 4.8 MCM/yr

3/: With data of CD11, CD52 and CD82:

23.08 MCM/yr x (1,390 - 270) km^2 / 1,390 km^2

+ 0.42 MCM/yr + 3.45 MCM/yr = 20.8 MCM/yr

4/: With data of CA3: 5.10 MCM/yr x (112 km^2 / 249 km^2) = 2.3 MCM/yr

5/: With data of CE & CA4:

(18.17 + 14.37) MCM/yr x 174 KM^2 / (190 + 323) km^2 = 11.0 MCM/yr

6/: With data of DB, DC1, DD, DA25 and DE:

(11.16 + 4.18 + 0.34 + 0.14 + 5.42) MCM/yr x 426 km^2

/ (161 + 183 + 96 + 100 + 280) km^2 = 11.0 MCM/yr

Table A-13 PRELIMINARY ESTIMATES OF RUNOFF AT REPRESENTATIVE DAMSITES AND PLACES

No.	Name of Dam	Drainage Area (km^2)	Riverbed Elevation (m AMSL)	Annual Rainfall (mm)	Annual Rainfall (MCM)	Natural Runoff (MCM)	Runoff Coeffi. (%)
Wala Basin							
1.	Wala	1,770	484	202	358	16.0	4.5
Mujib Basin							
2.	Siwaqa	440	723	130	58	2.0	3.4
3.	Qatrana	1,640	770 *	85	129	2.3	1.8
4.	Sultani	950	819	118	108	1.9	1.8
5.	Khabra	290	660 *	237	69	3.5	5.1
6.	Nukheila	3,560	179	143	502	18.1	3.6
Hasa Basin							
7.	Upper Hasa	1,019	805 *	89	90	1.6	1.8
8.	Qallat	416	805 *	85	35	0.6	1.8
9.	Tannour	2,052	360	106	218	6.6	3.0

* means that the elevation is approximately read on a map of 1:50,000.
Source: The Study Team

Table A-14 PRESENT GROUNDWATER PRODUCTION AND POTENTIAL IN THE STUDY AREA

(MCM/yr)

Basin (1)	No. (2)	Well Field (3)	Owner (4)	Purpose (5)	Nos. of Well (6)	Yield (7)	Present Production (8)	Balance (7)-(8) (9)	Total Potential (10)	New Develop. Potential (11)
Wala	(1)	Wala	private	irrigation	29	2	2	0	2	-
Mujib	(2)	Siwaqa-Qatrana	WAJ	MWS to Amman	19	9	17	-8	14	5
	(3)	Qatrana	WAJ	irrigation	3	1	1	0	1	-
	(4)	Ghuweir		MWS to Karak	3	0.3	0.3	0	0.3	-
	(5)	Sultani	WAJ	MWS to Karak	3	3	1.4	1.6	3	-
	(6)	Abiad	WAJ	phosphate	6	3.5	2.8	0.7	3.5	-
	(7)	New Sultani*		-	-	-	-	-	4.0	4.0
	(8)	Lajjun*	WAJ	oil shale	6	-	-	-	5	5
		Mujib sub-total			34	16.8	22.5	-5.7	30.8	14.0
Hasa	(9)	Hasa	WAJ	phosphate	10	6.5	6.9	-0.4	6.5	-
	(10)	Darawish*	WAJ	cement	2	0.6	0.4	0.2	6.9	5.5
			private	irrigation	9	0.8	0.5	0.3	-	-
		Hasa sub-total			21	7.9	7.8	0.1	13.4	5.5
Total					84	26.7	32.3	-5.6	46.2	19.5

Note: (1) MWS means municipal water supply.
(2) Irrigation purpose includes local domestic supply.
(3) * shows potential well field.
(4) New development potential Column (11) = (10) - (7)

Source: Hasa basin by the JICA study team, Wala and Mujib basin by the JICA Mujib study (Ref. A-4)

Table A-15 COMPARISON OF ESTIMATES OF GROUNDWATER POTENTIALS

(MCM/yr)

Basin	Basin No. 1/	NWMP Ref. A-2	SJWCSS Ref. A-5	Mujib Study Ref. A-4	This Study
Wala	5.3	13	-	30 2/	15.0 3/
Mujib	5.4	10.5	8.7	35.4	30.8 3/
Hasa	5.8.1	10 4/	13	-	13.4

1/: after NWMP
2/: including the right bank of the Wala basin (21 MCM/yr, WAJ), which is outside the Study Area
3/: estimates by WAJ and the Study Team
4/: including discharge from deep aquifer. Annual groundwater recharge is estimated at 14 MCM/yr, and available resources including discharge from deep aquifer at 20 MCM/yr respectively.

Table A-16 COMPARISON OF ESTIMATED PER CAPITA MUNICIPAL WATER DEMAND

(lcd)

Locality	This study			JICA Mujib Study (Ref. A-4)			WAJ South Jordan (Ref. A-5)		
	1985	1995	2005	1985	1995	2005	1985	1990	2005
Karak	100	127	160 1/	92	110	124	100	105	125
Tafila	100	127	160	92	110	124	100	105	125
Mu'tah/Mazar 2/	70	105	160	86	97	110	70	75	95
Hasa 2/	70	105	160	86	97	110	70	75	95
Towns with 3,000 or more	70	90	115 3/	86	97	110	70	75	95
Communities with 3,000 or below	55	74	100	59	73	86	55	60	80

1/ 160 lcd imply the one after completion of sewerage systems and introduction of solar-heated hot water system.
2/ Mu'tah/Mazar and Hasa area are growth points of the Study Area. It is assumed, therefore, that both area will be provided with sewerage systems by the year of 2005.
3/: including 20 lcd for home garden project on top of WAJ South Jordan estimates

Table A-17 PROJECTED MUNICIPAL WATER DEMAND

(MCM/yr)

Sub-region		1985	1995	2005
Karak Governorate				
Karak	Karak	0.53	0.92	1.79
	Others	0.47	0.79	1.37
	Sub-total	1.00	1.71	3.17
Qasr	Qasr	0.37	0.63	1.08
Mazar	Mazar	0.13	0.25	0.68
	Mu'tah	0.09	0.18	0.48
	Others	0.37	0.62	1.07
	Sub-total	0.58	1.04	2.23
Ayy	Ayy	0.13	0.21	0.37
	Others	0.11	0.18	0.32
	Sub-total	0.24	0.40	0.69
Desert	Desert	0.06	0.09	0.20
Karak Total		2.24	3.87	7.36
Tafila Governorate				
Tafila	Tafila	0.54	0.93	1.82
	Others	0.19	0.32	0.56
	Sub-total	0.73	1.25	2.37
Bsaira	Bsaira	0.09	0.14	0.25
	Others	0.10	0.17	0.29
	Sub-total	0.19	0.31	0.54
Hasa	Hasa	0.10	0.18	1.40
	Others	0.01	0.02	0.04
	Sub-total	0.11	0.21	1.44
Tafila Total		1.04	1.77	4.36
Amman Governorate				
	Dhiban	0.08	0.13	0.23
	Others	0.12	0.20	0.35
Amman Total		0.20	0.33	0.58
Grand Total		3.48	5.97	12.30

