Distr.
GENERAL
E/ESCWA/ENR/1992/6
13 April 1992
ORIGINAL: ENGLISH

UNITED NATIONS

ECONOMIC AND SOCIAL COUNCIL

ECONOMIC AND SOCIAL COMMISSION
FOR WESTERN ASIA

Energy and Natural Resources Division

WATER RESOURCES DATABASE IN THE ESCWA REGION

United Nations

92-0160

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ABBREVIATIONS

BCM	Billion cubic metres
GW	Ground water
km^2	Square kilometres
km^3	Cubic kilometres
m	Metres
m^3/s	Cubic metres per second
mm	Millimetres
mm/a	Millimetres per annum
MCM	Million cubic metres
MCM/a	Million cubic metres per annum
mgd	Million gallons per day
MSF	Multi-stage-flash
Q	Rate of discharge
ppm	Parts per million
RO	Reverse osmosis
SW	Surface water
TDS	Total dissolved solids
ESCWA	Economic and Social Commission for Western Asia
FAO	Food and Agriculture Organization
UNWC	United Nations Water Conference
UAE	United Arab Emirates
WMO	World Meteorological Organization

Foreword

This document comprises output (b) of programme element 1.1, entitled "Updating data on water and other natural resources in the region", from the programme of work for the biennium 1990-1991. Because this report was prepared during ESCWA's repatriation period, the scope of the output was reduced to cover only "Water resources database in the ESCWA region". The Economic and Social Commission for Western Asia (ESCWA) acknowledges the valuable assistance of Mr. Jean Khouri, who served as consultant during the preparation of this study.

INTRODUCTION

The United Nations Water Conference (UNWC) (1977), in recommendation A of the Mar del Plata Action Plan, stressed the importance of acquiring more information about the quantity and quality of water resources in order to improve their management and conservation. It stated that the "regular and systematic collection of hydrometeorological, hydrological and hydrogeological data needs to be promoted and be accomplished by a system for processing quantitative and qualitative information for various types of water bodies."

One of the main requirements for efficient water-resources planning, management and allocation, as well as for more reliable research, is the availability of adequate and accurate water data which is relevant over the long term. In many countries of the ESCWA region, the available water-sector data is insufficient, and sometimes lacks the consistency and continuity required to facilitate the establishment of a national comprehensive water database for planning and management purposes. In some countries of the region, programmes designed to measure basic data from relevant observational stations, as well as to collect, process, store and periodically disseminate these data, have been undertaken in recent years. Plans to strengthen and update the existing observational networks are also being considered in most countries of the region. However, the lack of coordination and of access to reliable water data with long-term relevance is a common phenomenon in most of the concerned government institutions in the region, due to the inavailability of a comprehensive national water-resources database, or to the restrictive nature of such data (in compliance with the internal policies of some member countries).

The establishment of national water databases may facilitate the development of a regional water database, the main objectives of which are:

(a) To minimize wasted and scattered efforts in searching for, obtaining, and checking the availability, reliability and adequacy of water data;

(b) To develop and maintain a relatively simple, operational system for the improvement, updating and continuous monitoring of water data presently available;

(c) To define future data collection, compilation and processing needs;

(d) To enhance and facilitate research and the efficient planning, development and management of water resources.

The study was undertaken in two phases. This report comprises the outcome of the first phase, implemented during the biennium 1990-1991. It presents important time-independent data, such as regional hydrological and hydrogeological set-ups and shared water resources (surface- and ground-water units and systems). In addition, regional time-dependent information and data on water-resources supply and demand (surface and ground water, rainfall rates, etc.) and water networks are tabulated to the extent possible.

Equal emphasis has been given here to surface- and ground-water systems. Some practical aspects are explored in the sections on water-resources availability, occurrence and quality. The paragraphs pertaining to observation networks give an indication of the accuracy, reliability and adequacy of available data and information on water resources. Current information on regional water systems is also presented. The water systems of the Mashrek subregion (countries of the eastern Mediterranean) are described first, followed by those of the Arabian Peninsula subregion; the water resources of countries situated upstream are thus described before those of countries located downstream. Such an approach allows for a better understanding of the systems as they move on a downward gradient, from source to sink. The last chapter includes time-series data on rainfall, surface and ground water, water balances and water structures, as well as information on water-monitoring systems, for some countries of the ESCWA region.

I. CLIMATE AND PHYSIOGRAPHY

A. Climate

The ESCWA region is characterized by a generally arid climate; the southern part is extremely arid. Higher precipitation occurs in coastal mountain ranges and in the extreme north and north-east (the Touroz-Zagros mountain range). The belt of relatively high rainfall extends southwards into the Upper Jezira area (figure I) of the Syrian Arab Republic and Iraq. Further south, however, precipitation decreases sharply, producing a semi-arid belt over the Syrian Steppe, or Badia (figure II).

Egypt and the eastern Mediterranean countries are influenced by Mediterranean frontal depressions, which undergo modification as they pass over the area. Average precipitation in the Syrian Steppe varies between 150 and 70 millimetres (mm), increasing at the Palmyrian mountain range to around 250 mm, and to 600 mm around Jabal Al-Arab, the east and west banks of the Jordan River and the Anti-Lebanon mountain range. The Lebanon mountain range and Mount Hermon, in the southern Anti-Lebanon range, receive more precipitation (1,000 mm to 1,500 mm). Egypt's climate is extremely arid; average rainfall is about 10 mm/a. Along the Mediterranean coastal area, average annual rainfall is approximately 200 mm.[1/]

Most of the Arabian Peninsula is characterized by a hot, dry climate caused by air masses moving from the eastern Mediterranean towards the Arabian Gulf. The Hijaz, Asir, Yemen and Oman mountains come under the influence of two types of a much milder climate: Mediterranean and monsoon. Although average precipitation in these highlands is relatively low, rainfall is well distributed throughout the year, with peaks in spring and autumn. Annual rainfall is about 300 mm in the eastern Red Sea mountain belt of Saudi Arabia.[2/] In the eastern regions of the Arabian Peninsula, average annual rainfall varies from 30 mm to 50 mm in the northern area and 40 mm to 90 mm in the north-east, diminishing to around 10 mm in the Rub Al-Khali (Empty Quarter) in the south-east.[3/]

B. Physiography

The region is essentially flat (figure III), though relatively narrow mountain ranges extend along the coastlines of the Red Sea, the Mediterranean and the Gulf of Oman. In the Mashreq region's interior, mountains and plateaus are found mainly in the north; they are mostly low-relief features, and include the Palmyrian mountains and the Hauran and Hamad plateaus. Higher mountains (the Zagros range) are encountered in north-east Iraq.

The Hamad Plateau extends over a large area in the south-eastern and central parts of the Mashrek. Its altitude ranges between 1,000 metres (m) above sea level in the south and 600 m in the north. Beyond the Al-Oulab area of the eastern Syrian Arab Republic, the plateau passes into the Badiat Al-Sham plain, which slopes gently towards the Euphrates River.

Figure I. Average annual precipitation

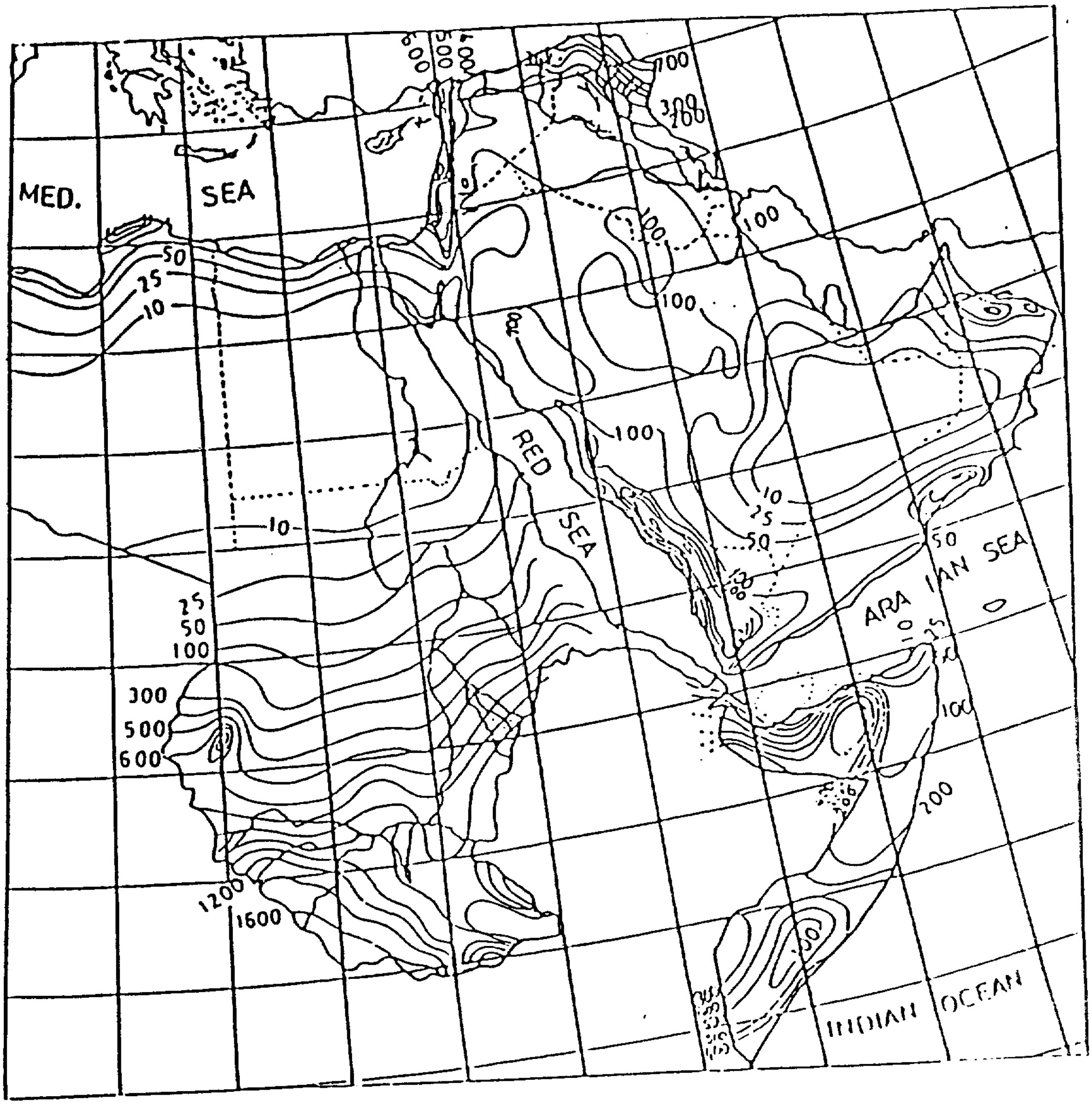


Figure II. Climatic zones

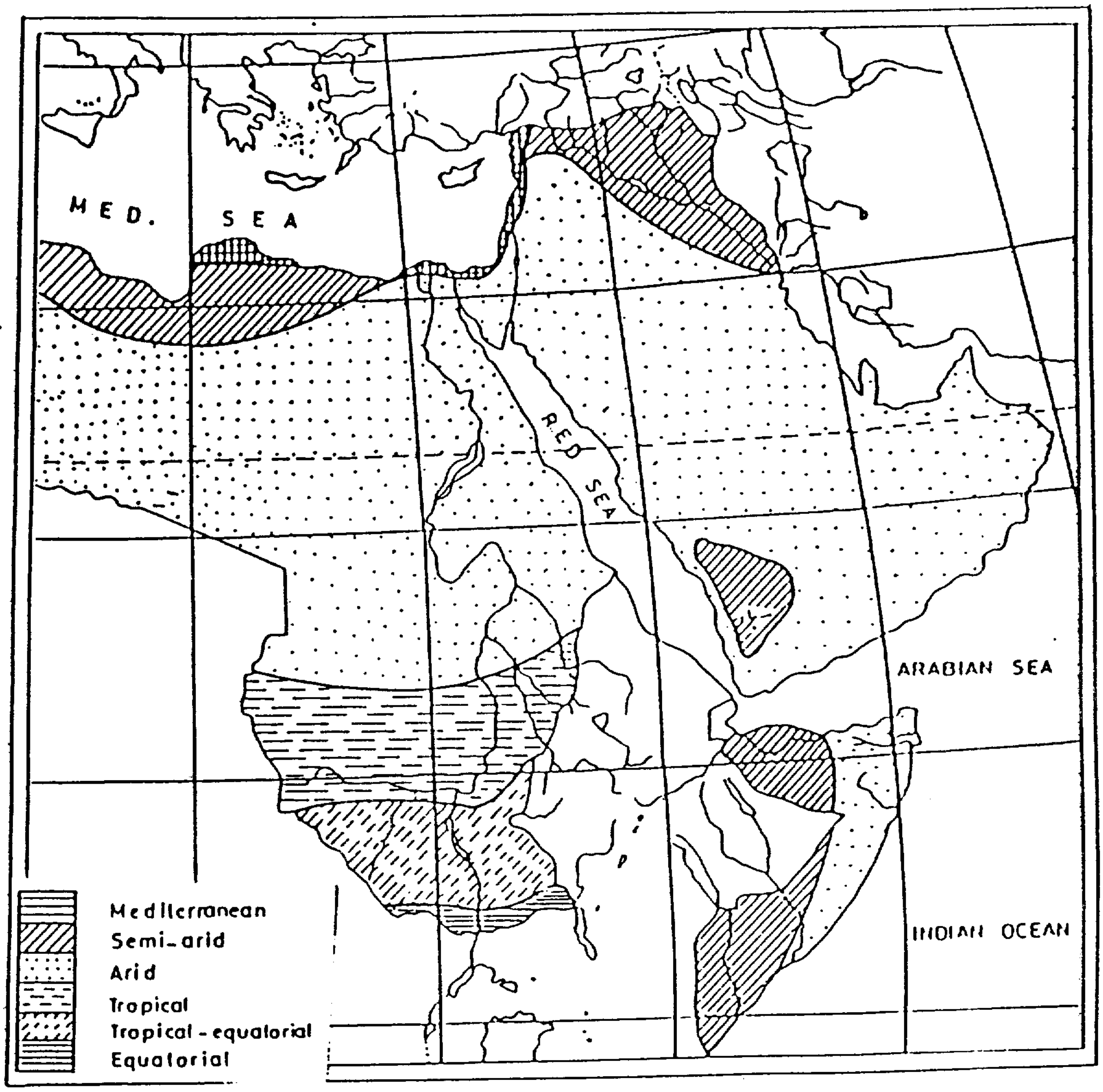
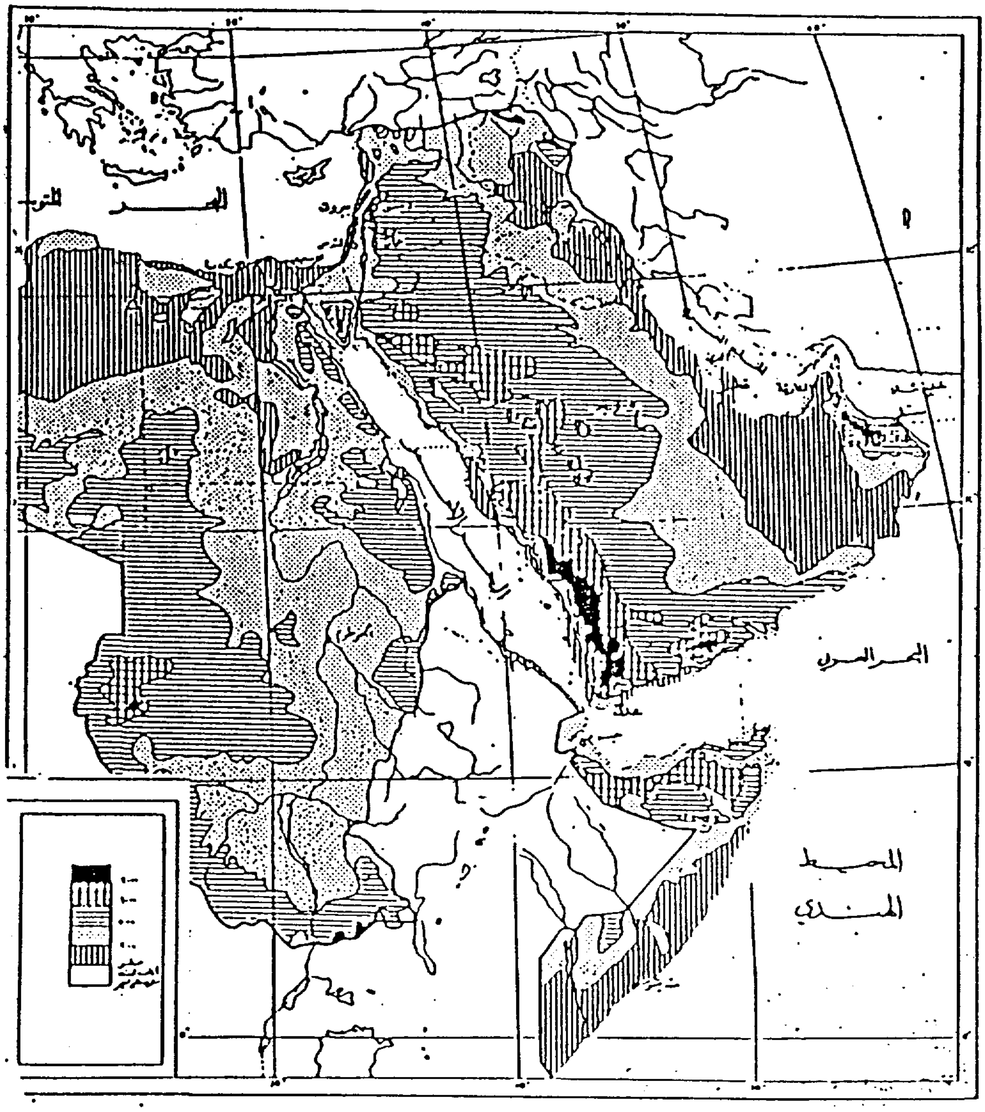


Figure III. <u>Main topographical features of the region</u>



M.Obeisy,1986

In the north-west, the Palmyrian mountain chain branches from the Anti-Lebanon range north of Damascus and extends in a north-easterly direction, terminating some 20 km west of the Euphrates. South of Damascus, the basaltic plateau of Hauran and Golan extends into Jordan and north-west Saudi Arabia. Jabal Al-Arab, a volcanic mountain in the southern Syrian Arab Republic, rises to 1,800 m above the volcanic plateau, and ranges in height between 600 m and 1,000 m.

The western areas of the Mashrek and Arabian Peninsula are dominated by the Great Rift system dividing the Afro-Arabian Precambrian Shield. The rift zone extends northwards from the Red Sea through Wadi Araba, the Dead Sea, and the Jordan Valley, into Beqa'a and the Ghab plain. Mountain ranges exist on both sides of the rift. High mountains can be found in the Mashrek, including the Lebanon mountain range (3,080 m) on the western side and the Anti-Lebanon chain (2,629 m) -- including Mount Hermon -- on the eastern side of the rift.