Note: In accordance with the Population Scenario 3 of the Master Plan
Source: The Study Team

Table A-18 PROJECTED INDUSTRIAL WATER DEMAND IN THE STUDY AREA

(m^3/day)

Project	-1990	-1995	-2000	-2005
Mu'tah Industrial Estate ($0.6-1.0$ m^3/day/worker x workers)	0	840 1,400	1,500- 2,500	1,500- 2,500
New Karak Industrial Zone (1 m^3/day workshop x 270 + Others)	300	300	300	300
Old Karak Handicraft Center (0.2 m^3/day/worker x 40 workers + 0.05 m^3/day/visitor x 300 visitors + miscellaneous)	0	30	30	30
Outer Tafila Industrial Estate ($0.6-1.0$ m^3/day/worker x workers)	0	300- 500	600- 1,000	600- 1,000
Tafila Industrial Zone (1 m3/day workshop x 270 + Others)	300	300	300	300
Tafila Handicraft Center (0.2 m^3day/worker x 20 workers + 0.05 m^3/day/visitor x 150 visitors + miscellaneous)	0	15	15	15
Industrial Estate along Desert Highway (50 m^3/day ha x Area or 1 m^3/day worker x workers)	0	0	1,500	3,000
Sub-total	600	1,785- 2,545	4,245- 5,645	5,745- 7,145
Other small/medium industrial development (1 m^3/worker)	250	500	1,000	1,500
Total increase	850	2,285- 3,045	5,245- 6,645	7,245- 8,645

Source: The Study Team (see Annex-D for details)

Table A-19 PROJECTED WATER DEMAND IN THE MUJIB-HASA BASIN

(MCM/yr)

No.	Water Use	1985	1995	2005	Remarks
1.	**Municipal**				
1.1	Karak Governorate	2.70 1/	3.87	7.36	Scenario 3
1.2	Tafila Governorate	1.16 1/	1.77	4.36	Scenario 3
1.3	Dhiban area	0.20 1/	0.33	0.58	Scenario 3
1.4	Ghor Safi area	0.60 1/	0.70	0.81	Ref.A-5, p.3-21
1.5	To Greater Amman	15.00	36.00	36.00	2/
	Municipal sub-total	19.66	42.67	49.11	
2.	**Irrigation & livestock**				
2.1	Exist. groundwater irri.	22.5	22.8	22.8	3/
2.2	Exist. spring irrigation	12.5	12.5	12.5	4/
2.3	New irrigation projects	-	5.0	5.0	
2.4	Livestock farming	-	0.9	1.8	5/
2.5	Southern Ghor				
	(1) Stage I	37.6	37.6	37.6	6/
	(2) Stage II	-	23.5	23.5	
	Irrigation sub-total	72.6	102.3	103.2	
3.	**Industry**				
3.1	Phosphate	10.0 1/	11.0	11.0	7/
3.2	Cement	0.6 1/	0.6	0.6	
3.3	Industrial complex in Karak, Tafila & Hasa	0	1.0	2.9	Scenario 3
3.4	Oil shale at Lajjun	0	0.8 8/	5.0	
3.5	Oil shale at Sultani	-	-	2.0	
3.6	Potash	6.7 1/	10.0	12.0	9/
3.7	Dead Sea Chemical Complex	0	14.0	14.0	
	Industry sub-total	17.3	37.4	47.5	
4.	**Environment**				
4.1	Greenbelt	0	0.6	0.6	
4.2	Water park and green park	0	1.8	3.0	10/
	Environment sub-total	0	2.4	3.6	
	Total	109.56	184.77	203.41	

Source: Integrated by the Study Team

1/: WAJ's data given in the Water Sector Committee's comments on the Progress Report

2/: Preliminarily assumed as a possible maximum sum of the safe yield of existing and prospective well fields, and prospective surface flow resources as follows:

Qastal well field	2.0
Siwaqa-Qatrana well field	15.0
New Sultani well field	4.0
Wala base flow	15.0
Total	36.0 MCM/yr

3/:

Wala basin	:	21.0 (WAJ, as of 1986)
Mujib basin	:	1.0
Hasa basin - Tel Burma	:	0.5 --> 0.8

4/: Consisting of 7.5 MCM/yr in the Study Area and 5.0 MCM/yr along Wadi Wala in its north bank

5/: Presently included in the irrigation use

6/: Ref. A-12, p.81

7/: El Abiad mine 3.5 MCM/yr and El Hassa mine 7.5 MCM/yr

8/: For pilot plant of 5,000 barrel/day

9/: Company's information. Unit water requirement of 5.0 m^3 per ton of potash and target potash production of 2.5 x 10^6 ton/y in 2000.

10/: Only fresh water requirement. Desilted slime water of 2.1 MCM/yr would additionally be required.

Table A-20 WATER RESOURCES IN THE MUJIB-HASA BASIN

(MCM/yr)

No.	Basin	Place	Water Resources Potential: Base Flow	Flood Flow	Ground Water	Total	Source
1.	**Wala**	- confluence	23.0				
		- weir site G.S.		13.5			
		- private well			13.0		JICA Mujib
		- Qastal well (WAJ)			2.0		JICA Mujib
	Wala sub-total		<u>23.0</u>	<u>13.5</u>	<u>15.0</u>	<u>51.5</u>	
2.	**Mujib**	- confluence	12.0				
		- Mujib G.S.		19.5			
		- Qa El Hafila		2.2			JICA Mujib
		- Siwaqa-Qatrana well			15.0		WAJ
		- Sultani well for Karak			3.0		+ 1.6
		- New Sultani well			4.0		6.3-1.6-0.7
		- Abiad well			3.5		+ 0.7
		- Ghuweir well			0.3		WAJ
		- Lajjun well			5.0		JICA Mujib
	Mujib sub-total		<u>12.0</u>	<u>21.7</u>	<u>30.8</u>	<u>64.5</u>	
3.	**Hasa**	- Ghor Safi	26.0				
		- Tannour		6.6			
		- Qa El Hasa		1.7			2.2 x 1019 /1310 km^2
		- Hasa well			6.5		
		- Darawish well			6.9		
	Hasa sub-total		<u>26.0</u>	<u>8.3</u>	<u>13.4</u>	<u>47.7</u>	
4.	**Ghor**						
		- Ibn Hammad (Ain Maghara)	9.3				Ref. A-12
		- Ain Sikkein	2.0				Ref. A-12
		- Wadi Karak	4.2				Ref. A-12
		- Dhira	1.4				Ref. A-12
		- Isal	0.9				Ref. A-12
		- Numeira(Hudeira)	0.8				Ref. A-5
		- Feifa	3.2				Ref. A-12
		- Khanzeira	1.4				Ref. A-12
		- Alluvial fans in Southern Ghor			11.5		WAJ
	Ghor sub-total		<u>23.2</u>	-	<u>11.5</u>	<u>34.7</u>	
	Grand Total		84.2	43.5	70.7	198.4	

Source: Integrated by the Study Team

Table A-21 WATER RESOURCES DEVELOPMENT POTENTIAL IN THE MUJIB-HASA BASIN

(MCM/yr)

No.	Basin	Place	Water Resources Potential: Base Flow	Flood Flow	Ground Water	Total	Source/ Remarks
1.	**Wala**	- confluence	19.5				15 % loss
		- Wala dam		10.8			13.5 x 80 %
		- private well			13.0		JICA Mujib
		- Qastal well (WAJ)			2.0		JICA Mujib
	Wala sub-total		19.5	10.8	15.0	45.3	
2.	**Mujib**	- confluence	10.2				15 % loss
		- Qatrana dam		2.0			WAJ
		- Sultani dam		0.3			WAJ
		- **Siwaqa dam**		0.6			JICA Mujib
		- **Khabra dam**		2.2			JICA Mujib-0.5
		- **Nukheila etc. dam**		11.7 1/			WAJ
		- **Karak Highland dams**		1.1			
		- Siwaqa-Qatrana well			15.0		WAJ
		- Sultani well for Karak			3.0		+1.6
		- **New Sultani well**			4.0		6.3-1.6-0.7
		- Abiad well			3.5		+0.7
		- Ghuweir well			0.3		WAJ
		- Lajjun well			5.0		JICA Mujib
	Mujib sub-total		10.2	17.9	30.8	58.9	
3.	**Hasa**	- Ghor Safi	26.0				no loss
		- **Tannour**		2.1			Ref. A-12
		- **Hasa dam**		1.8			
		- **Tafila Highland dams**		0.6			
		- **Hasa well**			6.5		
		- **Darawish well**			6.9		
	Hasa sub-total		26.0	4.5	13.4	43.9	
4.	**Ghor**	- Ibn Hammad 2/	9.3				Ref. A-12
		- Ain Sikkein	2.0				Ref. A-12
		- Wadi Karak	4.2				Ref. A-12
		- Dhira	1.4				Ref. A-12
		- Isal	0.9				Ref. A-12
		- Numeira(Hudeira)	0.8				Ref. A-5
		- Feifa	3.2				Ref. A-12
		- Khanzeira	1.4				Ref. A-12
		- Alluvial fans			11.5		WAJ
	Ghor sub-total		23.2	-	11.5	34.7	
5.	**Transfer from Ma'an**		-	-	2.1	2.1	Ref. A-5
	Grand Total		78.9	33.2	72.8	184.9	

Note: Dams and well fields in **bold face** are proposed ones either in this study or previously, while the others are existing although some of them need a reinforcement in number of wells.

1/: 19.5 MCM/yr x 80 % - (1.1 + 2.2 + 0.6)   2/: Ain Maghara

Table A-22 ALTERNATIVE FRESH WATER ALLOCATION PLANS FOR THE MUJIB-HASA BASIN IN 2005

(MCM/yr)

No.	Water Use	Demand in 2005	Water Allocation Plan			
			Case 1 Highland	Case 2 Amman	Case 3 Ghor	Case 4 Potash
1.	**Municipal**					
1.1	Local demand	13.11	13.11	13.11	13.11	13.11
1.2	To Greater Amman	36.00	**29.0**	36.0	**24.0**	**17.0**
	Municipal sub-total	49.11	42.11	49.11	37.11	30.11
2.	**Irrigation & livestock**					
2.1	Exist. groundwater irri.	22.8	22.8	22.8	22.8	22.8
2.2	Exist. spring irrigation	12.5	12.5	12.5	12.5	12.5
2.3	New irrigation projects	5.0 1/	5.0	5.0	5.0	5.0
2.4	Livestock farming	1.8	1.8	1.8	1.8	1.8
2.5	Southern Ghor					
	(1) Stage I	37.6	37.6	37.6	37.6	37.6
	(2) Stage II	23.5	23.5	**16.5**	23.5	23.5
	Irrigation sub-total	103.2	103.2	96.2	103.2	103.2
3.	**Industry**					
3.1	Phosphate	11.0	11.0	11.0	11.0	11.0
3.2	Cement	0.6	0.6	0.6	0.6	0.6
3.3	Industrial complex in Karak, Tafila & Hasa	2.9	2.9	2.9	2.9	2.9
3.4	Oil shale at Lajjun	5.0	5.0	5.0	5.0	5.0
3.5	Oil shale at Sultani	2.0	2.0	2.0	2.0	2.0
3.6	Potash	12.0	12.0	12.0	12.0	12.0
3.7	Dead Sea Chemical Complex	14.0 2/	**2.25**	**2.25**	**7.0**	14.0
	Industry sub-total	47.5	35.75	35.75	40.5	47.5
4.	**Environment** (Greenbelt, water park and green park)	3.6	3.6	3.6	3.6	3.6
	Total	203.41	**184.66**	**184.66**	**184.41**	**184.41**

1/: In view of the expected severe water shortage, the original estimate of 24 to 37 MCM/yr was decreased to a practical level.

2/: Provided by the Water Sector Committee in its comments on the Draft Final Report, while the figure of 2.25 MCM/yr was provided by APC in March 1987 (see Section 5.6).

Note: (1) Water resources development potential is 184.9 MCM/yr.
(2) Figures in boldface shows partial allocation to the demand.

Source: The Study Team and the Water Sector Committee

Table A-23 DRAFT ALLOCATION PLAN BY SOURCE OF WATER FOR THE MUJIB-HASA BASIN IN 2005 (1/4)

(MCM/yr)

No.	Water Use	Allocation in 2005	Base flow		Flood Flow		Ground Water		Total
			Source	Amount	Source	Amount	Source	Amount	
1.	Municipal								
1.1	Karak network	7.36	W. Karak (Ain Sara)	1.0			Sultani Ghuweir Lajjun	3.0 0.3 3.06	
	Karak sub-total	7.36		1.0		0		6.36	7.36
1.2	Tafila network	4.36					Nijil Darawish	2.1 2.26	
	Tafila sub-total	4.36		0		0		4.36	4.36
1.3	Dhiban area	0.58	W. Wala	0.58		0		0.	0.58
1.4	Ghor Safi area	0.81		0		0	Alluvial fans	0.81	0.81
1.5	To Greater Amman	29.00	W. Wala	11.0			Qastal Siwaqa-Qat. New Sultani	2.0 14.0 2.0	
	Greater Amman Sub-total	29.00		11.0		0		18.0	29.00
	Municipal sub-total	42.11		12.58		0		29.53	42.11
2.	Irrigation & livestock								
2.1	Exist. groundwater irri.								
	- Wala basin	21.0					Wala private	21.0	over production
	- Mujib basin	1.0					Qatrana	1.0	
	- Hasa basin	0.8					Darawish	0.8	
	sub-total	22.8		0		0		22.8	14.8

Table A-23 DRAFT ALLOCATION PLAN BY SOURCE OF WATER FOR THE MUJIB-HASA BASIN IN 2005 (2/4)

(MCM/yr)