In the Arabian Peninsula, there is a high-altitude zone (over 1,800 m) extending from Taif through Asir into Yemen. The highest peak in the Peninsula is Bani Shaib (4,260 m), near Sana'a, Yemen. An isolated mountain range dominates the Arabian shore of the Gulf of Oman. It sweeps northwards in an arc some 650 km long from Ras Al-Had, the easternmost point of the Arabian Peninsula, into Ru'us Al-Jibal, the gateway to the Gulf. The Rub Al-Khali desert, one of the most arid areas in the world, extends between these two main ranges, the Hadramaut plateau and the Gulf. A bajada zone (a zone of coalescing piedmont outwash fans) extends from the mountains into the desert periphery. This transitional feature between the mountains proper and the full desert often indicates important water-resources and grazing potential.

Egypt is essentially a flat region, generally less than 500 m above sea level. In the south-west, Jabal Uweinat rises to about 2,000 m. The eastern ranges which overlook the Gulf of Suez and the Red Sea rise to an elevation of between 1,800 m and 2,000 m. In the north, the bottom of some depressions (Qattara, Siwa) are below sea level. The western and eastern deserts comprise approximately 96 per cent of the total area of the country (902,000 km^2), while the Nile Valley and the Nile Delta cover around 36,000 km^2 (including Fayoum and Lake Naser).[1/]

II. HYDROLOGY

A. General hydrological characteristics

The hydrology of the region is characterized primarily by aridity; the main drainage systems are ephemeral. Temporal and spatial variations in rainfall patterns are reflected naturally in wadi or stream flows. The hydrological characteristics of ephemeral, intermittent and permanent streams and wadi networks depend on the physiographical, hydrogeological and climatological properties of catchments. The catchment areas of the region's large rivers (the Nile, Euphrates and Tigris) extend beyond the Arab region

into climatic zones in low and high latitudes where precipitation is high and rainfall variations are relatively low. In spite of this, these rivers have witnessed periods of drought which, in the south, have extended up to eight years. The catchment of medium-sized rivers extend within the region and are consequently influenced by frequent droughts experienced in various parts of the region. Geology plays an important role in the eastern Mediterranean countries, where the aquifers are composed mainly of highly permeable and karstic carbonate rocks. The capacity of these rocks to transmit water is high, but water moves quickly to discharge zones -- usually karstic springs. Aquifers are generally unable to store quantities of water sufficient to sustain base flow during the long, dry summer season. Flows in the majority of the coastal rivers of the Syrian Arab Republic and Lebanon are intermittent; the hydrograph is characterized by a sharp, high peak. In contrast to the karstic terrain of the eastern Mediterranean region, the Oman mountains and Red Sea highlands are essentially composed of impermeable ophites and metamorphic or volcanic rocks of low permeability. Underground storage of surface run-off is possible only in the shallow, fissured weathered zones or in wadi fill gravels. The low and extremely irregular precipitation in these highlands has resulted in an ephemeral wadi system in the Arabian Peninsula and large areas in Egypt and the Mashrek. The ephemeral drainage patterns are often dense; water generally disappears in the vast gravel plains and sandy deserts. Even in coastal areas the water rarely empties into the sea; several wadis end in inland or coastal sabkhas.

B. Identification and delineation of surface-water units

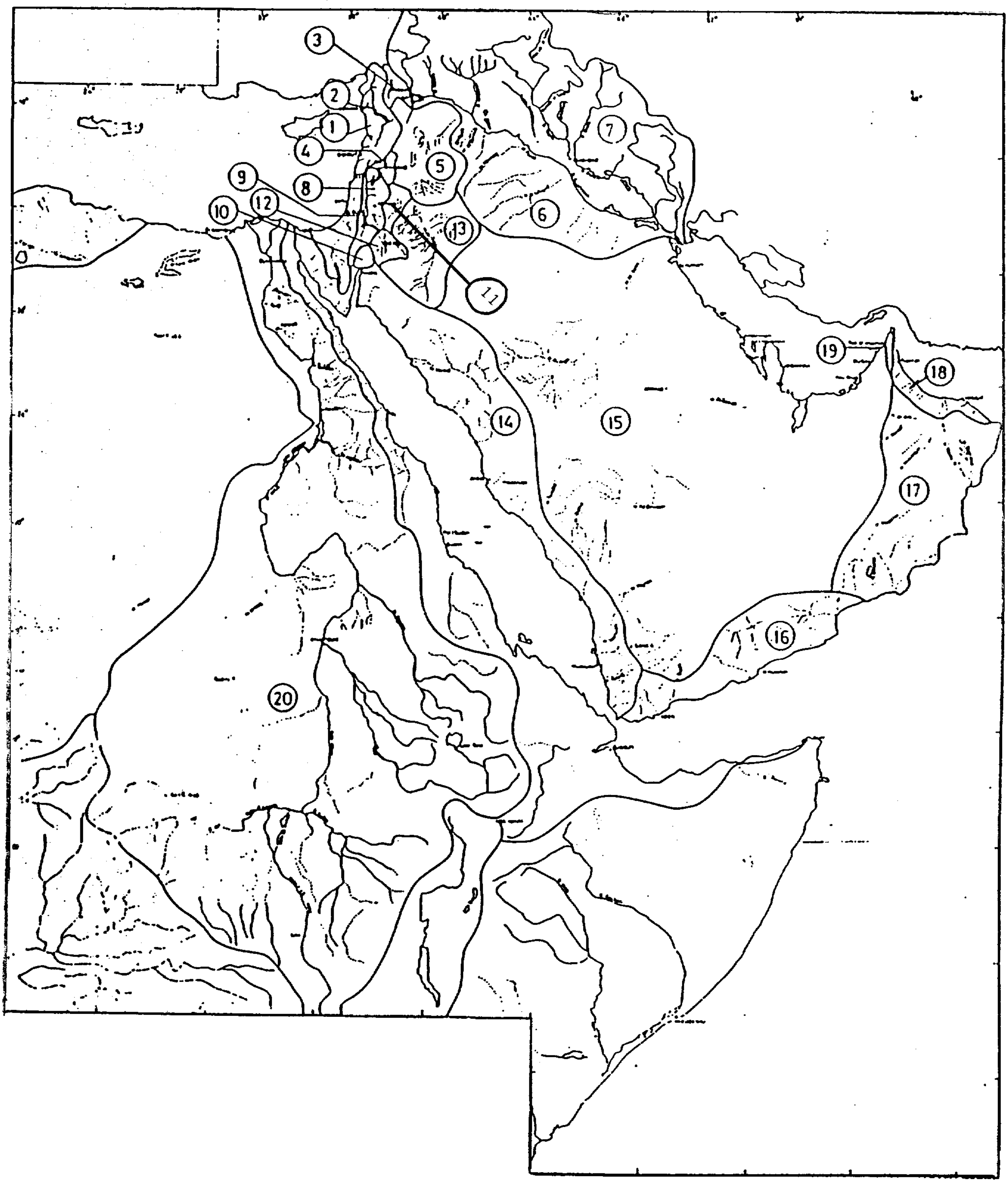
Surface-water units are classified as individual basins when the river is large and the flow is permanent or intermittent. Ephemeral drainage is usually classified into systems or networks of several wadis.

Surface-water units or basins have been delineated on a regional basis. Boundaries of perennial rivers (surface-water divides) are usually well defined, as is the case with the Nile, Tigris, Euphrates, Yarmouk, Litani, Orentis, and others.

In arid, large wadis are recognized as hydrological units at national levels. Although such delineation is useful for practical or even scientific purposes, it cannot be adopted at the regional level, though larger units comprising several wadis originating at a regional divide and emptying into the same base level (sea, sabkha, etc.) are recognized. Regional hydrological units or "wadi systems" could, of course, be subdivided at the national level into several smaller units; twenty such hydrological (drainage) units are recognized in the region (figure IV). Description of stream and flow characteristics is systematic, facilitating the establishment of a regional hydrological database.

Figure IV. Hydrological units in the ESCWA region

(See key on next page)



Hydrological units in the ESCWA region

(Key for figure IV)

SW*1	Mediterranean coastal Basin
SW2	Orentis Basin
SW3	Aleppo Basin
SW4	Damascus Basin
SW5	Syrian Steppe Basin
SW6	Euphrates River Basin
SW7	Tigris River Basin
SW8	Jordan River Basin
SW9	Dead Sea Basin
SW10	Wadi Araba Basin
SW11	Azraq Basin
SW12	Jafr Basin
SW13	Wadi Sirhan Basin
SW14	Tehama wadi system
SW15	Eastern Arabia wadi system
SW16	South Yemen wadi system
SW17	West and South Oman desert wadi system
SW18	East Oman mountain (Batina) wadi system
SW19	United Arab Emirates (UAE) wadi system
SW20	Nile River Basin

* SW = Surface Water

III. HYDROGEOLOGY

A. Hydrogeological classification of geological units

Numerous aquifers have been identified, mapped and investigated in the region. Ten have been identified in the eastern and southern Mediterranean subregions; among these, only four aquifers are of regional importance.4/ In the Arabian Peninsula, 16 water-bearing formations have been identified and studied, seven of which can be considered major aquifers.3/

The Food and Agriculture Organization of the United Nations (FAO) has recognized three aquifer complexes (levels) in the Arabian Peninsula and Gulf States:

(a) Lower: Wasia-Biyadh aquifer complex;
(b) Middle: Rus/Um Al-Radhuma/Upper Aruma aquifer complex;
(c) Upper: Dammam-Neogene aquifer complex.

In the ESCWA region, water-bearing formations can be classified (at the regional level) into six main aquifer complexes:

(a) Lower continental sandstone aquifer complex (Paleozoic-Lower Mesozoic);

(b) Upper continental sandstone aquifer complex (Upper Mesozoic);

(c) Lower carbonate aquifer complex (Mesozoic);

(d) Upper carbonate aquifer complex (Tertiary);

(e) Alluvial (clastic) aquifer complex (Neogene-Quaternary);

(f) Volcanic aquifer complex (Neogene-Quaternary).

The first aquifer complex comprises the Saq, Tabouk, Wajid and Minjur sandstone formations. The relative importance of each aquifer unit and intervening aquitards varies from one area to another. The complex as a whole is of paramount importance in the Arabian Peninsula, and extends from southern Jordan across Saudi Arabia to Yemen.

The Lower Mesozoic carbonate aquifer complex is one of the most prolific complexes in Lebanon, the Syrian Arab Republic and Jordan. It consists of a thick sequence of limestones and dolomites of the Jurassic and Cretaceous periods. The Jurassic and Cretaceous aquifer units are separated by a relatively thin aquitard from the Aptian-Albian period. The thick sequence of limestone and dolomite is folded and fractured in the Lebanon-Anti-Lebanon Mountain belt of Jordan, the Syrian Arab Republic and Lebanon.

Tertiary carbonates are extremely important aquifers in the northern Syrian Arab Republic and eastern Arabia (figure V). The Neogene-Quaternary aquifer complex occurs widely in the entire region and is particularly

important in major depressions and basins. It is of vital economic importance to several countries in the region and is often developed for agricultural purposes; in several areas, it is over-developed.

In the eastern Mediterranean subregion, the lower carbonate aquifer complexes are separated from the upper carbonate complex by a thick aquiclude consisting of marls and marly limestones of the Maestrichtian-Lower Paleogenic age, while in the Arabian Peninsula the Jurassic carbonate rocks form the principal aquiclude which separates the lower sandstone aquifer complex from the upper sandstone and carbonate aquifer complexes. The Rus anhydrite, the Lower Fars and other low-permeability formations act as aquitards or even poor aquifers rather than as aquicludes.

B. Identification and delineation of aquifer systems

Twenty aquifer systems have been recognized in the ESCWA region (figure VI). Some of these, such as the western Arabia sandstone aquifer system, extend over a vast area, while others, such as the Ghouta (Damascus plain) and Batina alluvial aquifer system are of limited areal extent, but form distinct natural units of a composite nature and are of great economic importance. Some aquifer systems extend beyond the limits shown in figure VI; this is particularly true for the sandstone aquifer systems of Saudi Arabia and the carbonate aquifer system of the eastern Mediterranean.

Figure V. Lithology of aquifer systems

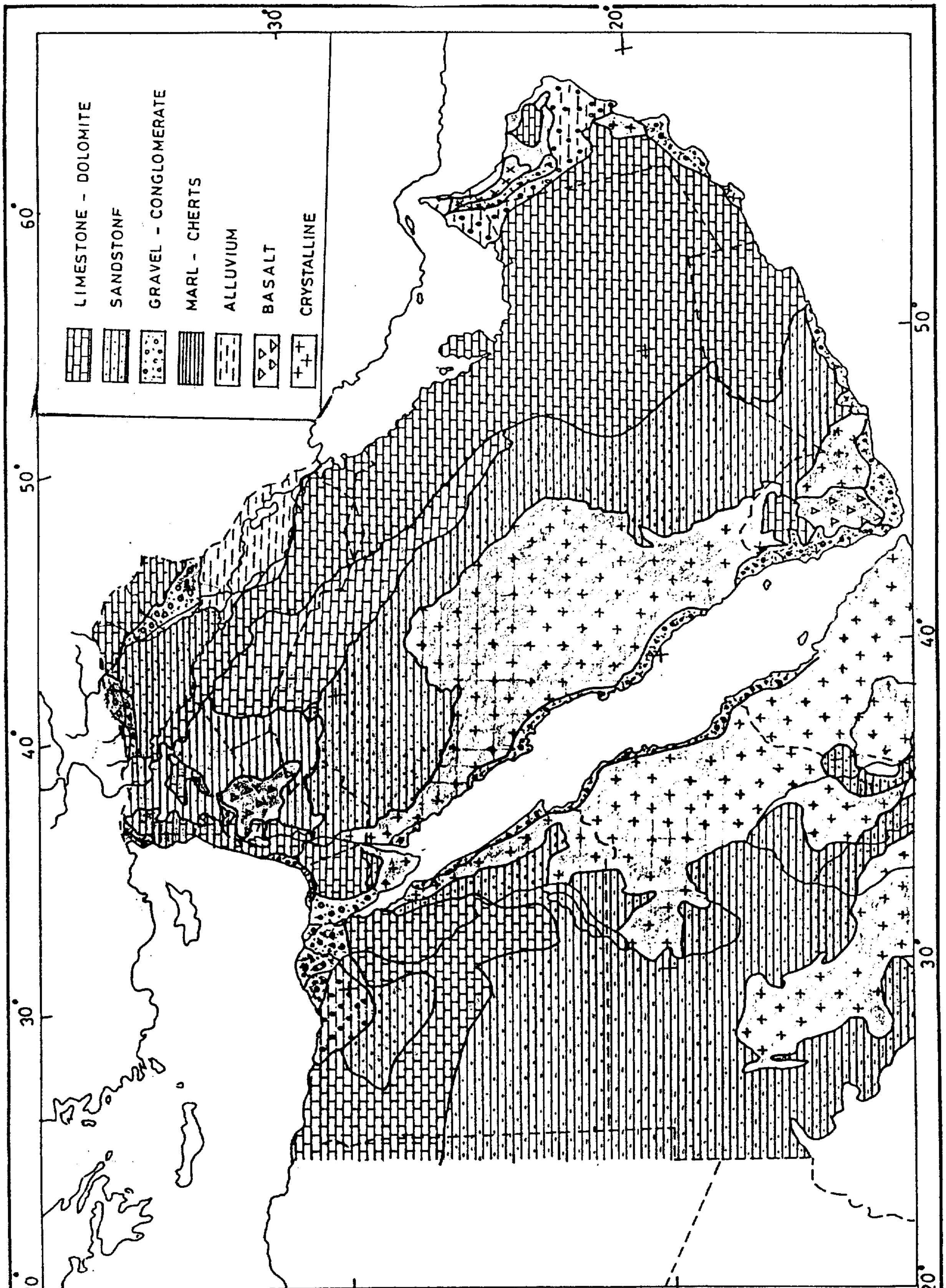
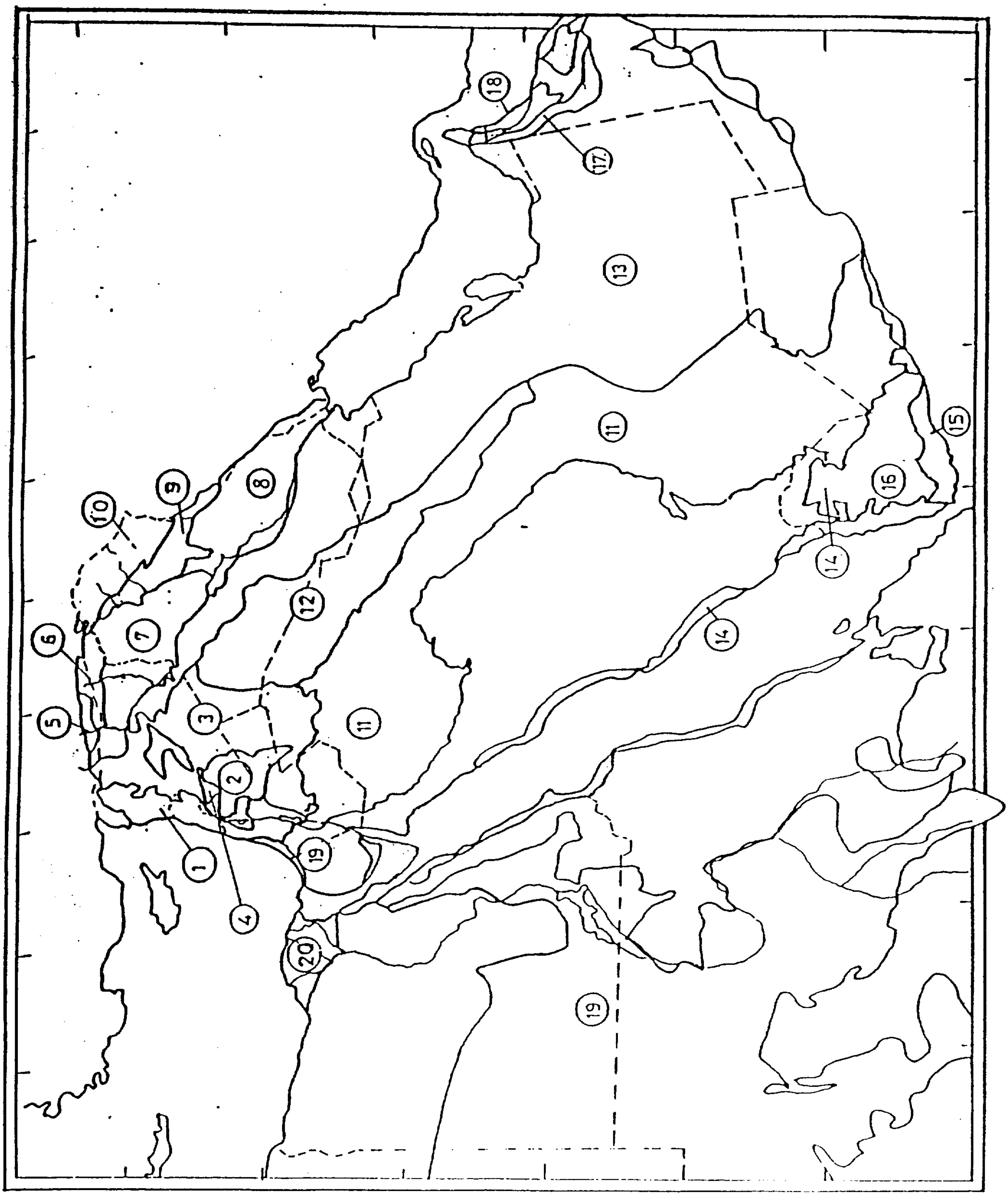


Figure VI. Aquifer systems in the ESCWA region

(See key on next page)



Aquifer systems in the ESCWA region

(Key for figure VI)

GW*1	Eastern Mediterranean carbonate aquifer system
GW2	Jabal Al-Arab basaltic aquifer system
GW3	Syrian desert aquifer system
GW4	Ghouta (Damascus plain) aquifer system
GW5	Jezira Tertiary limestone aquifer system
GW6	Jezira clastic aquifer system
GW7	Jezira Lower Fars-Upper Fars aquifer system
GW8	Mesopotamian alluvial aquifer system
GW9	Mesopotamian clastic aquifer system
GW10	Jagros carbonate aquifer system
GW11	Western Arabia sandstone aquifer system
GW12	Central Arabia Cretaceous limestone aquifer system
GW13	Eastern Arabia Tertiary carbonate aquifer system
GW14	Tehama alluvial aquifer system
GW16	Yemen highlands aquifer system
GW17	Western Oman mountains-bajada aquifer system
GW18	Batina alluvial aquifer system
GW19	Nubian sandstone aquifer system
GW20	Nile Valley-Nile Delta aquifer system

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* GW = Ground water

IV. SHARED SURFACE-WATER SYSTEMS

A. Euphrates River (SW6)

(a) Source: Furat sou and Murat sou, the headwaters of the Euphrates River, are found at an altitude of about 3,000 m in the Turkish highlands (Tauros mountains).