No.	Water Use	Allocation in 2005	Base flow		Flood Flow		Ground Water		Total
			Source	Amount	Source	Amount	Source	Amount	
2.2	New irrigation projects	5.0	W. Karak	0.9	Siwaqa dam	0.6			
	and livestock farming	1.8	at Ain Sara		Qatrana dam	2.0			
					Sultani dam	0.3			
					Karak H.dam	1.1			
					Tafila H.dam	0.6			
					Dabba dam	0.3			
					Nukheila dam	1.0			
	New irri. sub-total	6.8		0.9		5.9		0	6.8
2.3	Exist. spring irrigation	12.5	Springs	7.5	Wala dam	5.0		0	12.5
2.4	Livestock farming (included in item 2.2)								
2.5	Southern Ghor		W. Hasa	26.0	Nukheila dam	4.38	Alluvial	10.69	
	- Stage I	37.6	Ibn Hammad	9.3	Wala dam	5.8	fans		
	- Stage II	23.5	Ain Sikkein	2.0					
			W. Karak	2.3					
			Dhira	1.4					
			Isal	0.9					
			Numeira	0.8					
			Feifa	3.2					
			Khanzeira	1.4					
			W. Wala	7.92					
			W. Mujib	1.51					
			less spring	-7.5	(see item 2.3)				
			less Wala	-8.0	(compensation for over production by private wells)				
			less Wala	-1.0	(compensation for over production in Hasa well field)				
	Southern Ghor sub-total	61.1		40.23		10.18		10.69	61.1
	Irrigation sub-total	103.2		48.63		21.08		33.49	103.2

Table A-23 DRAFT ALLOCATION PLAN BY SOURCE OF WATER FOR THE MUJIB-HASA BASIN IN 2005 (3/4)

(MCM/yr)

No.	Water Use	Allocation in 2005	Base flow Source	Base flow Amount	Flood Flow Source	Flood Flow Amount	Ground Water Source	Ground Water Amount	Total
3.	Industry								
3.1	Phosphate	11.0					Abiad Hasa	3.5 7.5	over production
	Phosphate sub-total	11.0		0		0		11.0	11.0
3.2	Cement	0.6		0		0	Darawish	0.6	0.6
3.3	Potash	12.0	W. Mujib	8.59	Nukheila dam Tannour dam	1.31 2.1			
	Potash sub-total	12.0		8.59		3.41		0	12.0
3.4	Industrial complex in Karak, Tafila & Hasa	2.9		0		0	Darawish Darawish Lajjun	0.4 1.0 1.5	(Tafila) (Hasa) (Karak)
	Complex sub-total	2.9		0		0		2.9	2.9
3.5	Oil shale at Lajjun	5.0		0	Khabra dam Dabba dam	2.2 2.36	Lajjun	0.44	
	Oil shale sub-total	5.0		0		4.56		0.44	5.0
3.6	Oil shale at Sultani	2.0		0		0	New Sultani	2.0	2.0
3.7	Dead Sea Chemical Complex	2.25		0	Nukheila dam	2.25		0	2.25
	Industry sub-total	35.75		8.59		10.22		16.94	35.75

Table A-23 DRAFT ALLOCATION PLAN BY SOURCE OF WATER FOR THE MUJIB-HASA BASIN IN 2005 (4/4)

(MCM/yr)

No.	Water Use	Allocation in 2005	Base flow		Flood Flow		Ground Water		Total
			Source	Amount	Source	Amount	Source	Amount	
4.	Environment (Greenbelt, water park, and productive green park)	3.6		0	Hasa dam	1.8	Darawish	1.8	
	Environment sub-total	3.6		0		1.8		1.8	3.6
Water resources		184.9		78.9		33.2		72.8	184.9
Total allocation		184.66		69.8		33.1		81.76	184.86
Unallocated resources		0.24		9.1 1/		0.1 2/		-8.96 3/	0.24

Source: The Study Team

1/: Decrease of base flow due to over production (9.0 MCM/yr) + Unallocated Mujib base flow (0.1 MCM/yr)

2/: Unallocated flood flow of Nukheila, Dabba, etc. dams (0.1 MCM/yr)

3/: Unallocated groundwater of Darawish (0.04 MCM/yr) - Over production (9.0 MCM/yr)

Over production 9.0 MCM/yr = 8 MCM/yr by the private irrigation in the north bank of Wadi Wala + 1 MCM/yr by El Hassa Phosphate Mine in the Hasa well field

Table A-24 DRAFT ALLOCATION PLAN OF WASTEWATER IN 2005

(MCM/yr)

No.	Source of Wastewater	Available Water	Water Use	Allocated Water
1.	Effluent of El Abiad Phosphate Mine (TDS 1,800 ppm)	1.1	- Productive green and greenbelt	1.1
2.	Effluent of El Hassa Phosphate Mine (TDS 3,600 ppm)	2.2	- Water park - Golf course	0.2 2.0
3.	Wastewater of Karak, Mu'tah and Mazar Cities	2.8	- Wadi Karak irrigation	2.8
4.	Wastewater of Tafila City	1.5	- Productive green	1.5
5.	Wastewater of Hasa City	1.5	- Productive green	1.5
	Total	9.1		9.1

Source: The Study Team

Table A-25 LIST OF SPRINGS IN THE STUDY AREA (1/6)

Ser. No.	ID No.	Name	Location	Palest. Grid North	Palest. Grid East	Lat. (N)	Long. (E)	Discharge (lit/min) Max.	Discharge (lit/min) Min.	Discharge (lit/min) Mean	Altitude (m)	P_H	Salinity (ppm)
1	DE40	Seil Eluixa	Dana	010.2	208.7	304100	353650	37.19	24.41	30.71	1330	7.65	320 B
2	DE41	Seil Asfal	Dana	009.8	208.6	304040	353645	17.87	15.80	16.84	1300	7.55	410 C
3	DE42	Zubei diya	Dana	010.5	208.3	304050	353635	5.04	3.05	4.04	1210	7.60	448 C
4	DE43	Khalid	Dana	010.5	209.3	304050	353635	5.62	5.05	5.34	1140	7.70	608 C
5	DB20	Dawara	Dawara	025.7	205.4	304920	353430	2.59	1.98	2.28	1040	7.80	307 C
6	DB21	Mawardeh/Tehta	Tafila	027.0	205.9	305000	353505	4.26	4.25	4.26	900	7.80	352 C
7	DB21A	Mawardeh/Feuqa	Tafila	026.9	205.9	305002	353506	1.40	1.40	1.40	900	7.75	403 C
8	DB22	El-Balad	Sinifha	028.0	204.1	305030	353530	2.59	1.37	2.11	1000	7.50	384 C
9	DB23	El-Hasdeh	Sinifha	028.8	204.1	305055	353400	4.79	2.41	3.60	1020	7.70	269 C
10	DB24	El-Beidah	Sinifha	027.0	205.6	305000	353455	5.05	3.74	4.35	1020	7.90	392 C
11	DB30	Unser	Sinifha	027.7	207.7	305030	353615	22.75	2.77	7.13	1000	8.4	294 A
12	DB31	Shalha	Sinifha	027.9	207.5	305030	353600	13.20	4.25	6.80	900	7.5	320 A
13	DB32	Um-Qaryah	Sinifha	027.9	208.5	305025	353640	24.34	2.50	8.62	995	7.65	275 A
14	DB33	El-Jaheer	Sinifha	027.1	208.6	305000	353650	6.88	5.54	6.30	1080	7.75	416 C
15	DB34	El-Beida	Sinifha	027.9	209.1	305030	353700	28.80	0.36	5.90	960	8.05	256 A
16	DB35	Um-Keis	Sinifha	028.3	206.5	305030	353645	11.34	3.53	7.53	980	7.5	301 B
17	DB36	El-Had	Sinifha	028.6	208.4	305050	353640	17.86	1.80	7.30	990	7.55	307 B
18	DB37	El-Faraheed	Sinifha	027.9	208.6	305025	353530	2.60	2.59	2.60	850	7.65	416 C
19	DB38	Arajan	Tafila	027.8	208.6	305025	353545	3.53	1.80	2.74	1000	7.8	269 C
20	DB39	Jarrar	Tafila	028.1	208.8	305035	353655	7.06	1.19	3.41	940	7.5	275 C
21	DB40A	Zibleh	Tafila	028.0	205.2	305030	353440	0.54	0.19	0.31	940	7.8	294 C
22	DB42	Um-Es-Sa'id	Tafila	028.0	208.9	305105	353750	5.04	1.42	3.17	1000	7.68	435 C
23	DB47	El-Babeur	Tafila	029.6	209.8	305015	353700	1.08	0.51	0.80	1030	7.40	416 C
24	DB48	Abil	Tafila	023.95	207.38	304850	353540	8.07	0.36	2.30	1200	7.75	262 C
25	DB51	Farab	Aima	032.8	213.7	305303	353540	3.05	3.05	3.05	885	7.55	416 C
26	DB52	Safih	Aima	032.0	210.0	305245	353645	6.17	3.06	4.95	970	7.90	403 C
27	DB53	Karma	Idba'a	032.0	210.0	305420	353540	2.60	1.26	1.86	870	7.40	416 C
28	DB54	Um-Kamata	Idba'a	032.0	210.0	305420	353540	3.05	1.98	2.54	870	7.90	416 C
29	DB55	Marwaa	Idba'a	032.2	213.7	305420	353540	2.60	1.40	1.99	850	7.50	464 C
30	DB56	Hammamat Afra	Afra	042.55	209.2	305750	353700	997.0	273.0	635.0	570	7.35	384 A