(b) Drainage area: 444,000 km^2;[5/] length: 2,330 km[6/] (table 1).

(c) Precipitation: The catchment upstream from Kiban has an area of 64,000 km^2.[7/] More than 50 per cent of this area exists at altitudes exceeding 1,600 m. Average annual precipitation in the headwater area ranges from 500 mm to 900 mm, and most of the precipitation occurs as snow in winter. Precipitation decreases to 300 mm to 450 mm in southern Turkey and the north-east Syrian Arab Republic in the catchment area of Khabour, the main tributary to the Euphrates River. In the steppe areas south of the Euphrates River, the catchment areas of ephemeral streams receive an average of about 150 mm to 200 mm. Run-off occurs mainly after intense rainstorms or thundershowers in autumn or spring; gentle rains in winter rarely cause run-off.

(d) Stream flow: The average annual flow in the Syrian Arab Republic is about 26.8 BCM.[6,7/] Discharge at Al-Thourah is 850 m^3/s. During the period 1924-1973, maximum recorded discharge was 6,720 m^3/s and minimum discharge was 142 m^3/s.[7/]

The Euphrates River is regulated by several dams, the largest of which are: Ataturk (49 BCM capacity); Kiban (30.6 BCM capacity); and Al-Thourah (11.6 BCM capacity). The average annual yield of the watershed above Kiban Dam is 19.4 BCM, while downstream it is 7.4 BCM.[7/]

Perennial tributary streams include the Sajour, Belikh and Khabour. The Sajour's average flow is about 4 m^3/s. The Belikh River has an average annual flow of about 150 MCM.[7/] The Khabour is the largest tributary in the Syrian Arab Republic, with an annual flow of about 1.5 BCM and an average discharge of 50 m^3/s. Maximum discharge during the recorded period is 386 m^3/s.[7/] A smaller dam has been constructed downstream from Al-Thourah to regulate the flow from Al-Thourah Dam.

A temporary arrangement for the management of the Euphrates Basin has been made; the situation will be further complicated after the completion of Ataturk Dam and other projects now under construction. A more integrated regional management system for the shared resources is urgently needed.

B. Tigris River (SW7)

(a) Headwaters: The Tigris River originates in the eastern Tauros mountains at an altitude ranging between 1,000 m and 1,500 m. The river flows southwards through Diyar Bakr, then turns eastwards, where it is joined by three headwater tributaries: the Butman River (fairly high in the mountain ranges, at 3,000 m); Kazran-Jay; and a tributary which originates near the Iraqi-Turkish borders.

(b) Drainage areas: 471,606 km^2 distributed over four countries, as follows:[5]

Area	Km^2
Iraq	253 000
Turkey	57 614
Syrian Arab Republic	834
Iran	16 015
Total	471 606

(c) Precipitation: Mean annual rainfall over the catchment area is about 800 mm; precipitation ranges from 440 mm to 1,600 mm. Snowfall on mountains and hills of 1,000 m to 4,500 m contributes to floods occurring in late winter. The amount of data available on snow cover, however, is too limited to warrant precise interpretation.

(d) Tributaries:

(i) Great Zab River: This is the largest tributary of the Tigris River. Its headwaters originate from the Ararat mountains, at an altitude of 4,636 m. The total catchment of the river is 25,810 km^2, 16,000 km^2 of which is in Iraq.[5,8] The length of the river is 392 km and joins the Tigris south of the town of Mosul. The average annual stream flow is about 13.18 km^3. Maximum recorded discharge is 10,570 m^3/s and minimum flow is 67 m^3/s.[5]

(ii) Little Zab River: Headwaters of the Little Zab River drain about 21,475 km^2 at the border zone between Iraq and Iran (15,975 km^2 in Iraqi territory). The length of the river is 400 km; it joins the Tigris River north of Fatha.[5,8]

The average annual river discharge is 7.17 km^3; maximum and minimum annual discharge is 17.01 km^3 and 3.02 km^3 respectively. The recorded maximum was 3,420 m^3/s. Annual safe yield after construction of the Dokan Dam (6.8 km^3 capacity) is about 5.07 km^3.[5]

(iii) The Al-Adheim River: The headwaters of this river rise at the Kura Dagh and Shwam highlands, and drains over a 13,000 km^2 area which lies entirely within Iraq. The length of the river is 330 km.[5] Average annual discharge is 0.79 km^3; maximum and minium annual discharge is 1.85 km^3 and 0.18 km^3, respectively.[5] Al-Adheim River is an intermittent stream subject to flash floods which reach up to 13,000 m^3/s.[5] The flow usually stops between June and October.

(iv) Dayala River: The headwaters of the Dayala River (386 km long) are in Iranian territory. It drains an area of about 31,896 km^2, 24,072 km^2 of which is in Iraq.[5,8] The principal tributaries of

the river are Seirawan and Tangro. The annual average, maximum and minimum flow is 5.74 km^3, 14.27 km^3 and 2.44 km^3, respectively. The flow has been regulated through the construction of two dams: Derbandani Khan (3 km^3 capacity) and Hemin Dam (3.95 km^3 capacity).[5/]

(v) Al-Tayib River: The Al-Tayib River originates in the Zagros ranges and drains an area of about 5,000 km^2.[5/] The average annual discharge is about 1 km^3. The length of the river is 80 km.[5/]

(vi) Dweirij River: This river originates in the Zagros mountains. It is about 110 km long, with a basin area of about 3,000 km^2.[5/]

(vii) Korkha River: The headwaters originate on the south flanks of the Zagros mountains in Iran. Th Khorkha River drainage basin area is about 46,000 km^2; its average annual flow is about 6.3 km^3, and it empties into Hor Hweiziya.[5/]

(viii) Karon River: This river's headwaters originate in the Zagros mountains in Iran. The drainage basin area is about 58,100 km^2. The length of the river is 630 km and its average annual discharge is 24.7 km^3 in Ahwaz.[5/] The river joins Shat Al-Arab south of Basra; its fresh water improves the quality of Shat Al-Arab waters.

(ix) Shat Al-Arab River: This river is formed by the merging of the Tigris and Euphrates rivers at Al-Qurna. The total catchment area is about 808,000 km^2, its length is 110 km, and the width of its channel ranges between 600 m and 2,000 m.[5,9/] Its annual average discharge at Basra is 21.0 km^3. The annual flow increases at Al-Fao[5/] to 35.2 km^3, where the river empties into the Arabian Gulf.

(e) Stream flow: Average annual flow of the Tigris River is estimated at 50 BCM.[10/] Minimum measured flow (in 1930) was 19 BCM, while it reached 106 BCM in 1969. At Mosul, maximum recorded flow was 7,539 m^3/s and minimum flow was 88 m^3/s. Probable maximum flood is about 30,000 m^3/s.[5/] Table 2 summarizes the streamflow measurements at stations shown in figure VII.

(f) Regulation: Several major storage facilities and diversion structures have been built on the Tigris River and its main tributaries. All these dams and hydraulic structures serve to regulate and control the flow of the Tigris River, and have paved the way for the execution of large irrigation projects, including integrated irrigation-drainage systems.

The basic features of the more important hydraulic projects on the Tigris and Euphrates rivers and their tributaries are shown in table 1 and table 3. Completed structures include Kiban Dam in Turkey (31 BCM capacity), Qara Qaya (9.6 BCM capacity), and Al-Thourah in the Syrian Arab Republic (11.6 BCM capacity). Important structures presently under construction include three large dams on the Tigris River in Turkey and the Ataturk Dam on the Euphrates River (49 BCM capacity).[8/]

Table 1. <u>Dams constructed on the Euphrates River</u>

	Storage capacity (BCM)	Live storage (BCM)	Dead storage (BCM)	Reservoir (lake) Area (km^2)	Length (km^2)
Kiban	30.600	20.600	10.000	615.000	125.000
Qara Qaya	9.540	5.580	3.960	268.000	168.000
Ataturk	49.000	..	..	817.000	181.000
Teshrin	1.300	..	..	..	70.000
Al-Thourah	11.000	7.300	4.300	604.000	90.000
Al-Tandhini (Regulator)	0.090	0.025	0.065	27.000	26.000
Haditheh	11.300	9.200	1.500	650.000	..
Habaniyeh	3.560	2.960	0.600	..	..

<u>Source</u>: Arab Center for the Studies of Arid Zones and Dry Lands, "Hydrology of the Euphrates River" (vol. III) a report by R. Asfari presented at the <u>Seminar on Surface Water Hydrology</u>, Damascus, 11-17 September 1985 (ACSAD/HS/P49).

Figure VII. The Euphrates and Tigris river basins

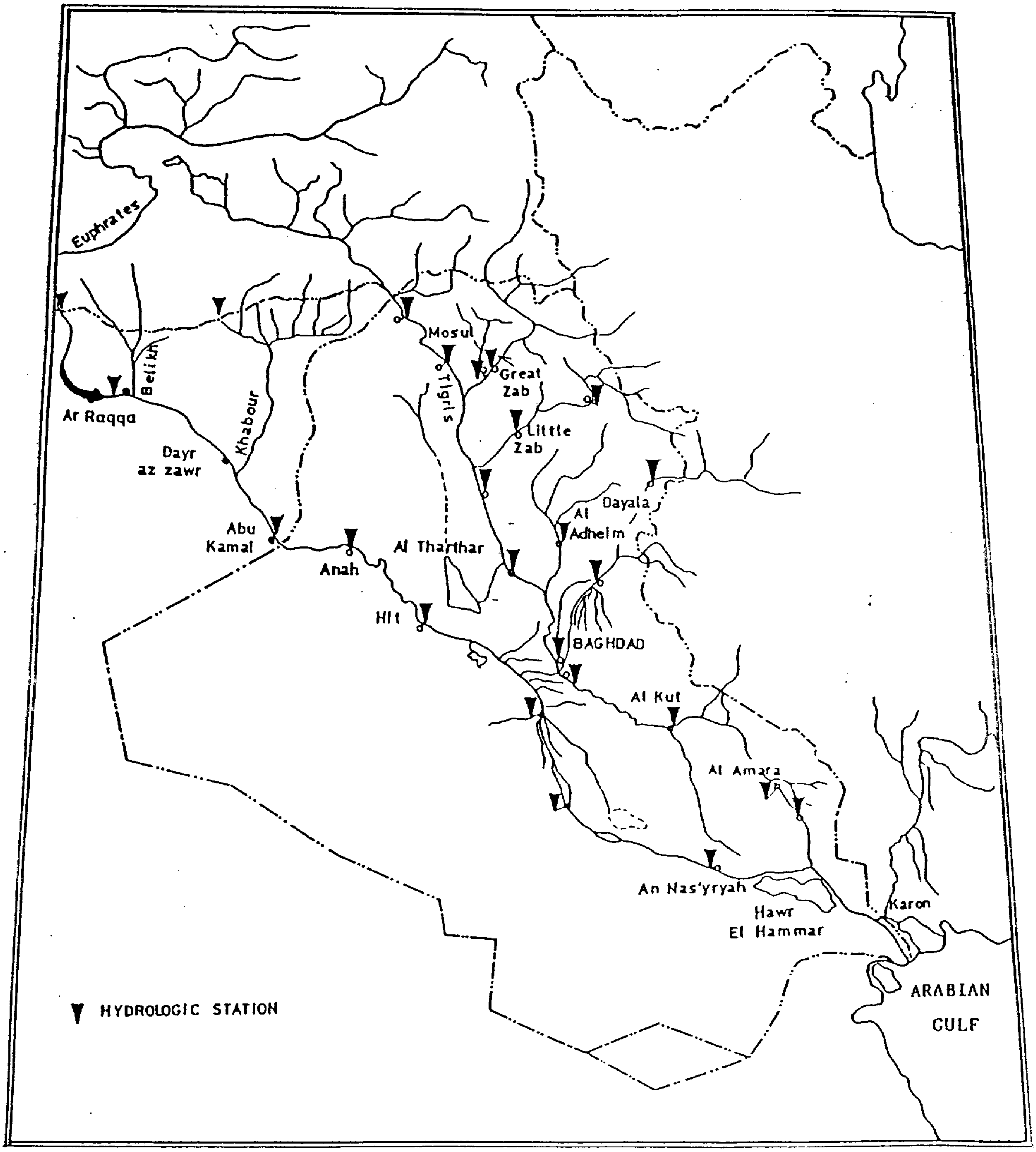


Table 2. Average discharge at various reaches of the Euphrates and Tigris rivers in Iraq (gains and losses)

Gauging station	Stream flow (December-March); run-off from rainfall (m^3/s)	Stream flow (April-July); snow-melt and rainfall (m^3/s)	Base flow (August-October) (m^3/s)
Euphrates			
Heet	808	1 642	343
Al-Himdyeh	538	1 135	210
Al-Shannafyeh	498	848	167
Al-Nasseryeh	406	787	172
Tigris			
Tassan	630	890	253
Al-Mosul	717	903	272
Al-Fohhah	1 404	2 169	458
Sannurah	1 134	1 524	492
Baghdad	1 210	1 864	373
Al-Kout	1 046	1 462	292
Al-Amarat	162	235	82
Qalaot Saler	48	72	26
Great Zab			
Bakhmeh	322	735	148
Esky Balh	372	728	150
Little Zab			
Dokan	256	208	136
Alton Kubry	302	247	137
Al-Adheine			
Antanah	52	141	117
Dayala			
Derbandi Khan	179	169	107

Source: M. Al-Sharaf, Pollution Control and Water Resources of Iraq (Baghdad, Al-Hurria, 1976).

Table 3. Dams on the Tigris River

Dam structure	Normal retention level (m)	Normal storage (BCM)	Live storage (BCM)	Reserve storage (BCM)
Dakar	511.00	6.80	5.50	0.40
Tharthar	62.00	77.60	38.50	7.80
Fatha	177.50	23.30	19.30	2.70
Mosul	329.00	10.70	9.70	1.80
Bekhma	550.00	8.30	7.80	6.60
Derbandi Khan	485.00	3.00	2.50	1.10
Himrin	104.00	3.95	2.30	1.40

Source: Economic Commission for Western Asia, "Assessment of the water resources situation in the ECWA region", 1981 (E/ECWA/NR/L/1/Rev.1).

C. The Orentis basin (SW2)

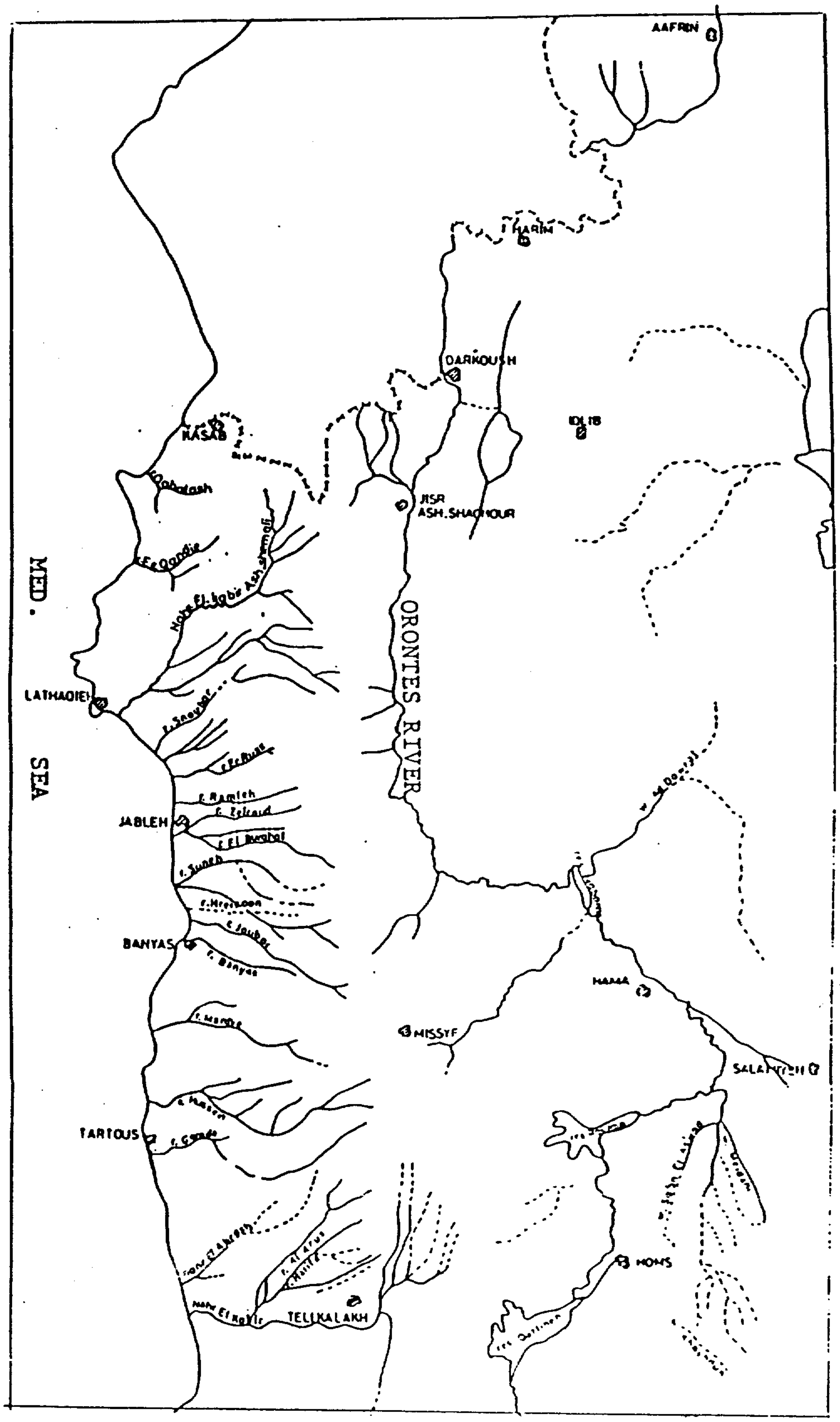
(a) Source: The Orentis River originates in Lebanon (in northern Beka'a) at Al-Labweh spring near Baalbeck, at an elevation of 400 m (figure VIII).