Table A-25 LIST OF SPRINGS IN THE STUDY AREA (2/6)

Ser. No.	ID No.	Name	Location	Palest. Grid North	Palest. Grid East	Lat. (N)	Long. (E)	Discharge (lit/min) Max.	Discharge (lit/min) Min.	Discharge (lit/min) Mean	Altitude (m)	P_H	Salinity (ppm)
31	CA52A	El-Mansheyyeh	Imra'a	087.2	210.4	312230	353800	0.38	0.38	0.38	530	7.25	755 C
32	CA53	Ezzarra'ah	Imra'a	087.2	211.9	312230	353900	3.05	1.08	2.06	630	8.15	1248 C
33	CAA20	Yarut	Yarut	080.6	217.3	311850	354205	9.97	3.64	7.55	530	7.47	365 A
34	CAA21	El-Juheibeh	Yarut	080.4	215.0	311845	304055	16.34	4.00	9.76	550	7.7	307 C
35	CAA22	El-Fara'a	W Ibn Hammad	078.3	218.9	311745	354130	204.0	56.88	100.87	640	8.05	414 B
36	CAB20	Um-Khasheibeh	Jauza	064.2	212.0	311030	353950	7.20	4.29	5.74	780	7.8	793 C
37	CAB21	Shargeyyah	Jauza	063.0	212.0	310930	353900	1.98	0.90	1.56	830	8.1	358 C
38	CAB22	Ikfaifeh	Jauza	064.1	212.6	311000	353935	1.44	1.08	1.26	700	7.65	499 C
39	CAB26	Al-Sharoub	Jauza	063.1	209.5	310930	353740	0.77	0.43	0.60	390	7.50	960 C
40	CAB27	Lebaleyyeh	Jauza	063.8	210.5	310950	353800	3.52	2.88	3.20	690	7.65	704 C
41	CAB28	Idliboat	Jauza	063.8	208.8	310050	353650	1.08	0.65	0.86	570	7.80	780 C
42	CAB29	Bazzazeh	Jauza	063.8	208.8	310950	353650	0.14	0.14	0.14	640	7.70	750 C
43	CAB30	Judeia	Jauza	063.9	209.8	310955	353735	4.42	2.59	3.50	590	7.90	716 C
44	CAB31	Ezgharah	Jauza	060.0	210.2	310755	353850	1.98	1.42	1.61	830	7.7	1472 C
45	CAB32	Faza'a	Jauza	063.9	209.8	310755	353735	0.77	0.42	0.62	880	7.90	704 C
46	CAB33	Isdeir	Jauza	061.6	210.7	310830	353810	1.08	0.54	0.81	670	7.80	819 C
47	CAB34	Aia El-Balad	Aia	060.7	211.1	310800	353830	7.06	6.16	6.61	885	8.0	358 C
48	CAB35	Sufsafah	Aia	061.3	211.1	310830	353830	5.04	2.60	3.58	985	7.50	304 C
49	CAB36	Al-Jaheir	Aia	061.3	211.1	310830	353830	3.05	2.59	2.82	590	8.0	320 C
50	CAB37	Um El-Tawaqi	Aia	060.0	211.1	310755	353830	3.53	3.53	3.53	920	7.6	318 C
51	CAB38	Al-Beida	Aia	061.3	210.6	310830	353810	18.40	4.25	8.18	740	7.6	461 C
52	CAB39	Ithwaibeyyah	Aia	061.0	210.3	310820	353800	7.98	5.04	6.51	740	7.15	614 C
53	CAB40	Ammal	Aia	059.5	211.1	310735	353830	5.62	3.52	4.57	880	8.3	429 C
54	CAB41	Algam	Aia	062.0	209.3	310855	353725	1.44	0.79	1.12	890	7.65	387 C
55	CAB42	Faraj	Aia	058.6	210.9	310700	353830	0.38	0.38	0.38	1100	6.60	332 C
56	CAB43	Um Aimar	Aia	059.5	211.8	310830	353955	1.40	0.77	1.08	880	7.60	742 C
57	CAB44	Hamdouneh	Aia	059.6	210.5	310830	353815	1.08	0.38	0.73	870	7.78	582 C
58	CAB45	Kathrabba	Kathrabba	060.8	209.1	310815	353715	4.32	2.05	3.68	820	7.36	384 C
59	CAB46	Isdeir	Kathrabba	061.1	209.1	310815	353710	1.98	0.72	1.35	790	8.80	544 C
60	CAB47	Atin	Kathrabba	061.8	208.0	310840	353625	0.38	0.16	0.27	700	7.65	493 C

Table A-25 LIST OF SPRINGS IN THE STUDY AREA (3/6)