(b) Drainage area: 216,000 km^2; length: 487 km.[6/]

(c) Precipitation: The river and its tributaries drain highlands or plateau areas situated on both sides of the Rift Valley. The western mountains receive precipitation ranging from 600 mm to 1,500 mm. Snowfall in Lebanon and the Syrian Arab Republic coastal mountains contributes to stream flow. Precipitation in the eastern catchments is much lower, ranging from 400 mm to 600 mm; consequently, eastern tributaries are all ephemeral streams.

(d) Stream flow: Average annual flow of the Orentis River is estimated at 2,400 MCM.[11/] Maximum and minimum daily discharge is 10 m^3/s and 400 m^3/s, respectively. The mean annual discharge of the river increases steadily in the upper middle reaches, but nearly doubles in the lower reaches, as can be seen from the following estimates at various gauging stations along the river course:

Figure VIII. <u>Rivers of the north-west Syrian Arab Republic</u>



Measurements sites	Catchment area (km^2)	Mean annual discharge $Q(m^3/s)$
Qusseir	1 690	16.1
Qattineh	3 390	19.6
Rastan	4 820	26.1
Mhardeh	12 660	36.1
Jisr-Shughur	1 513	60.8
Dergush	15 540	75.5

Source: Union of Soviet Socialist Republics, Selkhozpromexport, "Hydrogeological and hydrological surveys and investigations in four areas of the Syrian Arab Republic: Hydrology", vol. I, Book 1 (Summary report), (Tbilisi, 1982).

* Q = rate of discharge.

Large karstic springs discharging into the Orentis, which results in the above-mentioned increase in river flow, include the following:

Reach	Number of springs	Total discharge (m^3/s)
Headwater springs (Lebanon)	3	13.11
Upper reach	4	2.25
Hama-Mhardeh	7	0.45
Chizer spring	1	6.42
Achorreh	6	2.27
West Ghab	19	3.90
East Ghab	10	7.59
Lower reach	4	2.24
Total	54	38.23 = 1 200 MCM

Source: Syrian Arab Republic, State Planning Commission and the United States Department of Agriculture, Water Resources in Syria, by C. E. Stewart, (Damascus, 1979).

(e) Regulation: In addition to the Qattineh reservoir (200 MCM capacity), there are two large reservoirs -- Rastan (225 MCM) and Mhardeh (50 MCM) -- which regulate water flow and generate electricity. Water of the Orentis is used intensively for irrigation, water supply and industry. The main canal of the Homs-Hama irrigation system comprises land of about 23,000 hectares and is fed by the Qattineh reservoir.

The Mhardeh reservoir supplies water to the Asharneh plain, while the Rastan reservoir acts as a retarding reservoir in a system supplying water to the irrigated lands of Asharneh and Al-Ghab.

Recent projects carried out in the Al-Ghab area include the construction of 3 dams: Afamia (92 MCM capacity); Qastoun (26 MCM capacity); and Zeizoun (68 MCM capacity).

D. Jordan River basin (SW8)

(a) Headwaters: The Dan, Banias and Hasbani rivers form the headwaters of the Jordan River. The point of confluence of the headwater tributaries is about 4 km south of the northern borders of the occupied territories. It lies at an altitude of 90 m above sea level (figure IX).

(b) Drainage area and total length: 181,140 km^2[12/] and 225 km, respectively.

(c) Precipitation: Precipitation in the higher catchment area ranges from 800 mm to 1,600 mm. Snowfall contributes about 25 per cent of the annual yield of the Upper Jordan Basin. Precipitation in the Yarmouk basin and other lower catchments ranges between 250 mm and 600 mm.

(d) Stream flow: The Jordan River empties into the Dead Sea. The average annual discharge at its mouth at Lake Tiberias is about 875 MCM. Maximum and minimum annual flow is 1,650 MCM (measured 1942-1943) and 648 MCM (1933-1934), respectively.[13/] The flow of the river in the early 1950s reflects its natural flow rate, estimated as follows:[13/]

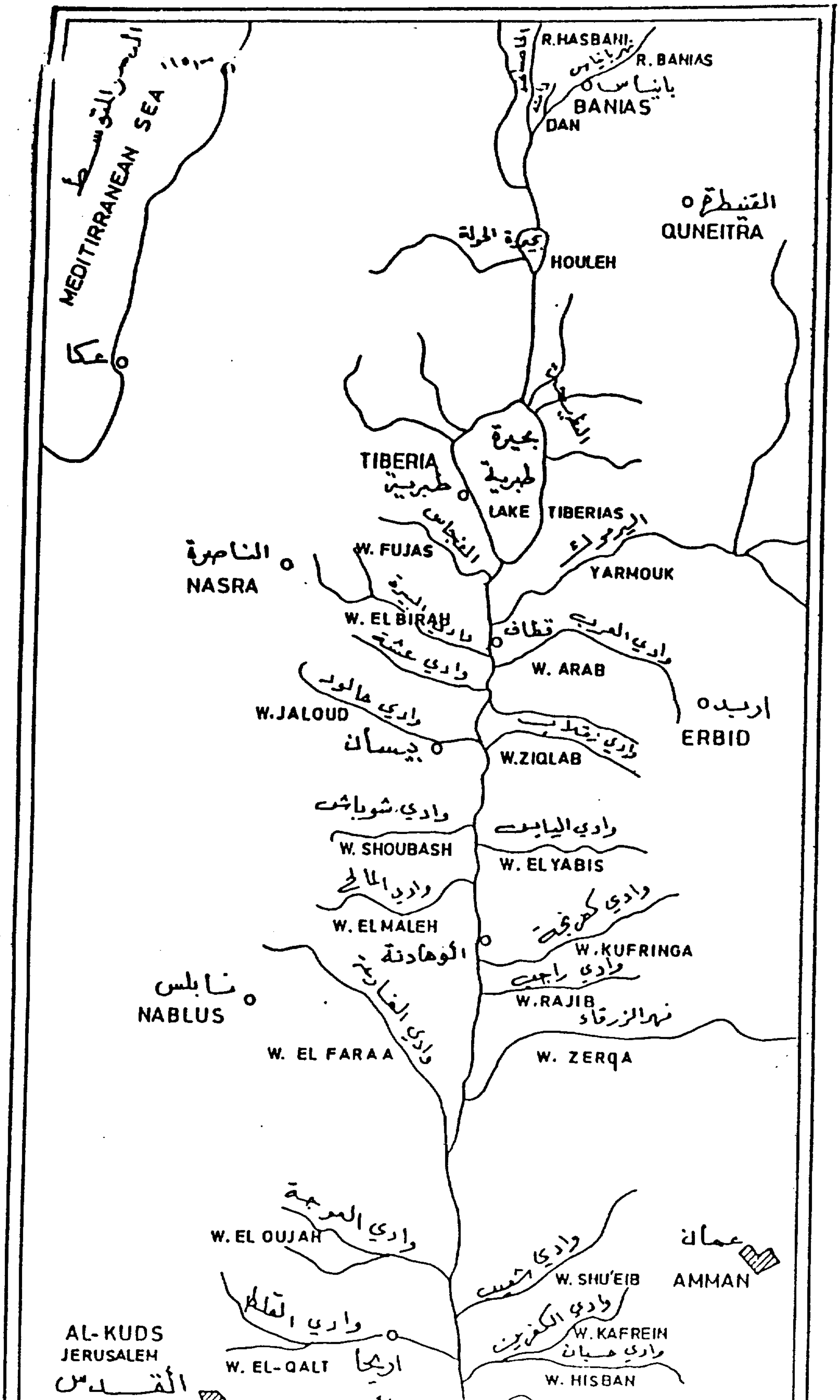
	(MCM)
Average annual flow from tributaries	1 880
Total loss by evaporation	630
Average discharge at the Dead Sea	1 250

(e) Major tributaries:

(i) Dan River: The Dan River source is at Tel Al-Qadi in the occupied territory near the Syrian Arab Republic border. Average annual stream flow between 1950 and 1975 was 240 MCM.[13/] Average annual flow was recently estimated at 260 MCM. Maximum yearly discharge for the same period is 285 MCM (1949-1950), while minimum annual flow is 217 MCM (1961-1962).

(ii) Banias River: Its source is Banias cave near the foot of Mount Hermon in Syrian occupied territory, at an altitude of 329 m. Stream flow is variable; annual average yield is 120 MCM for the period 1950 to 1975.[13/]

Figure IX. Jordan River and its tributaries



(iii) Hasbani River: The Hasbani River source is at the north-western flanks of Mount Hermon in Lebanon, at an altitude of about 900 m. Average annual stream flow of the Hasbani River (between 1950 and 1975) was 153 MCM.13/ Maximum total flow for the period 1947 to 1975 was about 236 MCM in 1947-1948 and the minimum in a water-year was about 635 MCM in 1960-1961.13/

(iv) Yarmouk River: Tributaries to the Yarmouk River either rise on the western flanks of Jabel Al-Arab and flow westward or rise in the Golan Heights and flow southward. The following table summarizes the ground-water and run-off components of stream flow of the main tributaries and the principal streams:

River/Wadi	Average annual flow run-off (MCM)	Average annual base flow (MCM)		Total (MCM)
		Springs	Seepage	
Rakad River	85			
Aalan River	37	45	6	173
Yarmouk River	24			
Wadi Al-Thahab	12	203	11	273
Wadi Al-Zeidi	23			
Total	181	248	17	446

Source: Economic and Social Commission for Western Asia, "Water resources in the Syrian Arab Republic: current and future uses and their role in achieving water and food security", from the Proceedings of the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region, Damascus, 13-16 November 1989 (E/ESCWA/NR/1990/3).

(v) Zarqa River: The Zarqa River drains about 4,056 km^2, which is by far the largest area on the east bank of the Jordan River. Estimated average annual stream flow of the Zarqa River is 95 MCM; measured flows for the period 1951 to 1966 were about 71 MCM.14/

(vi) Small east bank side wadis: The eastern flank of the highlands bordering the Jordan Valley is drained by small wadis. The total drainage area of small east bank wadis is about 2,180 km^2. Estimated annual flow in these wadis is about 112 MCM.

(vii) Small west bank side wadis: After emerging from Lake Tiberias, numerous small wadis join the Jordan River. Their total drainage area is 2,344 km^2. No information is available on their contribution to the Jordan River.

E. Nile River basin (SW20)

The Nile constitutes Egypt's principal water resource. Ground water is important, especially in the New Valley. The Nile ranks among the greatest rivers in the world. Its basin area is about 2,960,000 km^2 and its total length is about 6,825 km, crossing nine countries which share the river basin: Egypt, Sudan, Ethiopia, Uganda, Kenya, Tanzania, Swandi, Burundi and Zaire.

(a) Stream flow: According to the water master plan of Egypt,[15/] the flow characteristics of the Nile River can be summarized as follows:

In Khartoum, the annual Blue Nile discharge into the White Nile is about 54 MCM. The total flow rises to about 82.5 BCM. To this flow is added the final gain from Atbara River (12 BCM), thus increasing the annual yield to about 94.5 BCM. Annual flow arriving at Aswan is 84 BCM. Present annual flow available for use in Egypt is 55.5 BCM, after deducting Sudan's entitlement as per the Nile Water Agreement between Egypt and Sudan.

As regards water quality, the total dissolved solids (TDS) for the Nile ranges from 175 ppm to 180 ppm at Aswan and from 200 ppm to 210 ppm at the Delta Barrage.

(b) Dams and reservoirs: The first structure erected on the Nile for its entire course was Al-Qanater Al-Khairiya Barrage; the dam was operational by 1886. The Delta Barrage was constructed a few kilometres to the south in 1930. A dam was built at Aswan between 1898 and 1902, with a capacity of 1 BCM. Its height was raised twice (in 1912 and 1934) to reach a maximum storage capacity of 5 BCM.

Several dams have been built in the area (table 4):

(i) Egypt: Naga' Hammadi, Isna, Assiut, Zifta and Edina barrages;
(ii) Sudan: Jabal Aulia, Sennar, Khashm-Al-Gibra and Roseires dams;
(iii) Uganda: Owen Falls dam.

The Aswan Dam is now known as the Old Aswan Dam in order to distinguish it from the recently built High Aswan Dam, which was constructed between 1960 and 1968. All the dams mentioned above were designed on the basis of annual storage.

Table 4. Some characteristics of dams, reservoirs and swamps in Egypt, Sudan and Ethiopia

Name	Year of completion	Possible rise of water level (m)	Volume (km^3)	Surface and/or length of reservoir	Losses (evaporation) (MCM)
Egypt					
Edfina Sudd	(bank for protection against marine intrusion)				
Faraskur Sudd	(bank for protection against marine intrusion)				
Zifta Barrage	1 902	3.80	..	..	..
Delta Barrage	1 847	1.50	..	..	..
	1 890	3.50	..	..	..
Mohammad Ali Barrage	1 939	4.20	..	..	..
Assiut Barrage	1 902	3.50	..	..	..
	1 933	3.50	..	..	..
Naga' Hammadi Barrage	1 909	4.65	..	..	..
Isna Barrage	1 909	2.00	..	..	..
Aswan Dam	1 902	18.00	1.00	225 km	..
	1 912	25.00	2.40	..	..
	1 934	34.00	6.30	360 km	..
Aswan High Dam	1 970	97.00	164.00	500 km	..
				6 000 km^2	10 000
Sudan					
Khasm Al-Gibra Dam	1 964	(20)	..	..	60
Sennar Dam	1 925	16.0	..	140 km	280
Roseires Dam	1 966	50.0	0.45	290 km	450
Ethiopia					
	1 934	34.00	6.30	360 km	..
Frontier between Sudan and Ethiopia	..	..	..	..	..
Lake Tana	..	..	..	3 100 km^2	Equal rainfall
Jabal Aulia Dam	1 937	6.55	3.60	500 km	2 800
Baro Pibor Sobat swamp	..	..	..	..	4 000
Bahr Al-Ghazal swamp	..	..	..	..	15 000
Bahr Al-Jabal swamp	..	..	..	8 300 km^2	12 000

Source: C. Gischler, Water Resources in the Arab Middle East and North Africa, (Cambridge, Cambridge University Press, 1979).

V. SHARED GROUND-WATER SYSTEMS

Most countries in the region are linked to one another by regional aquifers subject to over-exploitation and contamination. The major shared aquifers in the region are listed below:

A. Eastern Mediterranean carbonate aquifer system (GW1)

(a) Aquifer: The eastern Mediterranean carbonate aquifer is a regional complex of carbonate rocks comprising two major hydrogeological units -- a Lower Jurassic unit composed mainly of limestone and dolomite and an Upper Cenomanian-Turonian aquifer, also composed of limestones and dolomites.

(b) Occurrence: This regional aquifer system is best observed in the following areas:

The Alouite mountains (Syrian Arab Republic)
The Palmyrian mountains (Syria Arab Republic)
The Anti-Lebanon range (Syrian Arab Republic-Lebanon)
Mount Hermon (Syrian Arab Republic-Lebanon)
The Lebanon mountains (Lebanon)
The eastern and western highlands (Jordan)

B. Jabal Al-Arab basaltic aquifer system (GW2)

The main aquifer is made of basalt, but the basalt is a complex layering of flows of different ages, and variations do occur on the micro and macro scales. The thickness of the basalt layers also changes markedly from one area to another, between the vast volcanic plateau of the south-west Syrian Arab Republic, east Jordan and northern Saudi Arabia; accordingly, the saturated thickness and degree of saturation varies from one place to another. The aquifer is composed of several lava flows, with total thickness ranging from 300 m near Jabal Al-Arab to 20 m to 80 m in the Hamad Basin.

C. Jezira Tertiary limestone aquifer system (GW5)

(a) Aquifer: This aquifer, essentially limestone and dolomite, is of the Middle Eocene age and may extend into the Oligocene.[16/] It forms one hydrogeological unit in the Jezira area of the Syrian Arab Republic and is some 200 m to 300 m thick in Turkey. The thickness of the Paleogenic limestones increases in an eastwardly direction, to about 560 m in the Jezira of the Syrian Arab Republic, and to 1,034 m in Qaratchok. In spite of its great thickness in the eastern area, the aquifer is hydrogeologically more important in the north-western part of Jezira.

(b) Occurrence: The water-bearing limestone formation outcrops in Turkey to the north of the border zone, extending from the Belikh area to the Khabour River in the Syrian Arab Republic. The aquifer extends along the Syrian Arab Republic-Turkish borders, from Ain Al-Arab east of the Euphrates to Ras Al-Ain and beyond. The Khabour River channel between Ras Al-Ain and Hassakeh forms the southern border of the aquifer system, which also extends southwards as

far as the Jebel Abdel Aziz area in the Syrian Arab Republic. Ground-water recharge to the aquifer system is estimated at 1,600 MCM/a, and discharge occurs via the two large springs in the Syrian Arab Republic: Ras Al-Ain (40 m^3/s) and Ain Al-Arus (6 m^3/s).16/

D. Jezira Lower Fars-Upper Fars aquifer system (GW7)

The well-known Lower and Upper Fars formation consists of gypsum beds interbedded with limestones, clags and marls. It extends over the vast Mesopotamian plain of the Lower Jezira of the Syrian Arab Republic and Iraq from the Belikh River in the west to the Tigris River and Tharthar depression. The southern boundary more or less coincides with the middle reach of the Euphrates (from Raqqa in the Syrian Arab Republic to Al-Ramadi in Iraq).

E. Western Arabia sandstone aquifer system (GW11)

(a) Aquifers: Four principal sandstone aquifers -- the Saq, Tabuk, Wajid and Minjur -- are recognized in the Arabian Peninsula. They range in age from the Cambrian to the Triassic periods. Hydrodynamically, they can be subdivided into three aquifer subsystems:

(i) The Saq-Tabuk sandstone aquifer subsystem, extending from northern Saudi Arabia to Jordan;

(ii) The Minjur sandstone aquifer subsystem, occupying the middle of the Riyadh area;

(iii) The Wadid sandstone aquifer subsystem, found mainly in southern Saudi Arabia and in Yemen.

The hydraulic properties of the major aquifers can be summarized as follows:3/

Table 5. Hydraulic parameters of the western Arabia sandstone aquifer system (GW11)

Aquifer	Area	Transmissivity (m^2/s)	Storativity
Saq	Qassim	$2.7x10^{-2}$ to $4.0x10^{-4}$	$1.3x10^{-3}$ to $2.5x10^{-5}$
Saq	Tabuk	$9x10^{-3}$ to $3.8x10^{-2}$	$1.2x10^{-3}$
Wajid	Wadi Al-Dawasir	$5.7x10^{-4}$ to $2x10^{-2}$	$2x10^{-4}$ to $4x10^{-4}$
Upper Tabuk	Turbeh	$7x10^{-4}$	..
Middle Tabuk	Tabuk	$1.7x10^{-3}$	..
Middle Tabuk	Qassim	$1.0x10^{-3}$ to $1.6x10^{-3}$	$2.7x10^{-4}$ to $2.5x10^{-3}$
Lower Tabuk	Qassim	$4.0x10^{-4}$ to $1.5x10^{-4}$	$6.7x10^{-4}$
Minjur	Riyadh	$0.5x10^{-3}$ to $1.4x10^{-3}$	..
Minjur	Riyadh	$1.7x10^{-3}$ to $7.2x10^{-3}$	$1.3x10^{-4}$
Minjur	Riyadh	$1x10^{-2}$ to $1.6x10^{-2}$	..

Source: Saudi Arabia, Ministry of Agriculture and Water, "Water and development in the Kingdom of Saudi Arabia", by M.N. Othman, (Jeddah, 1983).

The results of investigations carried out to asses the ground-water resources potential in these aquifer systems are summarized as follows:

Table 6. Ground-water resources potential of the GW11 aquifer system

Aquifer	Annual recharge (MCM)	Ground water in storage (MCM)		
		Proven Reserve	Probable Minimum	Probable Maximum
Saq[a,b]	230	6.5×10^4	1×10^5	2×10^5
Wajid[a,b]	114	3×10^4	5×10^4	1×10^5
Tabuk[c]	..	..	1.3×10^3	..
Mainjur[a]	80	1.7×10^4	3.5×10^4	8.5×10^4

Sources: Arab Center for the Studies of Arid Zones and Dry Lands, Preparation and Updating of Hydrogeological Maps of the Dammam Formation: Phase I of Mapping Project, final report, (Damascus, 1986); Arab Center for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Arab Economic Development, "Water resources and their utilization in the Kingdom of Saudi Arabia", a paper by M.N. Othman, M.S. Al-Kaltham and M.I. Buraithen presented at the Symposium on Water Resources and Their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic); BAAC and WRDP, Water Resources of Saudi Arabia: Vol. I, National Water Plan, a report prepared for the Ministry of Agriculture and Water, (Saudi Arabia, 1979).

a/ Egypt, Ministry of Public Works and Water Resources, Water Research Institute, Research Institute for Groundwater, Hydrogeological Map of Egypt, (Cairo, 1988);

b/ Saudi Arabia, Ministry of Agriculture and Water, "Water and development in the Kingdom of Saudi Arabia", by M.N. Othman, (Jeddah, 1983);

c/ Jordan, Natural Resources Authority, "Groundwater resources in the Jordan Valley," by B. Hirzallah (Amman, 1973).

(b) Ground-water quality: Water of good quality for domestic uses, industry, irrigation and livestock watering is available from various members of the Paleo-Triassic aquifer system. The dissolved-solids content of ground water from the Saq aquifer does not generally exceed 1,000 ppm, although water in the deeper horizons usually has a higher dissolved-solids content and is of a sodium-chloride type. Fresh water from the Wajid aquifer is of a bicarbonate type; the dissolved-solids content is commonly less than 1,000 ppm. Water from the Tabuk aquifer (mainly at lower and middle levels) is generally of fair to good quality; it ranges from 400 ppm to 3,500 ppm of total dissolved solids.[3/] Water from the Minjur aquifer is of a calcium-sodium/sulphate-chloride type; the concentration of sodium and chloride ion concentration increases with depth. The thermal waters of the formation contain considerable amounts of carbon dioxide.

F. Central Arabia sandstone aquifer system (GW12)

(a) Aquifers and areal extent: The Cretaceous aquifer system comprises the Biyadh and Wasia sandstones in Saudi Arabia. Their combined thickness is about 1,000 m. Ground water occurs under unconfined conditions, especially in the aquifer's outcrop, which extends over a vast area (from Wadi Al-Dawasir in Saudi Arabia to Rutba in Iraq). The dissolved-solids content of the lower member, the aquifer in the outcrop (recharge) area, is about 150 ppm. In the Kharj area, the dissolved solids range from 550 ppm to 900 ppm. The water quality of the Wasia sandstone aquifer varies widely from one place to another. The TDS ranges in the outcrop area from 1,000 ppm to 3,000 ppm, while the water in the Biyadh aquifer stagnates, and its TDS values rise substantially -- from 4,000 ppm to 80,000 ppm to 150,000 ppm. The Wasia aquifer then carries on with a TDS content of 4,000 ppm to 5,000 ppm.[18/]

(b) Ground-water resources: Ground-water resources in the Biyadh and Wasia aquifers has been estimated by various consultants to have a potential annual recharge of 252 MCM[18/] and 420 MCM,[17/] respectively. The quantity of water in storage is estimated at 120 BCM, though it is probable that storage amounts to as much as 290 BCM.[3/]

The hydraulic characteristics of the Cretaceous aquifer system vary widely in the extensive confined and unconfined parts of the hydrogeological systems. For many areas in Kuwait, Iraq, Jordan and northern and southern Saudi Arabia, information is scarce or incomplete. In some areas, the aquifer is either saline or unproductive, and its development is consequently not feasible.

The hydraulic parameters of the aquifer system, compiled from various regional and national sources, is presented in the following table:

Table 7. Hydraulic parameters of the Cretaceous aquifer system of central Arabia

Aquifer	Area	Transmissivity (m^2/s)	Storativity
Biyadh	Wadi Nasah	$1x10^{-2}$ to $1.5x10^{-2}$	$1.1x10^{-1}$ to $1.3x10^{-1}$
"	Kharj	$1x10^{-2}$	..
"	Biyadh	$9.3x10^{-3}$ to $1.1x10^{-2}$	..
"	Sahbah	$1.4x10^{-1}$	..
Wasia	Khrais	$5.2x10^{-2}$ to $9.7x10^{-2}$	..
"	Riyadh	$2x10^{-2}$	$2x10^{-4}$
"	Abkik	$1.7x10^{-4}$	..
"	Shadkan	$9.5x10^{-3}$	..
"	Hufuf	10^{-5}	..
"	Hefr Al-Batin	$3.8x10^{-3}$ to $4.8x10^{-3}$	..
Skaka	Skaka	$3x10^{-4}$ to $2.8x10^{-3}$	$6.7x10^{-4}$ to $9.8x10^{-4}$
Tayarat	Rutba	$1.0x10^{-3}$ to $1.0x10^{-4}$	$1x10^{-2}$

G. Eastern Arabia Tertiary carbonate aquifer system (GW13)

Aquifers and areal extent: The aquifers consist primarily of limestones and dolomites. The wole sedimentary complex is hydraulically interconnected and is a recharging-discharging aquifer system.18/ The subdivisions (or main aquifers) are as follows:

(a) The Um Al-Radhumah aquifer is composed of limestone and dolomites, and ranges between 240 m and 700 m in thickness. It occurs in Saudi Arabia, Kuwait, Iraq, Qatar, the United Arab Emirates and Oman;

(b) The Dammam aquifer is composed of limestone and dolomite interbedded with shale, with a thickness ranging between 20 m and 500 m. It occurs in Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates and Oman;

(c) The Neogene aquifer is composed of sandstone, sandy marl and chalky limestone of variable thicknesses. It occurs in Kuwait, Qatar, the United Arab Emirates and Oman.

The Tertiary carbonate aquifers of eastern Arabia has been investigated by the Food and Agriculture Organization of the United Nations (FAO).18/ Ground-water recharge into the aquifer is estimated at 1,150 MCM, while the estimated discharge from the system is 1,200 MCM. Other estimates for the recharge of the Um Al-Radhumah, Dammam and Neogene aquifer members are 406 MCM, 200 MCM and 238 MCM,3/ respectively. Fresh water is relatively rare in the aquifer complex, and occurs in the upper and lower zones of the hydrodynamic system.

Water in the unconfined part of the Um Al-Radhumah aquifer is mainly of a sulphate or chloride type. The TDS concentrations range from 300 ppm to 700 ppm, though water of good quality (900 ppm to 1,400 ppm) may be encountered in some localities. In Bahrain and Qatar, the aquifer is highly saline, with a TDS content of 6,000 ppm to 17,000 ppm. The TDS content in the Dammam aquifer member ranges from 1,000 ppm to 6,000 ppm. Good water quality in the upper reaches of the aquifer system may be encountered.

H. Nubian sandstone aquifer system (GW19)

This system is made up of a sequence of continental sandstones and sands intercalated with argillaceous beds of the Carboniferous to the Middle Cretaceous ages.19/ Its thickness reaches up to several thousands metres.

In the eastern desert of Egypt, the Nubian sandstone complex is a water-bearing formation where ground water occurs under confined artesian condition (flowing wells). Water can be obtained there from shallow carbonate and deep sandstone formations. The deeper water-bearing formations are more extensive and contain larger quantities of ground water. The thickness of the Nubian aquifer complex in the central eastern desert is about 400 m.

In the Sinai Peninsula, the Nubian sandstone complex is the principal aquifer. The depth to the aquifer is, on the average, 700 m to 900 m in central Sinai, increasing north-westward, to about 2,500 m along the Mediterranean coast. Artesian pressure in central Sinai is about 200 m above sea level.

Ground water encountered in the Nubian aquifer system is generally of excellent quality. Its TDS content ranges from 100 ppm to 800 ppm. The volume of stored ground water in the aquifer system in Egypt (western, eastern desert and Sinai) is estimated at 5,000 BCM.[17/]

Ground-water abstraction from the Nubian aquifer system in different areas where it occurs is estimated as shown in the following (tables 8 and 9):

Table 8. Ground-water extraction in Egypt, 1984

Hydrogeological area	Total (MCM)	Drinking (MCM)	Irrigation (MCM)	Number of wells
Nile Delta	920	620	300	4 030
Cairo	300	300	--	150
Nile Valley	760	260	500	4 800
Western desert	440	5	435	300
Eastern desert	5	0.5	4.5	20
Sinai	35	4	31	80
Total	2 460	1 189.5	1 270.5	9 380

Source: Egypt, Ministry of Public Works and Water Resources, Water Research Institute, Research Institute for Ground water, Hydrogeological Map of Egypt, (Cairo, 1988).

Table 9. Ground water extracted from the Nubian sandstone aquifer in each oasis

Oasis	Quantity of exploitable water (MCM)	Extraction in 1981 (MCM)
Kharga	70	78
Dakhla	430	198
Farafra	364	1
Bahraniya	100	50
Siwa	140	65
Total	1 104	392

Source: International Bank for Reconstruction and Development, in a joint project with the United Nations Development Programme and the Egypt Ministry of Irrigation, Water Master Plan of the Arab Republic of Egypt, technical reports 1-22, 1981, (UNDP-EGY/73/024).

Local ground water is extracted in the eastern desert, but quantities do not exceed 5 MCM to 10 MCM.

Ground-water extraction for agricultural use in the Sinai occurs predominantly along the northern coastal (Al-Arish) area. Average annual withdrawal is about 30 MCM.[1/]

VI. NON-CONVENTIONAL WATER RESOURCES

Because of their limited water resources and an overdraft situation which has resulted in reduced quantity and quality of the oil-producing countries have turned to the sea for their fresh-water supply. Considerable progress in desalination activities has been made in recent years.

The Gulf States are generally considered world leaders in non-conventional water-resources production, particularly in desalinating sea water and/or brackish ground water. Since the United Nations Water Conference (Mar del Plata, 1977), substantial progress has been made in desalination techniques, improving skilled manpower capabilities to maintain and operate desalination plants, and the progressive cost reduction of desalination per unit volume of water produced.

In Bahrain a long-term water-resources development policy is to produce distilled sea water and blend it with brackish ground water to bring the quality up to acceptable drinking-water standards. At Sitra desalination multi-stage-flash (MSF) plant, water production was increased from 5 MCM in 1975 to 35 MCM in 1985. Brackish ground-water desalination using reverse osmosis (RO) also increased from 14 MCM in 1975 to 28 MCM in 1988. Figure X shows Bahrain's development of desalinated water production as of 1980, and as projected up to the year 2000.

In Kuwait about one million cubic meters are produced daily from five MSF desalination plants. Figure XI shows the distilled and fresh-water production in Kuwait during the period 1954-1984.

In Qatar, desalinated water production was estimated at 96 MCM in 1986.

In 1976, an MSF desalination plant with a capacity of 4.8-7.2 million gallons/day (mgd) was constructed in the area of Oman's capital, Muscat. In 1982, a second MSF facility with the same capacity went into operation. In addition, two small brackish-water reverse-osmosis desalination plants have been constructed in Oman, bringing total current desalinated-water production to about 20 MCM/a.

Because of the limited conventional supplies available, Saudi Arabia came to rely heavily upon desalinated-water production to meet its domestic water demand. Since the creation of the Saline Water Conversion Corporation in 1965, several MSF and RO desalination plants have been set up in the country. Saudi Arabia is considered first in world desalinated-water production (sea water and brackish ground water). The production rate is reported to be 930 MCM/a. Some of the water produced is piped 485 kilometres inland to the capital, Riyadh.

Sea and brackish ground-water desalination is considered a major water-supply component providing most of the domestic water requirements in the United Arab Emirates. Total desalinated-water production capacity is reported to be about 163 MCM/a at present.

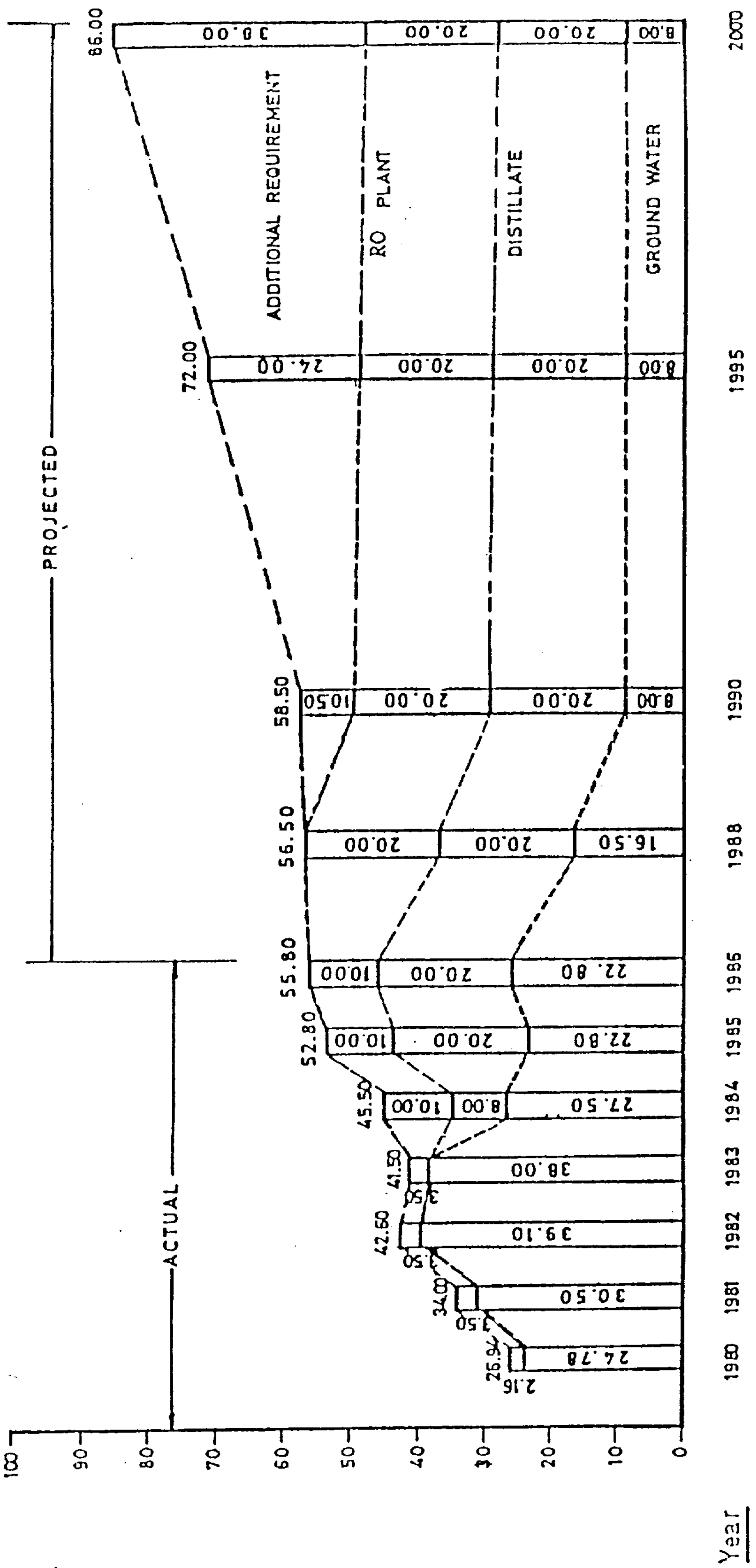
Due to the limited water resources available in most member States of ESCWA, the augmentation of conventional water supplies by non-conventional sources has become an important activity for developing such resources in the region. Waste-water reuse has been practised in some ESCWA member States for a considerable period of time; however, its application has been limited, and plans have been formulated for the large-scale development of this non-conventional supply source. Lack of knowledge of the long-term effects of treated sewage effluent use for various purposes and the unavailability of other water resources have limited the reuse of treated waste water on a wider scale. The development of new technologies and the rising costs of desalinating water have led to increased waste-water reuse during the last decade in the ESCWA region. Water reuse, whether in agriculture or for other purposes, still entails certain risks to humans, and must therefore be carefully monitored and controlled and its overall cost considered.

Jordan, the Gulf Cooperation Council States and Egypt have practised the application of waste-water reuse in agriculture and public gardening. Table 10 below shows the present and future (projected) treated sewage effluent use in these countries.