Ser. No.	ID No.	Name	Location	Palest. Grid North	Palest. Grid East	Lat. (N)	Long. (E)	Discharge (lit/min) Max.	Discharge (lit/min) Min.	Discharge (lit/min) Mean	Altitude (m)	P_H	Salinity (ppm)
61	CAB48	Eddukhn	Kathrabba	062.3	209.8	310905	353730	5.62	4.25	4.94	510	7.75	877 C
62	CAB49	Dhanab Thour	Kathrabba	061.8	209.2	310850	353730	4.25	4.25	4.25	700	7.3	525 C
63	CAB49A	Nahz-Dhanab Thour	Kathrabba	062.0	209.6	310855	353730	4.25	1.08	2.66	600	7.4	1088 C
64	CAB50	Irsaid	Kathrabba	062.4	207.5	310905	353650	1.40	0.97	1.18	830	7.96	704 C
65	CAB51	El-Kharrubeh	Kathrabba	061.9	208.3	310855	353640	2.29	1.00	1.64	670	7.6	502 C
66	CAB52	Um-Qweiq	Kathrabba	061.8	209.2	310850	353720	0.47	0.43	0.45	650	7.8	1101 C
67	CAB53	Fadduleh	Kathrabba	062.2	209.3	310900	353730	5.04	3.60	4.32	600	7.2	1114 C
68	CAB54	Ghazawah	Kathrabba	063.0	210.9	310930	353750	1.42	1.04	1.23	560	8.0	710 C
69	CAB55	Tuweireq	Kathrabba	063.8	210.6	310955	353810	1.06	1.06	1.06	475	8.2	720 C
70	CAC20	Huwala	Kathrabba	059.0	201.0	310720	353655	1.80	1.80	1.80	860	7.75	697 C
71	CAC21	Um El-Rakham	Kathrabba	058.7	208.8	310705	353655	0.29	0.25	0.27	800	7.55	480 C
72	CAC23	Eshjeir	Kathrabba	058.5	208.9	310700	353710	1.08	0.61	0.84	970	7.75	384 C
73	CAC24	El-Qala	Iraq	055.4	209.2	310520	353810	32.47	9.29	16.41	785	7.4	464 B
74	CAC25	Tara'in	Iraq	055.2	210.6	310515	353825	20.9	2.59	6.59	825	7.7	640 B
75	CAC26	Mugheisel	Iraq	055.2	211.0	310515	353825	12.8	1.40	7.48	810	8.02	384 B
76	CAC27	Fawwarah	Iraq	055.1	211.0	310510	353820	3.53	3.05	3.29	845	7.3	691 C
77	CAC27	El-Balad	Iraq	058.0	209.0	310640	353710	6.59	6.59	6.59	825	7.65	364 C
78	CAC28	Abu Andeileh	Iraq	055.8	211.0	310530	353825	1.42	1.08	1.25	875	8.0	454 C
79	CAC28A	El-Baqqa	Iraq	055.9	211.0	310535	353825	3.42	2.62	3.02	880	8.4	416 C
80	CAC36	El-Amoud	Iraq	055.0	210.5	310505	353805	5.05	1.98	3.66	750	7.25	512 C
81	CAC31	El-Asi	Iraq	053.8	211.0	310405	353820	19.40	5.62	12.34		8.12	320 C
82	CAC33A	El-Beida	Iraq	053.2	211.0	310405	353825	4.14	3.06	3.60	880	7.5	352 C
83	CAC33C	Beida El-Wadi	Iraq	053.2	211.0	310405	353825	5.04	1.98	3.51	780	7.3	365 C
84	CAC33D	Es-Sadd	Iraq	054.4	210.8	310445	353810	5.04	3.06	4.05	790	7.1	493 C
85	CAC34	Fugaigees	Iraq	053.7	211.2	310425	353830	2.05	1.58	1.81	840	7.35	410 C
86	CAC35	El-Jafrat	Iraq	055.8	210.9	310525	353820	(0.77)	(0.77)	(0.77)	850	7.85	819 C
87	CAC38	El-Maqbiya	Iraq	055.3	211.0	310515	353825	6.59	6.16	6.38	830	7.65	352 C
88	CAC40	Ain W. Edleibat	Khnneizerq	052.2	209.7	310340	353725	0.54	0.25	0.38	940	7.8	461 C
89	CAC44	Habil	Khnneizirq	053.2	206.6	310410	353535	1.08	0.65	0.86	910	7.65	1075C

Table A-25 LIST OF SPRINGS IN THE STUDY AREA (4/6)

Ser. No.	ID No.	Name	Location	Palest. Grid North	Palest. Grid East	Lat. (N)	Long. (E)	Discharge (lit/min) Max.	Discharge (lit/min) Min.	Discharge (lit/min) Mean	Altitude (m)	P_H	Salinity (ppm)
90	CAC45	In'aileh	Khnneizirq	052.8	206.3	310355	353525	1.08	1.08	1.08	935	7.75	544 C
91	CAC46	Es-Sadd	Khnneizirq	053.3	206.0	310420	353510	3.06	2.60	2.83	780	7.1	1101 C
92	CAC47	Beit Salem	Khnneizirq	053.2	209.0	210335	353705	2.60	2.59	2.63	850	7.92	435 C
93	CAC48	Ajami	Khuneizerah	052.2	208.0	310335	353625	4.79	0.65	2.72	900	7.15	435 C
94	CAC49	El-Maqir	Khuneizerah	052.8	209.8	310255	353730	(0.77)	(0.77)	(0.77)	920	7.80	550 C
95	CAC50	Esdeir	Khuneizerah	052.9	209.9	310250	353740	(5.05)	(5.05)	(5.05)	915	7.45	352 C
96	CAC51	El-Besas	Khuneizerah	051.1	207.7	310300	353620	(0.77)	(0.77)	(0.77)	925	7.40	640 C
97	CAC52	El-Anid	Khuneizerah	051.6	207.2	310320	353600	1.98	1.26	1.62	770	7.72	1114 C
98	CAC53	El-Khashabeh	Khuneizerah	051.0	207.9	310555	353730	1.98	1.40	1.69	970	8.10	403 C
99	CAC54	Suraqa	Khuneizerah	050.5	209.6	310245	353720	3.52	3.06	3.29	975	8.30	294 C
100	CAC55	Wadi El-Ain	Khuneizerah	051.1	209.6	310300	353725	2.60	1.40	2.00	925	7.85	454 C
101	CAC56	Es-Sarab	Khuneizerah	052.1	208.3	310320	353645	1.40	0.65	1.02	975	7.90	313 C
102	CAC57	El-Muzrab	Khuneizerah	056.6	207.3	310320	353615	1.01	0.79	0.90	980	7.78	352 C
103	CE20	Sarah	Karak	067.3	216.3	311130	354145	2059.6	200.16	649.78	725	8.1	371 A
104	CE21	Kadhabeh	Karak	066.7	216.3	311125	354140	1.98	0.11	1.18	710	7.3	400 C
105	CE22	Deek	Karak	066.2	216.2	311110	354140	5.05	2.92	3.98	740	7.85	371 C
106	CE23	Safaafah/Fenqa	Karak	065.6	216.4	311050	354145	23.10	2.81	11.94	770	7.5	403 B
107	CE23A	Safafah/Fehta	Karak	065.7	216.4	311055	354145	10.30	10.30	10.30	760	7.5	403 C
108	CE24	El Balad	Infranj	064.7	215.3	311015	354105	4.75	4.25	4.50	960	7.5	294 C
109	CE25	Fah-Hebiya	Karak	064.7	216.0	311025	354130	144.0	3.62	30.78	810	8.7	320 A
110	CE26	Awwad	Karak	065.9	216.3	311100	354140	0.40	0.38	0.39	800	7.7	320 C
111	CE27	Basas	Karak	067.4	215.6	311150	354120	4.50	1.01	2.73	710	7.75	371 C
112	CE27A	Abdul Wahhab Tarama	Karak	067.6	215.8	311155	354115	0.65	0.54	0.60	690	7.8	448 C
113	CE28	Sad El-Habees	Karak	067.7	216.8	311200	354200	5.62	1.98	3.95	720	7.7	512 C
114	CE29	Khalaf/Sawadha	Karak	066.8	216.1	311130	354130	9.29	0.50	3.01	740	7.5	416 C
115	CE30	Issa Ayubi	Karak	066.4	216.2	311115	354140	2.59	1.98	2.18	725	7.95	339 C
116	CE31	Daeud	Karak	062.0	207.1	310400	353600	7.99	0.77	3.78	760	7.67	474 C
117	CE32	Sahour Tahta	Karak	067.2	213.9	311145	354010	2.60	2.59	2.60	740	7.4	883 C
118	CE33	Sahour Wasta	Karak	067.3	213.9	311145	354010	6.16	1.40	2.99	740	7.4	326 C