Table 10. Future treated sewage effluent in some ESCWA countries

Country	Volume of waste-water reuse (MCM)		Use
	Present	Future	
Bahrain	65	..	Gardening
Kuwait	40	..	"
Oman	9	..	"
Qatar	120	..	Irrigation
Saudi Arabia	400	..	"
United Arab Emirates	62	..	Gardening
Egypt	600	1 000	Irrigation
Jordan	35	116	"
Total	1 331	1 116	

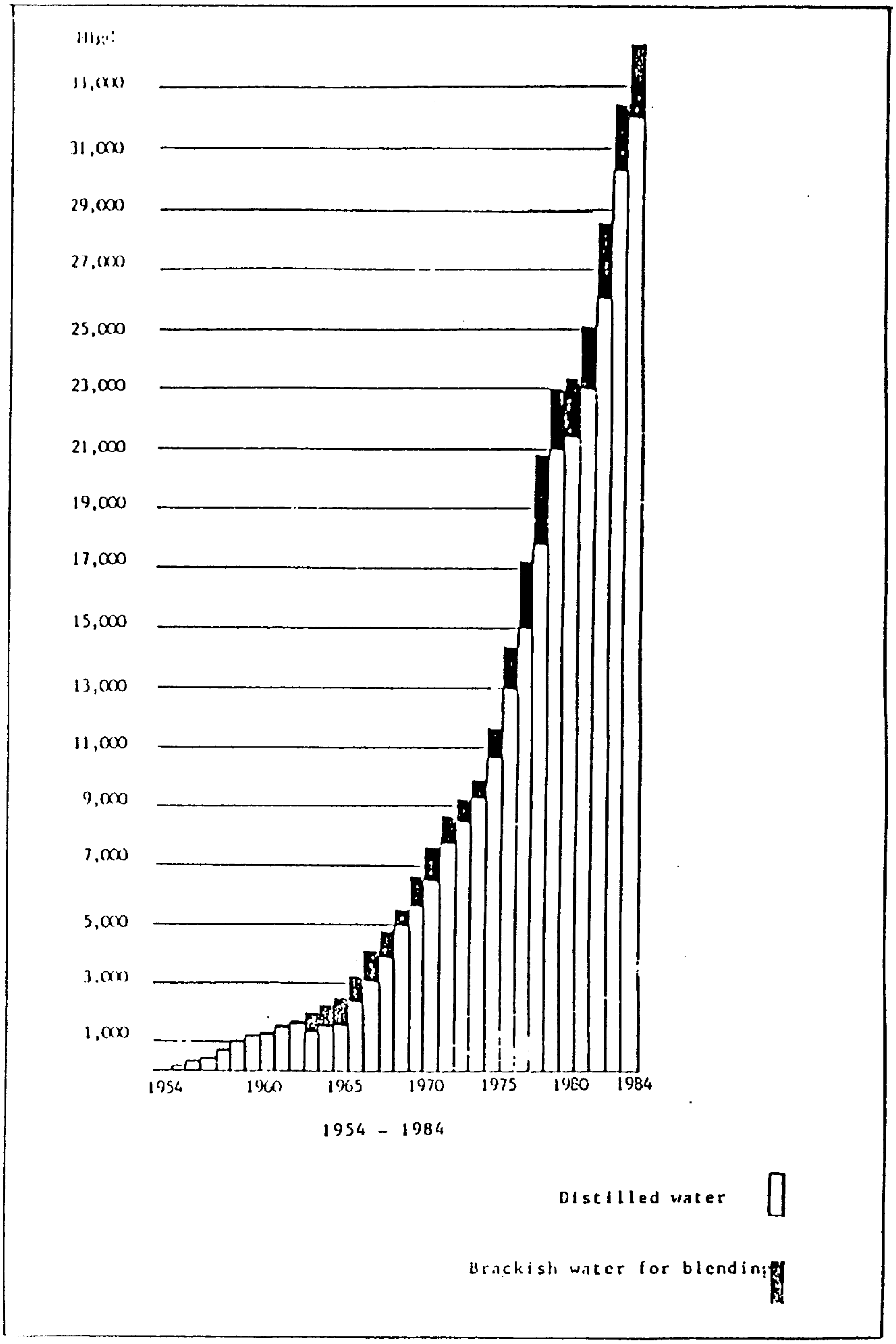
Figure X. Resources supply and demand in Bahrain, 1981-2000



Daily demand in millions of gallons

Source: Data supplied by Bahrain, Ministry of Electricity and Water, 1986.

Figure XI. Distilled and fresh-water production in Kuwait, 1954-1984



Source: Data supplied by Kuwait, Ministry of Electricity and Water.

VII. MONITORING SYSTEMS AND TIME-SERIES DATA ON WATER RESOURCES

A. Monitoring networks

In many countries of the region, significant progress has been made in establishing water-resources (surface- and ground-water) observational networks, which serve as tools for carrying out better, more realistic water-resources assessments and more efficient water planning, and also for the establishment of a good water database. Tables 11 to 17 show the monitoring-network systems established in the ESCWA region. As the tables reflect, none of the member States have networks covering the country in accordance with World Meteorological Organization (WMO) standards. Plans to strengthen and improve the existing monitoring systems in some member countries are being considered.

Table 11. Monitoring networks in the ESCWA region

Country	Meteorological stations		Hydrological stations	Hydrogeological stations	Records	Remarks
	Rainfall only	Meteorologcial				
Lebanon	47	38	124	327	1921-1975 (Rainfall) 1931-1975 (Hydrometry)	Monitoring system has deteriorated since 1975
Syrian Arab Republic (Damascus basin)	41	19	115	408	..	Table 12 shows details
Iraq	107	15	164	..	About 60 years (Met.) 30-75 years (Hydrometry)	
Jordan	296	25	33	228	10-88 Years (Met.) Since 1960 (Hydrometry & Hydrogeology)	Tables 13 and 14 show details
Saudi Arabia	529	52	267	502	Since 1960s for all	
Kuwait	..	2	..	133	Since 1961 for all	
Bahrain	..	2	..	64	15-18 Years (Met.) Since 1980 (Ground water)	Figure X shows observation network
Qatar	30	3	42 (ad hoc)	160	1966?-1990 (Met. Stns.)	Figure XI shows observation stations in Qatar
United Arab Emirates	27	10	19	239	Since 1980 (Hydrology) Since 1971(Hydrogeology)	Figure XII shows observation in UAE; detailed in table 15
Oman	..	..	52	820	Since 1970s (20-70 years)	
Yemen	..	15		449 (N) 223 (S)	Since 1982 (variable in some areas)	Figure XIII shows the observation stations, detailed in tables 16 and 17
Egypt	..	..	200 (Including other Nile-sharing countries)		More than 50 years	Figure XIV shows observation stations in Egypt

Table 12. Hydrological, hydrometeorological and hydrogeological observation networks in the Damascus Basin

Network	Number of stations		Density (km^2 per station)	Station records (Years)
	Recording	Non-recording		
Meterological				
Precipitation	--	41	200	15-30
Climate	19	--	421	16-44
Hydrological				
Permanent station	11	20	258	7-60
Project station	--	23	--	3
Springs (permanent)	1	61	--	15-50
Hydrogeological				
Permanent regime	--	159	503	5-11
Temporary project	--	229	--	5
Special project	20	--	--	5
(Fijeh)	--	--	--	--

Source: A. Al-Mesky, "Meteorological and hydrological networks in the Damascus Basin", a paper presented at the Damascus Basin Seminar, Damascus, 27-29 October 1990, (in Arabic).

Table 13. The hydrological network in Jordan

Basin name	Rainfall stations			Water level	Evaporation stations	
	Daily	Recorders	Totalization	recorders	Recording	Non-recording
Yarmouk	12	5	--	3	1	1
Zarqa	57	11	1	6	6	3
East Jordan side wadis	29	10	--	3	1	4
Dead Sea side wadis	32	19	4	8	3	5
Wadi Araba	19	10	--	5	3	--
Dead Sea	2	1	10	2	2	--
Desert	8	13	21	6	3	2
Total	159	69	36	33	19	15

Source: Economic and Social Commission for Western Asia, "The Jordanian experience in development and planning of water resources", paper presented by K. Radaideh at the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region, Damascus, 13-16 November 1989 (E/ESCWA/NR/1990/3).

Table 14. Regional density of rainfall stations in Jordan

	Size (km^2)	No. of stations 1960	No. of stations 1975	Density, 1975 (km^2 per station)	No. of stations, 1988	Density, 1988 (km^2 per station)
Yarmouk River Basin (Jordanian part)	1 475	36	41	36	47	31
Jordan river (East bank)	6 237	31	60	104	98	64
Dead Sea Basin	10 449	16	39	268	55	190
Wadi Araba Basin (north)	2 938	7	16	184	20	147
Wadi Araba Basin (south)	6 100	1	14	436	21	290
Desert areas	62 801	8	39	1 610	53	1 185
Total	90 000	99	209	431	294	306

Source: Economic and Social Commission for Western Asia, "The Jordanian experience in development and planning of water resources", paper presented by K. Radaideh at the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region, Damascus, 13-16 November 1989 (E/ESCWA/NR/1990/3).

Table 15. Hydrometeorological network in the United Arab Emirates

Wadi	Catchment Area (km^2)	Number of stations: Rainfall recording	Number of stations: Climatic	Number of stations: Wadi gauge recording	Network density (Stations per 10^3 km^2): Rainfall	Network density: Climatic	Network density: Wadi gauge
Bih	475.00	--	--	1	--	--	2.20
Nagab	90.00	-	--	1	--	--	10.80
Shimal	270.00	2	1	6	7.40	3.70	22.20
Zikt	72.00	1	--	--	13.70	--	--
Samah	71.00	2	--	--	--	2.80	--
Wurrayal	129.00	--	--	1	--	--	7.70
Siji	87.60	4	1	1	45.00	11.40	11.40
Ashwani	46.00	--	--	2	--	--	43.00
Ham	40.40	1	--	1	11.00	--	11.00
Slfuni	104.00	1	--	1	9.60	--	9.60
Nasas	110.00	-	1	--	--	9.00	--
Aghor	335.00	2	--	1	5.90	-	2.90
Hulu	185.00	2	1	--	10.00	5.40	--
Hatto	415.00	1	1	--	2.40	2.40	--

Source: Arab Center for the Studies of Arid Zones and Dry Lands, "Surface hydrology of the northern part of the United Arab Emirates", a paper presented by F. Al-Chami at the Seminar on Surface Water Hydrology in the Arab Region, 11-17 September 1985, (ACSAD/HS/P49).

Table 16. Monitoring network density in North Yemen

	Catchment	Rainfall No. of stations per $10^3 km^2$	Evaporation No. of stations per $10^3 km^2$	Wadi Gauge No. of stations per $10^3 km^2$
North and South Tehama	N. Tehama	5.3	0.9	1.8
	Wadi Mawr	11.3	3.2	11.3
	Wadi Surour	3.2	0.8	0.8
	Wadi Siham	6.9	0.5	0.5
	Wadi Riha	4.6	0.3	0.3
	Wadi Zabid	2.8	0.9	0.5
	Wadi Naklah, Damin, etc.	0.3	--	0.3
	Wadi Rasyan	1.2	0.8	--
	Wadi Nawza	--	0.2	--
East	Wadi Najran	1.8	1.3	--
	Rub Al-Khali	--	0.9	--
	Wadi Jawf	5.6	14.0	1.4
	Wadi Adhanah	34.0	6.3	3.8
	Ramlat Al-Sabatayn catchment	5.2	--	--
South	Wadi Tuban	0.5	--	--
	Wadi Bana	3.1	0.6	--
Average, North Yemen:		6.256	2.000	0.872

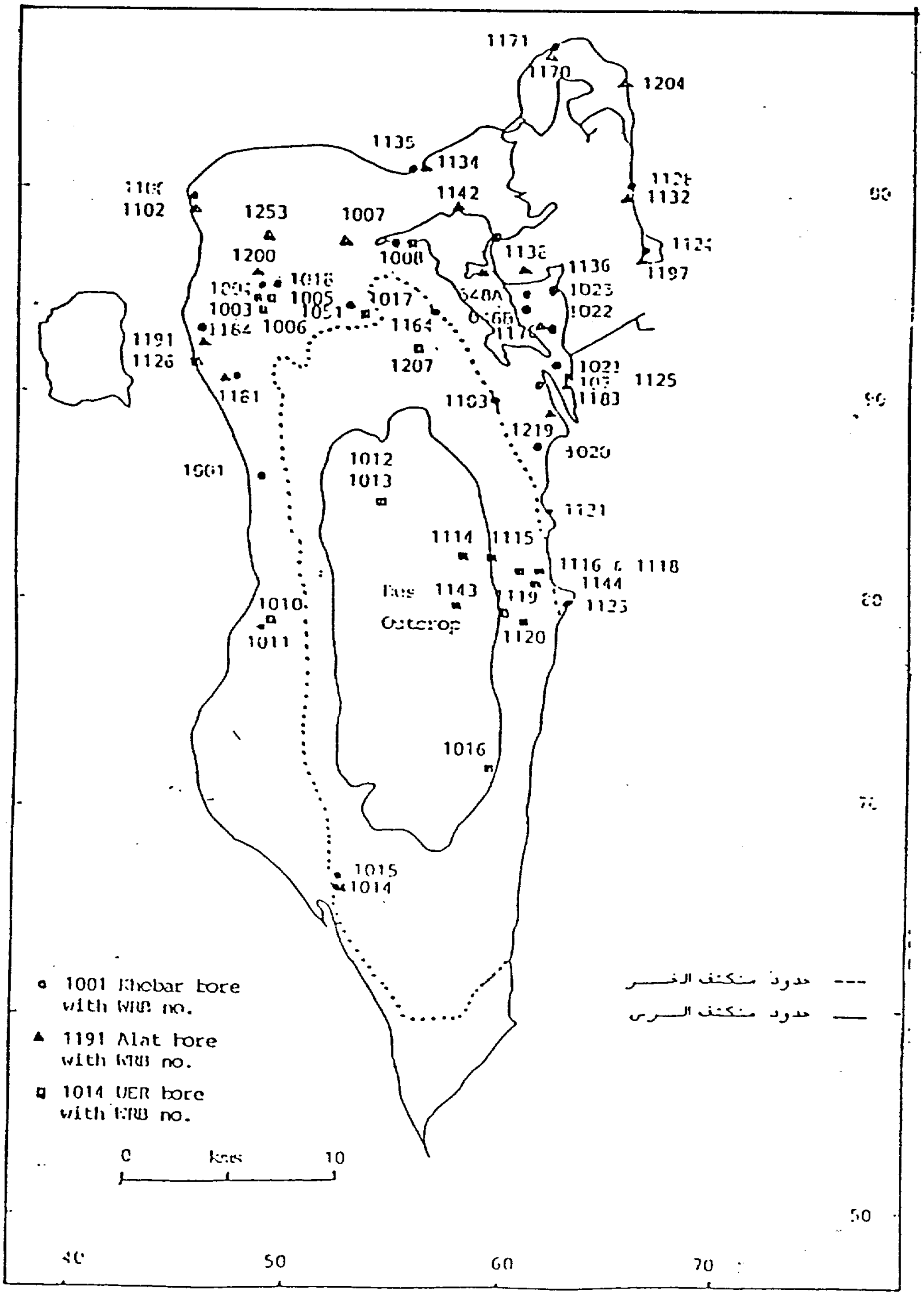
Source: Economic and Social Commission for Western Asia, "Prospects for water resources development in Democratic Yemen", paper presented at the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region, Damascus, 13-16 November 1989, (E/ESCWA/NR/1990/3).

Table 17. Hydrometeorological networks in the southern wadi system of Yemen

Wadi	Area (km^2)	Number of stations			Network density/km^2		
		Rainfall	Meteorological	Wadi gauge	Rainfall	Meteorological	Wadi gauge
Hadramaut	22 450	11	1	10	0.49	0.05	0.44
Maifaah	5 930	2	1	1	0.33	0.17	0.17
Beiaan	3 600	5	3	2	1.40	0.83	0.55
Ahwar (Delta)	6 400	1	1	1	0.18	0.16	0.16
Bana	7 200	4	1	2	0.55	0.13	0.28
Tuban	5 600	8	8	5	1.40	1.40	0.90
Maaden	180	1	1	2	5.50	5.50	11.00

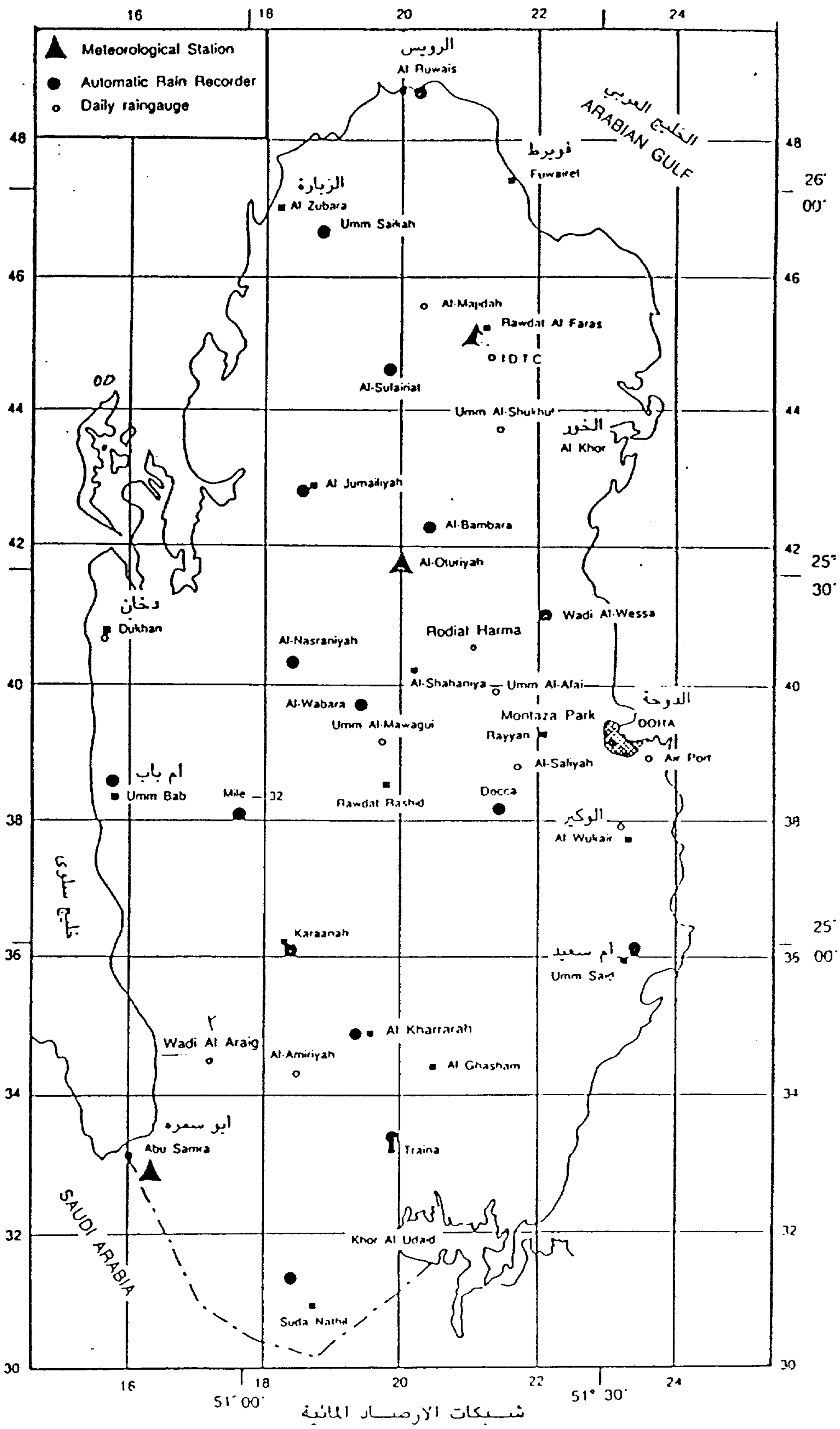
Source: Economic and Social Commission for Western Asia, "Prospects for water resources development in Democratic Yemen", paper presented at the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region, Damascus, 13-16 November 1989, (E/ESCWA/NR/1990/3).