Table A-25 LIST OF SPRINGS IN THE STUDY AREA (5/6)

Ser. No.	ID No.	Name	Location	Palest. Grid North	Palest. Grid East	Lat. (N)	Long. (E)	Discharge (lit/min) Max.	Discharge (lit/min) Min.	Discharge (lit/min) Mean	Altitude (m)	P_H	Salinity (ppm)
119	CE34	Sahour Feuqa	Karak	067.3	214.0	311140	354010	2.38	1.08	1.81	745	7.65	294 C
120	CE39	Ghazzal .	Badhan	069.9	213.2	311310	353940	6.48	1.08	4.50	350	7.5	768 C
121	CE40	Abdallah	Badhan	069.7	213.3	311305	353950	5.60	1.58	3.05	?	7.4	832 C
122	CE41	Kashif	Badhan	069.1	213.4	311245	353950	7.06	1.51	3.24	525	7.65	576 B
123	CE42	Abdel-Bahia	Badhan	069.8	213.3	311310	353945	8.64	1.15	5.09	400	7.8	678 B
124	CE43	Es-Zughna	Badhan	070.3	213.4	311325	354000	9.29	0	3.5	500	7.8	1536 B
125	CE45	Sedeir	Badhan	069.1	214.8	311210	354050	12.8	7.06	10.34	540	7.20	544 C
126	CE46	Abdel-Hamid	Badhan	069.9	213.2	311310	353945	7.06	7.06	7.06	560	7.40	576 C
127	CE47	Abu-Karak	Badhan	071.4	212.8	311400	353930	1.98	1.42	1.70	370	7.7	1664 C
128	CE49	El-Beek	Badhan	068.2	216.2	311114	354140	2.48	0.36	1.67	740	7.7	592 C
129	CE50	Hajrah	Eh.Um Haj	068.8	213.2	311230	353950	6.48	5.60	6.04	570	7.8	704 C
130	CE52	Shallatel/Hamid	Abiad	068.0	213.4	312110	353950	5.05	3.42	4.24	700	7.8	883 A
131	CE53	Da Jama'am	Abiad	069.3	212.4	311245	353915	10.30	2.59	5.62	700	8.0	358 A
132	CE55	Sakka/El Wasta	Abiad	068.6	212.7	311225	353925	10.30	1.08	4.76	725	7.95	384 B
133	CE57	El-Beida	Abiad	069.6	212.6	311300	353920	15.80	3.06	8.17	670	8.1	473 A
134	CE58	Bardayyeh	Abei Mumya	070.0	212.2	311315	?	15.12	1.40	5.59	?	7.4	563 A
135	CE61	Abu-Hallag	Abei Mumya	068.3	210.5	311320	353800	0.77	0.40	0.58	700	7.43	576 C
136	CE62	Qahwa	Abei Mumya	071.1	210.6	311350	353805	1.40	1.40	1.40	870	7.40	530 C
137	CE63	Shureitat/Feuqa	Moomya	070.7	212.1	311335	353905	2.38	1.08	1.65	500	8.2	448 C
138	CE63	Shureitat/Tehta	Moomya	070.0	210.5	311335	353905	1.40	1.07	1.24	820	7.9	896 C
139	CE64	Moomya (No.1)	Moomya	070.7	212.5	311335	353915	34.38	6.77	16.41	425	7.55	467 B
140	CE65	Moomya (Shamalleyya)	Moomya	070.6	212.8	311330	353930	39.23	5.04	21.82	300	7.3	467 B
141	CE66	Kathabeh	Moomya	070.7	212.4	311335	353915	28.70	0.0	12.50	430	7.9	471 B
142	CE67	Audat-Allah	Moomya	071.2	211.2	311350	353830	1.22	0.32	0.77	790	7.65	992 C
143	CD30	Lajjun	Lajjun	072.1	232.2	311420	355140	62.40	25.99	43.95	680	7.5	640 A
144	CD32	Mustawiyya	Faqq'an	086.2	216.4	312245	354150	15.12	9.61	12.36	910	7.7	514 C
145	CD35	Um-Ma'ual	Faqq'an	090.3	214.6	312410	354045	1.98	1.08	1.49	575	7.65	960 C
146	CF20	Irhab	Irhab	035.5	211.0	305435	353710	10.30	7.20	8.75	1180	8.1	358 C
147	CF22	Qastal	Irhab	036.9	210.5	305510	353705	0.80	0.65	0.72	1190	7.9	518 C

Table A-25 LIST OF SPRINGS IN THE STUDY AREA (6/6)

Ser. No.	ID No.	Name	Location	Palest. Grid North	Palest. Grid East	Lat. (N)	Long. (E)	Discharge (lit/min) Max.	Discharge (lit/min) Min.	Discharge (lit/min) Mean	Altitude (m)	P_H	Salinity (ppm)
148	CF23	El-Beida	Irhab	036.4	210.5	305500	353700	0.32	0.16	0.24	1180	7.95	576 C
149	CF30	Bir El-Harir	Tafila-Jurf	020.6	210.4	304645	354015	62.28	28.01	40.16	1300	8.1	314 B
150	CF32	El-Aweel	W. Hasa	038.8	211.2	305620	354455	19.12	8.62	13.87	510	8.09	429 C
151	CF33	Abu Shattal/Feuqa	W. Hasa	040.5	219.3	305720	354330	9.28	8.64	8.96	580	8.25	672 C
152	CF34	Mesrab	Kh. Khereub	030.8	216.2	305150	354135	4.79	4.79	4.79	960	8.15	326 C
153	CF35	Al-Qleib	W. Hasa	037.8	220.8	305540	354430	4.00	4.00	4.00	650	7.90	397 C
154	CF45	Jouzeh	Khawseira	049.1	208.8	310155	353655	0.50	0.40	0.45	1000	8.10	352 C
155	CF50	Mugheisel/Kabeira	Aina	042.6	224.3	305810	354630	93.40	28.76	60.0	770	7.75	320 A
156	CF51	Yahoudiyya/Kabeira	Aina	042.5	224.6	305810	354645	24.41	8.64	17.11	825	7.75	352 A
157	CF51A	Yahoudiyya	Aina	042.4	224.7	305810	354645	9.86	0.83	3.35	850	7.9	345 B
158	CF52	Iflat	Aina	042.0	224.3	305800	354630	36.50	4.04	15.79	670	8.3	333 B
159	CF53	Mesalla Feaqa	Aina	041.8	224.2	305750	354630	12.35	4.29	2.16	640	7.85	512 B
160	CF54	Mesalla Tehta	Aina	041.7	224.1	305750	354630	13.90	2.09	6.77	630	8.0	493 B
161	CF55	Irteija	Aina	041.8	224.1	305750	354630	1.30	0.79	1.02	530	8.0	544 C
162	CF56	Mawasi	Aina	042.0	223.3	305800	354610	2.60	2.60	2.60	640	7.8	336 C
163	CF57	Abu Shatlal	Aina	042.0	223.3	305800	354610	9.28	8.64	8.96	640	8.25	672 C
164	CD21	Museimir/Feuqa	W. Mujib	094.7	227.6	312630	354835	1.98	1.08	1.59	125	7.3	2368 C
165	CD21A	Museimir/Vasta	W. Mujib	095.2	227.3	312650	354840	1.08	1.08	1.08	120	7.4	2111 C
166	CD21B	Museimir/Tehta	W. Mujib	096.3	226.4	312720	354815	1.08	0.77	0.92	180	7.7	2225 C
167	CD22	Imram	Mathleutheh	096.0	219.3	312730	354340	11.34	11.34	11.34	180	7.62	1036 C
168	CD23	Aymat West	Mathleutheh	096.6	219.6	312730	354350	11.67	11.67	11.67	200	7.35	896 C
169	CD24	Aymat Beat	Mathleuthen	096.4	219.8	312735	354400	12.79	12.79	12.79	200	7.88	832 C

Source: National Water Master Plan, 1977

Table A-26 JICECO'S ESTIMATE OF WATER REQUIREMENTS OF DEAD SEA CHEMICAL COMPLEX

	Products/ Scheme	Water (MCM/yr)
1.	Phosphate calcination	3.00
2.	Oil sand	5.00
3.	Potassium sulphate, sodium sulphate	2.00
4.	Potassium nitrate	0.60
5.	Magnesium sulphate	0.20
6.	Magnesium oxide (precipitation-pyrolysis)	2.00
7.	Sodium carbonate (soda ash), potassium carbonate	5.00
8.	Bromine	0.60
	Chlorine	0.70
9.	Bromine derivatives	4.00
10.	Chlorine derivatives	4.00
11.	Phosphoric acid	4.00
12.	Fluosilicates	0.50
13.	Compound fertilizers	0.50
14.	Sodium tripoly phosphate	0.50
15.	Diacalcium phosphate	0.20
16.	Silica - lime bricks (Cm)	0.20
17.	Steam and power plant	5.00
18.	Non industrial purposes	2.00
	Total	40.00

Source: JICECO, Ref. A-14

F I G U R E S

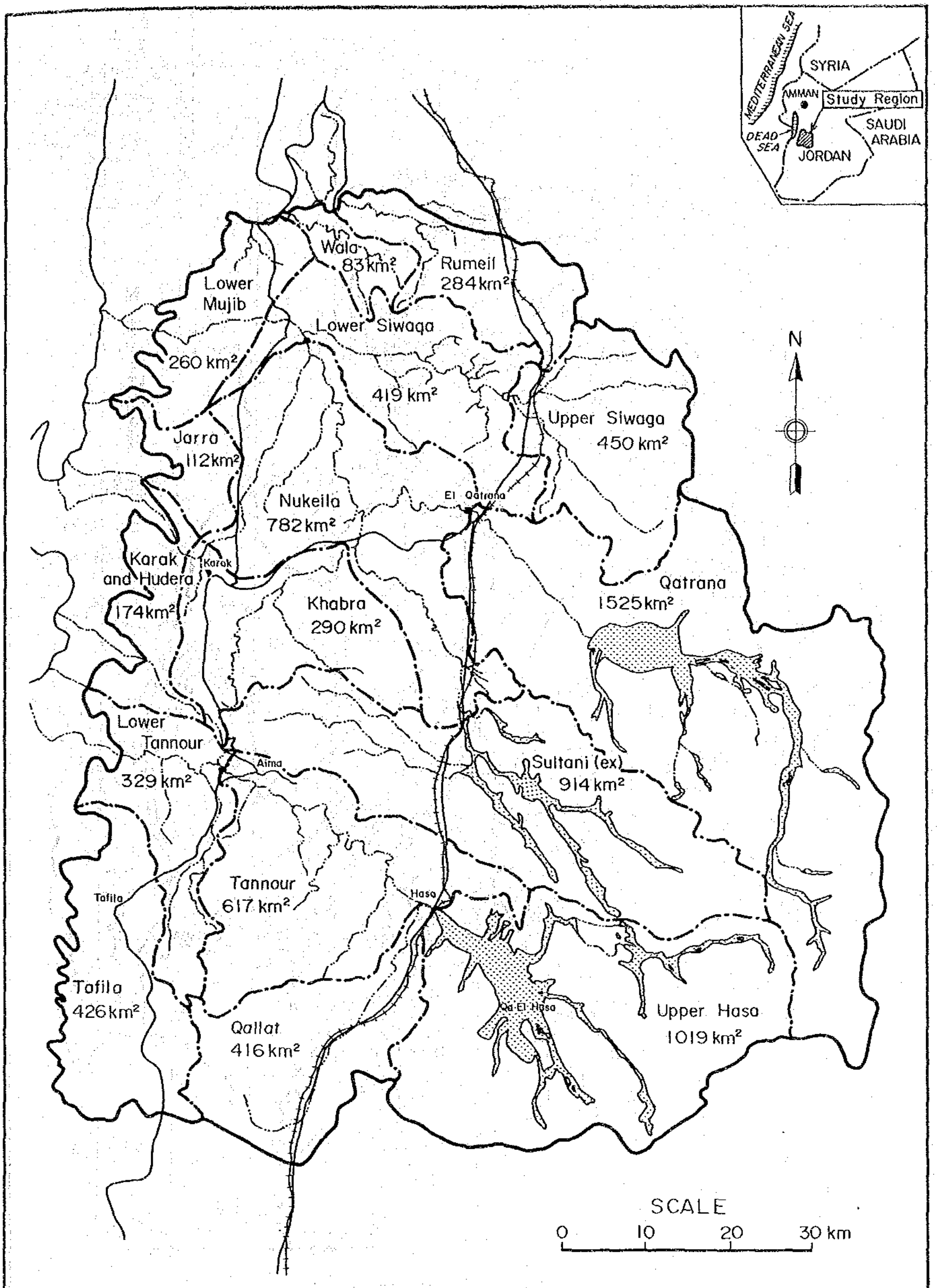

Fig. A-1 Sub-basins in the Study Area

THE HASHEMITE KINGDOM OF JORDAN
THE STUDY ON INTEGRATED REGIONAL DEVELOPMENT MASTER PLAN FOR THE KARAK - TAFILA DEVELOPMENT REGION

JAPAN INTERNATIONAL COOPERATION AGENCY