Figure XII. Location of observation wells (Bahrain)



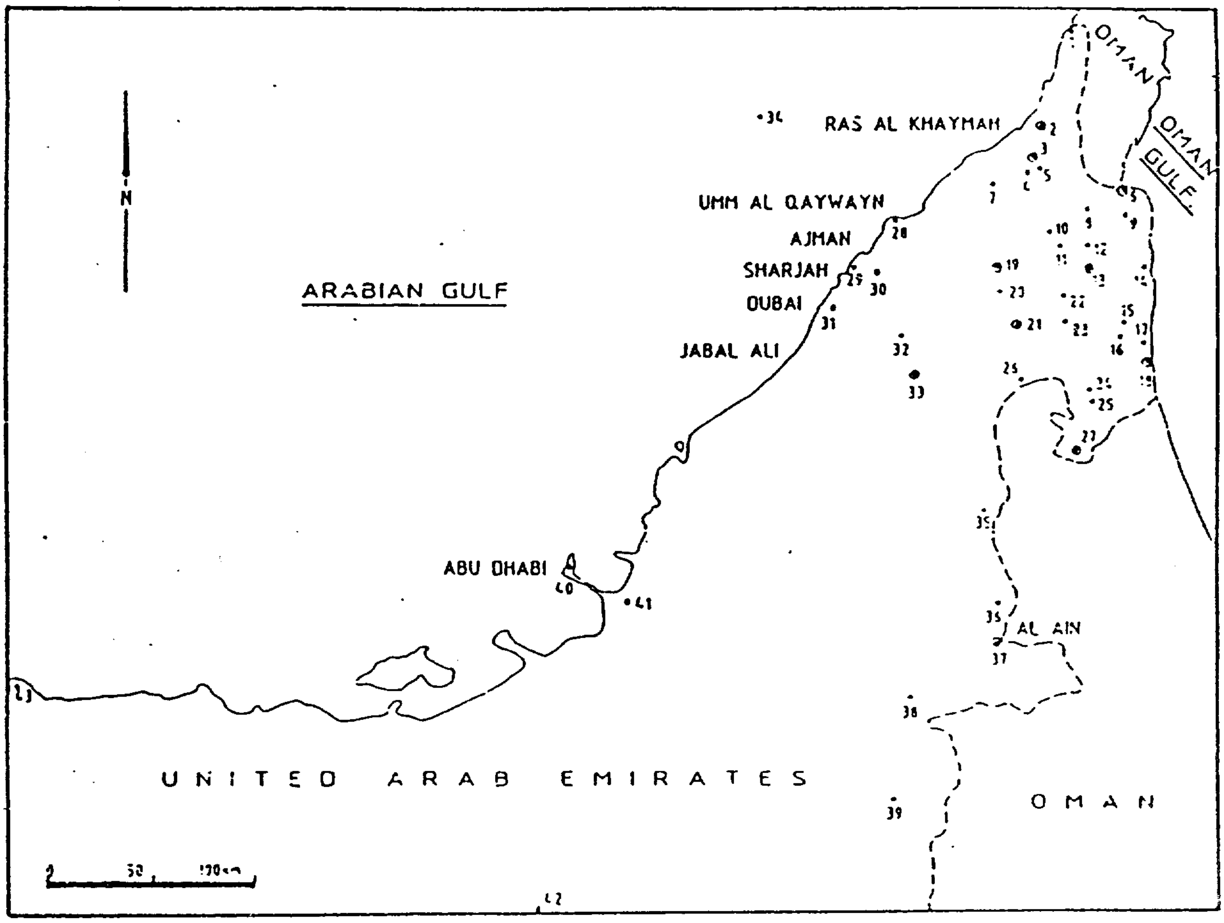
Source: Arab Centre for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Economic and Social Development, "Water resources and their utilization in the State of Bahrain", a paper by K. Al-Mansour and A. Al-Aradi presented at the Symposium on Water Resources and Their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

Figure XIII. Meteorological network (Qatar)



Source: Qatar, Ministry of Water and Electricity, Department of Agriculture and Water Research, Doha, "Groundwater in Qatar", by I.E. Harhash and A.M. Yousef, (Doha, 1985).

Figure XIV. Locations of meteorological stations in the United Arab Emirates



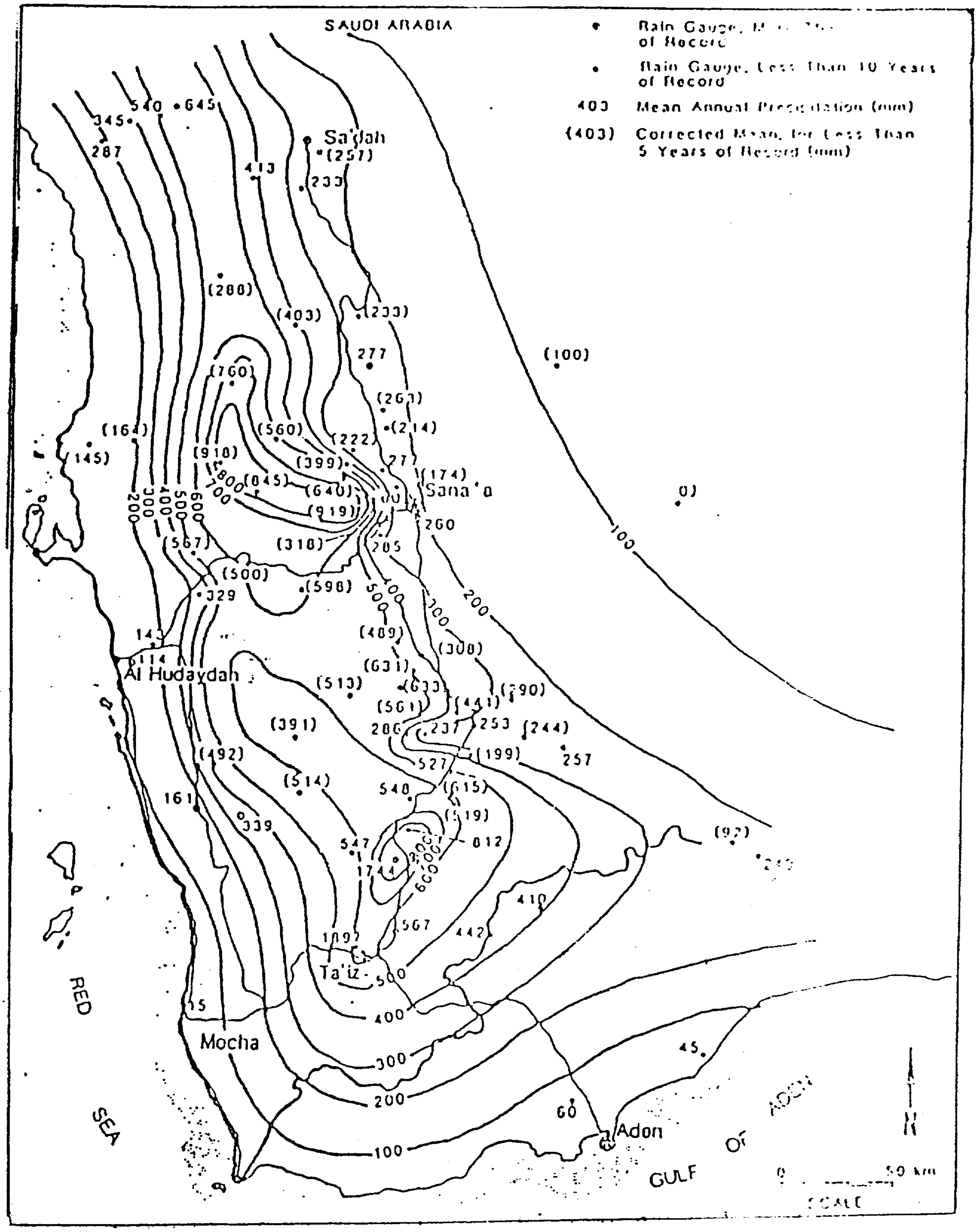
01	Sham	23	Sifuni
02	Burayrat	24	Munai
03	Digdaga	25	Howeilat
04	Ras Al Khaymah Airport	26	Fili
05	Khatt	27	Masfut
06	Diba	28	Umm Al Qaywayn
07	Hamraniyah	29	Sharjah
08	Sinnan	30	Sharjah Airport
09	Zikt	31	Dubai Airport
10	Idhn	32	Awir
11	Ghayl	33	Hibab
12	Asimah	34	Mubarrak Island
13	Masafi	35	Al Hayer
14	Khor Fakkan	36	Al Dha
15	Bithnah	37	Al Ain
16	Farfar	38	Ain Sukhnah
17	Fujayrah	39	Al Wagan
18	Kaiba	40	Abu Dhabi Old Airport
19	Falaj Al Mualla	41	Abu Dhabi New Airport
20	Dhayd	42	Asab
21	Mileiha	43	Jabal Dhannah
22	Siji		

LEGEND:

- • = Rainfall station
- ⊙ = Climatological station
- • = Airport Meteorological Station

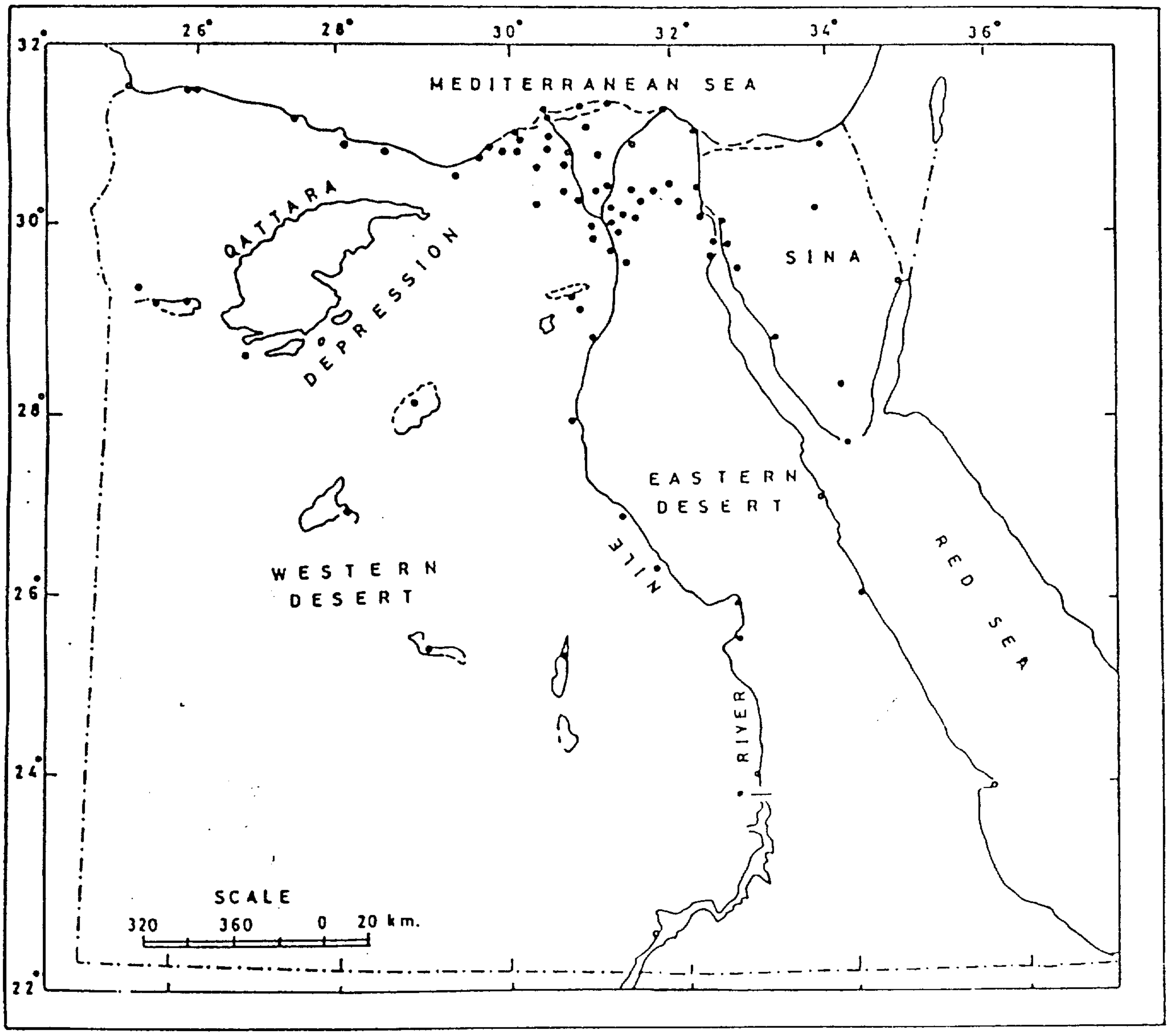
Source: Economic and Social Commission for Western Asia, "The safeguarding of water resources in the United Arab Emirates" a paper presented at the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region, Damascus, 13-16 November 1989, (E/ESCWA/NR/1990/3).

Figure XV. Distribution of mean annual precipitation in the Republic of Yemen



Source: Yemen, Sana'a Basin water resources assessment, Wash Field Report No. 164-A; June, 1986. Based on Figure 4-5 in Hydrology and Hydrogeology of the Yemen Arab Republic, Yominco, TNO-DGV.

Figure XVI. Rainfall network in Egypt



Source: Egypt, Ministry of Public Works and Water Resources, Water Research Institute, Research Institute for Groundwater, Hydrogeological Map for Egypt, (Cairo, 1988).

B. Regional water-resources data

Table 18. Conventional water resources in the ESCWA region

Country	1 Surface water (MCM)	2 Ground water Recharge (MCM)	3 Ground water Stored (MCM)	1+2 Total water resources (MCM)	Population in 1985 (Millions)	Per capita water share (m^3)
Bahrain	..	90	..	90	0.367	245
Egypt	62 000	4 500	6 000 000	66 500	46.923	1 417
Iraq	80 000	1 000	..	81 000	15.601	5 192
Jordan	900	590	12 000	1 490	2.645	563
Kuwait	..	160	..	160	1.498	107
Lebanon	4 800	3 000	1 316	7 800	3.435	2 271
Oman	1 470	564	..	2 034	1.016	2 002
Qatar	..	55	2 500	55	0.178	309
Saudi Arabia	3 208	2 338	354 050	5 546	10.116	548
Syrian Arab Republic	22 100	2 935	..	25 035	10.600	2 362
United Arab Emirates	150	134	5 000	284	0.772	378
North Yemen	2 100	1 000	..	3 100	2.248	1 379
South Yemen	1 400	400	..	1 800	5.815	310
Total	178 128	16 766	6 374 866	194 894	101.214	..

Sources: Arab Center for the Studies of Arid Zones and Dry Lands and the United Nations Educational, Scientific and Cultural Organization, Water Resources of the Arab Region by J. Khouri and A. Droubi, (Damascus, 1990), (ACSAD/UNESCO Pub. HS/R 68). Arab Center for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Economic and Social Development, "Water resources development in the Arab world and their future prospects", a paper by J. Khouri and W.R. Agha presented at the Symposium on Water Resources and Their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

Table 19. Domestic water-demand projections for the ESCWA region
(MCM)

Country	Year 1985	2000	2010	2020	2030
Bahrain	27	46	67	87	111
Egypt	1 267	2 578	3 960	5 362	7 090
Iraq	863	1 290	1 928	2 691	3 474
Jordan	116	216	323	450	581
Kuwait	109	187	271	356	453
Lebanon	151	280	419	585	755
Oman	74	127	184	242	307
Palestine	192	355	532	742	958
Qatar	13	22	32	42	54
Saudi Arabia	738	1 261	1 832	2 406	3 056
Syrian Arab Republic	466	865	1 293	1 805	2 330
United Arab Emirates	56	96	140	184	233
North Yemen	157	319	488	664	879
South Yemen	61	123	189	257	340
Total	4 290	7 765	11 658	15 873	20 621

Sources: Arab Center for the Studies of Arid Zones and Dry Lands and the United Nations Educational, Scientific and Cultural Organization, Water Resources of the Arab Region by J. Khouri and A. Droubi, (Damascus, 1990), (ACSAD/UNESCO Pub. HS/R 68). Arab Center for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Economic and Social Development, "Water resources development in the Arab world and their optimum use", a paper by S. Asad and N. Rofaeil presented at the Symposium on Water Resources and Their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

Table 20. Utilized water resources in the ESCWA region

	1	2	3	4	1+2	3+4	1+2+3+4
					Total utilized water		
Country	Surface water (MCM)	Ground water (MCM)	Desali- nated water (MCM)	Treated effluent (MCM)	Conven- tional (MCM)	Non- conven- tional (MCM)	Total (MCM)
Bahrain	..	153	16	1	153	17	170
Egypt	55 500	1 500	--	7 500	57 000	7 500	64 500
Iraq	45 000	1 200	--	..	46 200	--	46 200
Jordan	230	482	--	..	712	--	712
Kuwait	--	217	357	80	217	437	654
Lebanon	700	500	--	..	1 200	--	1 200
Oman	..	400	15	9	400	23.6	423.6
Qatar	--	112	67	20	112	87	199
Saudi Arabia	450	3 000	903	217	3 450	1 120	4 570
Syrian Arab Republic	4 734	1 666	--	..	6 400	--	6 400
United Arab Emirates	--	300	276	0.8	300	276.8	576.8
North Yemen	750	900	--	..	1 650	--	1 650
South Yemen	700	300	--	..	1 000	--	1 000
Total	108 064	10 730	1 634	7 827.80	118 794	9 461.4	128 255.4

Sources: Arab Center for the Studies of Arid Zones and Dry Lands and the United Nations Educational, Scientific and Cultural Organization, Water Resources of the Arab Region by J. Khouri and A. Droubi, (Damascus, 1990), (ACSAD/UNESCO Pub. HS/R 68). Arab Center for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Economic and Social Development, "Water resources development in the Arab world and their future prospects", a paper by J. Khouri and W.R. Agha presented at the Symposium on Water Resources and Their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

Table 21. Industrial water-demand projections for the ESCWA region (MCM)

Country	Year 1985	2000	2010	2020	2030
Bahrain	7	23	43	70	111
Egypt	127	645	1 386	2 145	3 345
Iraq	215	529	1 060	1 749	2 606
Jordan	58	143	258	405	581
Kuwait	55	123	217	320	453
Lebanon	75	185	335	527	755
Oman	27	84	147	218	307
Qatar	3	9	18	27	41
Saudi Arabia	74	315	641	962	1 528
Syrian Arab Republic	117	355	711	1 173	1 748
United Arab Emirates	14	48	91	147	233
North Yemen	15	50	104	167	255
South Yemen	39	131	268	432	659
Total	826	2 640	5 279	8 342	12 622

Sources: Arab Center for the Studies of Arid Zones and Dry Lands and the United Nations Educational, Scientific and Cultural Organization, Water Resources of the Arab Region by J. Khouri and A. Droubi, (Damascus, 1990), (ACSAD/UNESCO Pub. HS/R 68). Arab Center for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Economic and Social Development, "Water resources development in the Arab world and their optimum use", a paper by S. Asad and N. Rofaeil presented at the Symposium on Water Resources and Their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

Table 22. Rainfall and stream-flow data of the main rivers in the ESCWA region

Country	Area ($10^3 km^2$)	Average annual rainfall (mm)	Rainfall volume (BCM)	River flow (BCM)	Rainfall zoning: Less than 100 mm (BCM)	Rainfall zoning: 100-300 mm (BCM)	Rainfall zoning: More than 300 mm (BCM)
Jordan	94.5	50-650	8.5	0.88	3.99	2.74	1.77
Iraq	438.3	50-1200	99.9	104a/	4.72	54.49	40.69
Syrian Arab Republic	185.2	150-1000	52.7	33.7a/	0.55	25.37	26.78
Lebanon	10.4	200-1500	9.2	4.80	..	0.10	9.10
Palestine	27.0	100-1000	8.0	4.0	0.09	1.16	6.75
Egypt	1 001.4	20-200	15.26	59.5a/	11.13	4.13	..
Saudi Arabia	2 240.0	35-400	126.8	2.2b/	89.46	24.65	12.69
United Arab Emirates	77.7	80-160	2.4	0.1b/	1.10	1.30	..
Kuwait	17.8	30-140	2.4	..	..	..	..
Bahrain	0.7	75	0.05	..	0.05	..	..
Qatar	11.4	75	0.8	..	0.8	..	..
Oman	300.0	80-400	15.0	1.37b/	5.44	7.62	1.94
North Yemen	200.0	100-1000	46.08	1.00b/	4.72	12.14	29.22
South Yemen	388.7	10-400	21.08	1.4b/	2.27	18.65	0.16
Total	4 993.1	..	408.17	..	124.32	152.35	129.1

Sources: Arab Center for the Studies of Arid Zones and Dry Lands and the United Nations Educational, Scientific and Cultural Organization, Water Resources of the Arab Region by J. Khouri and A. Droubi, (Damascus, 1990), (ACSAD/UNESCO Pub. HS/R 68). Arab Center for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Economic and Social Development, "Water resources development in the Arab world and their optimum use", a paper by S. Asad and N. Rofaeil presented at the Symposium on Water Resources and Their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

a/ Including river flows from neighbouring countries.

b/ Intermittent stream flows.

C. National water-resources data

Table 23. Water balance of principal hydrogeological basins in Lebanon

Basin	Precipitation		Infiltration (Aquifer recharge)		Evapo-transpiration		Run-off	
	(mm)	(MCM)	(MCM)	(m^3/s)	(MCM)	(m^3/s)	(MCM)	(m^3/s)
Mediterranean	1 163	6 396	1 980	63.0	3 454	109	962	31.0
Interior	711	3 340	1 048	33.3	1 988	63	303	9.5
Total	1 874	9 736	3 028	96.3	5 442	172	1 265	40.5

Source: United Nations Statistical Office, "Ground water in the eastern Mediterranean and western Asia", 1982 (ST/ESA/112).

Table 24. Hydraulic balance sheets for the Interior Province basin, Lebanon

Zone	Area	Surface Area (km²)	Rainfall (mm)	Rainfall (MCM)	Water deficit (mm)	Water deficit (MCM)	Infiltration (mm)	Infiltration (MCM)	Run-off (mm)	Run-off (MCM)	Total outflow (mm)	Total outflow (MCM)
Karstic areas	Barouk-Niha	160	1 300	210	708	110	520	88	82	12	602	100
	Jdita	8	1 300	10.4	700	5.6	515	4	85	0.7	600	4.7
	Hermon	420	890	370	490	205	350	145	50	20	400	165
	North-east of Serghaya	10	500	5.0	275	3	200	2.0	25	0.2	225	2.2
	Lebanon, from Jdita to the Syrian border	960	1 070	1025	596	571.0	440	420.0	34	34.0	474	454.0
	Anti-Lebanon, from the Wazzani source to the north frontier	1 115	600	670	340	380	222	250	38	40	260	290.0
	South of the Bekaa Valley (Karaoun-Tell Al-Deir)	60	1000	58.0	634	37.8	345	20.0	21	1	366	21
	South of the Bekaa Valley (Marjayoun-Anjar)	245	790	195.0	419	103.0	355	88	16	4	371	92.0
	East of the Bekaa Valley (Terbol-Ras Baalbek)	52	440	23	256	13	169	9	15	1	184	10
	West of the Bekaa Valley (Zahle-Chmistar)	17	600	10.5	350	6	230	4	20	0.5	250	4.5
Permeable areas	Al-Marj Bekaa Hermel	1 260	450	560.0	360	450	21	23	69	87	90	110
Dry areas	Bekaa Valley (in general)	393	510	200	260	102	--	--	250	98	250	98
Total (rounded) (Interior Province)		4 700	710	3 300	425	2 000	220	1 000	65	300	285	1 300

Source: Economic and Social Commission for Western Asia, "Assessment of the water resources situation in the ECWA region", 1981 (E/ECWA/NR/L/1/Rev.1).

Table 25. Hydraulic balance sheets for the Mediterranean Province, Lebanon

Zone	Area	Surface area (km^2)	Rainfall (mm)	Rainfall (MCM)	Water deficit (mm)	Water deficit (MCM)	Infiltration (mm)	Infiltration (MCM)	Run-off (mm)	Run-off (MCM)	Total outflow (mm)	Total outflow (MCM)
Karstic areas	Ayoun-Harf Al-Kass	135	1 400	190	630	85	603	81	167	23	770	105
	Kasrouane	450	1 450	650	700	315	625	280	135	55	750	335
	Barouk-Niha	90	1 660	150	700	63	680	62	280	25	960	87
	Jisr Al-Qadi	17	1 200	2.2	600	1.1	356	0.6	244	0.5	600	1.1
	Total (rounded)	690	1 430	990	670	465	590	425	170	103	760	530
	Rachine-Chekka	700	1 400	980	640	450	570	400	190	130	760	530
	Batroun-Jounieh	360	1 100	400	550	200	485	175	65	24	550	200
	High plateaus of Lebanon	150	1 650	250	725	110	810	120	115	20	925	140
	Hadath-Hazmieh	10	880	8.8	585	5.85	185	1.85	110	1.1	295	2.95
	South Lebanon	910	850	770	450	400	340	315	60	55	400	370
	Chouf-Jezzine	130.5	1 400	183	700	92	560	73	140	18	700	91
	Total (rounded)	2 260	1 150	2 600	560	1 250	487	1 100	103	250	590	1 350
	North Lebanon	103	950	100	531	55	333	34	86	9	419	43
	South Lebanon	540	800	430	480	257	225	120	95	53	320	173
Permeable areas	Mountainous areas	100	1 650	165	740	75	410	40	500	50	910	90
	Coastal areas	375	900	335	630	235	135	50	180	50	270	100
	Total (rounded)	475	1 060	500	655	310	195	90	210	100	405	190
Low-permeable areas	Mountainous areas	248	1 650	410	740	185	165	40	745	185	910	225
	Mountainous areas	453	1 650	750	875	400	250	110	527	240	940	350
	Total (rounded)	700	1 650	1 150	829	585	220	150	610	425	829	575
	Jabal Terbol	66	1 000	66	500	33	200	13.2	300	20	500	33.2
Impervious	In the province	298	700	210	600	180	--	--	100	31	105	31
	North Lebanon	73	9 000	66	720	55	--	--	180	13	180	13
	In the province	300	850	256	680	204	-	--	170	50	170	50
Grand total (Mediterranean Province)		5 500	1 163	6 500	628	3 500	360	2 000	175	1 000	535	3 000

Source: Economic and Social Commission for Western Asia, "Assessment of the water resources situation in the ECWA region", 1981 (E/ECWA/NR/L/1/Rev.1).

Table 26.-27. Average annual and monthly surface-water flows, Lebanon

(a) Mediterranean Province

River	Monthly Flows (MCM) Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Average annual flow (MCM)
Al-Kabeer	25.52	35.62	33.87	29.69	16.18	10.61	7.26	6.71	5.84	4.70	6.21	7.87	190.01
Ostouene	5.80	10.46	9.71	9.77	7.43	5.43	3.50	3.30	3.00	2.50	2.16	2.05	65.11
Arka	5.84	16.80	11.57	6.06	5.93	3.86	2.54	2.44	2.38	2.10	2.70	2.74	64.96
Al-Bared	18.21	27.97	25.57	39.30	39.49	38.60	28.00	20.00	15.00	15.00	7.91	6.92	287.97
Abu-Ali	19.73	31.06	29.54	39.05	40.09	40.62	23.00	12.00	9.00	6.00	5.67	6.64	262.40
Al-Jawz	8.19	9.34	8.94	16.55	15.01	9.07	2.24	1.41	1.03	0.97	1.22	1.70	75.67
Ibrahim	29.10	50.40	42.90	74.00	108.00	109.00	45.00	21.00	10.00	7.50	6.00	5.00	507.90
Al-Kelb	16.08	30.50	36.80	48.60	41.00	25.70	16.00	10.50	8.00	7.00	6.50	6.88	252.56
Antelias	1.34	2.68	2.25	2.14	2.08	2.01	1.30	1.07	0.80	0.52	0.80	0.78	17.77
Beirut	6.94	20.20	24.30	24.80	14.37	4.39	1.37	0.80	0.62	0.26	0.67	2.64	101.36
Damour	37.10	87.60	57.60	24.50	19.30	12.73	5.56	3.35	2.33	1.76	2.52	2.15	256.50
Al-Awali	26.00	48.90	63.50	36.30	19.35	12.80	10.10	13.40	15.40	12.74	13.30	12.56	284.35
Saitaniq	0.91	3.56	2.96	1.72	1.42	0.37	0.23	0.05	0.03	0.02	0.03	0.11	11.31
Zahrani	4.36	8.10	8.20	5.75	3.92	1.86	1.27	1.03	0.87	0.80	0.97	1.56	38.59
River or Spring													
Lower Litani	5.10	3.22	18.75	28.80	18.10	30.40	11.34	4.21	3.91	1.92	2.04	2.04	129.83
Ras Al-Ain	2.28	2.93	2.02	2.86	2.54	2.50	2.33	2.28	2.09	1.97	1.96	2.30	28.06
Total	212.50	389.34	378.48	389.89	354.21	309.95	161.04	103.55	80.30	65.76	60.66	63.94	2 574.35

Source: Economic and Social Commission for Western Asia, "Assessment of the water resources situation in the ECWA region", 1981 (E/ECWA/NR/L/1/Rev.1).

(b) Interior Province

River	Monthly Flows (MCM) Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Average annual flow (MCM)
Al-Asi	31.20	32.60	32.10	44.05	52.60	55.74	54.16	53.06	45.98	40.05	37.04	33.88	512.46 a/
Upper Litani	41.50	14.70	115.90	105.70	84.00	56.40	32.40	35.30	22.10	21.60	24.30	27.40	641.30 b/
Al-Hasbani	7.39	15.72	27.36	26.85	21.00	13.02	9.39	7.91	6.83	5.04	4.28	6.60	151.39 c/
Total	80.09	63.02	175.36	176.60	157.60	125.16	95.95	96.27	74.91	66.69	65.62	67.88	1305.15 d/

Source: Economic and Social Commission for Western Asia, "Assessment of the water resources situation in the ECWA region", 1981 (E/ECWA/NR/L/1/Rev.1).

a/ 410 MCM goes to the Syrian Arab Republic.
b/ 220 MCM is stored in Qaraoun Lake.
c/ 140 MCM goes to Palestine.
d/ 550 MCM goes to the Syrian Arab Republic and Palestine.

Table 28. Distribution of annual rainfall volume in catchment areas in the Syrian Arab Republic

Total area of the country (Thousands of km²)	Total rainfall volume in the country (BCM)	Less than 100 mm			Between 100 and 300 mm			More than 300 mm		
		Rainfall volume (BCM)	Catchment area (Thousands of km²)	Percentage of total area	Rainfall volume (BCM)	Catchment area (Thousands of km²)	Percentage of total area	Rainfall volume (BCM)	Catchment area (Thousands of km²)	Percentage of total area
185.2	52.7	0.55	10.6	5.7	25.37	129	69.7	26.78	45.6	24.6

Source: Syrian Arab Republic, "Population growth and water security in the Syrian Arab Republic", by W.R. Agha, a professor at Damascus University, (Damascus, 1991).

Table 29. Perennial rivers in the Syrian Arab Republic

River	Flow Rate (m^3/s) Minimum	Maximum	Average	Average annual discharge (MCM)	Total length (km)	Length in the Syrian Arab Republic (km)	Remarks
Euphrates	250	2 500	888	28 000	2 880	680	Average annual discharge in Syrian-Turkish borders
Tigris	..	..	..	18 300	1 718	44	Average annual discharge in the Syrian Arab Republic
Khabour	35	386	45	1 500	405	405	Average annual discharge for Khabour and its tributaries
Al-Balikh	1-5	15-20	3-4	150	202	135	Tributaries in Turkey
Jaghjagh	1	8	3	126	124	100	From Khabour tributaries originating in Turkey
Afrin	2	450	8.8	280	149	85	Average annual rainfall rate for Afrin and its tributaries
Al-Aswad	..	..	..	..	..	..	
Queiq	..	60	3	95	126	110	
Sajour	..	25	3.8	120	108	48	One of the Euphrates tributaries
Orentis	10	400	63.5	2 400	487	343	Length of the river: 79 km in Iskandaroun and 65 km in Lebanon
Al-Kabir Al-Shimali	0.8	150	10.3	325	80	56	Length of the river: 24 km in Iskandaroun
Al-Kabir Al-Janoubi	..	160	10.2	320	56	50	
Sinn	8.5	22	11	350	6	6	
Al-Hassin	..	50.5	..	42.6	..	..	Some of the hydrogeologists assess it as non-perennial river or wadi
Al-Qais	0.4	104	..	45	..	..	Tributary to Al-Hassin

Table 29. (continued)

River	Flow Rate (m^3/s)			Average annual discharge (MCM)	Total length (km)	Length in the Syrian Arab Republic (km)	Remarks
	Minimum	Maximum	Average				
Barada	5	25	11.1	350	79	79	
A'waj	0.7	12	3.2	100	91	91	
Sybarani	0.17	4.55	1.07	34	15	15	
Al-Janani	0.1	2.54	0.65	..	..	..	
Manein	..	..	..	..	..	..	
Yarmouk	7	100	..	250	130	47	Discharge is into Al-Mukarin

Source: Syrian Arab Republic, "Population growth and water security in the Syrian Arab Republic", by W.R. Agha, a professor at Damascus University, (Damascus, 1991).

Note: The Euphrates, Tigris, Al-Balikh, Jaghjagh, Sajour, Afrn, Queiq, Al-Aswad, Orentis, Yarmouk and Al-Kabir Al-Janoubi are considered joint rivers.

Table 30. International streams and main wadis in the Syrian Arab Republic

River	Flow Rate (m^3/s) Minimum	Maximum	Average	Average annual discharge (MCM) 1979	1982	Remarks
Al-Sonawbar	0.4	106	4.09	130	157	There are many non-perennial
Al-Roos		57.3	0.26	57	41	rivers and wadis with limited
Banias - the coast	0.1	3.54	1.01	31.85	44	flow rate, such as those in the following areas:
Marqiyah	0.12	143.5	2	63	122	
Al-Madeeq		3.36	0.32	10.12		Coastal Basin: Al-Ramla,
Harisoun		8.8	0.34	10.66	85	Zayroot, Al-Burghol,
Jouber		4.9	1.19	37.52	59	Al-Jilani, Al-Khalifeh,
Al-Ghamqa					67	Al-Aroos, Al-Qubtash, Hamim,
Al-Abrash					110	Al-Qaq, Al-Huweiz, Al-Khalij,
Al-Qash					78	Al-Qubla, Al-Aswad, Al-Salor,
Al-Qandeel					14	Al-Qirdaha, Al-Qabw
Tafshin		1.25		1.89		
Tel Doo				112		Orentis Basin: Saroot,
Salhab			0.64			Abu Ba'ara, Al-Qawaq,
Al-Barid			1.27			Al-Ghasouq
Al-Abyad			2.4			
Abu-Humamah			0.186			Yarmouk Basin: Al-Zaidi,
Al-Masrif			5.6			Harir, Al-Thahab,
Nafaq Al-Zarqa			0.8			Abu Al-Thahab
Raqad				0.6	45	Euphrates Basin: Al-Khanizeer,
Allan				6.18		Zarkan, Al-Jarahi, Al-Sarab
						Badia Basin: Al-Sab'a Byar, Al-Wa'er, Al-Sham, Al-Natf

Source: Syrian Arab Republic, "Population growth and water security in the Syrian Arab Republic", by W.R. Agha, a professor at Damascus University, (Damascus, 1991).

Note: Blank entries signify information not available.

Table 31. Estimated water resources in the Syrian Arab Republic water basins

Basin name	Area (km^2)	Average annual rainfall (MCM)	Total water resources (MCM)	Surface water (MCM/a)	Ground water & springs (MCM/a)	Volume of annual rainfall (MCM)	Annual ground-water inflow (recharge) (MCM)	Stream flow: rivers, wadis, springs (MCM/a)	Exploitation of ground water (MCM/a)	Source
Damascus	6 850	182	700	..	..	1 250	200	500	576	a/
(Barada	6 850	182	1 026	833	193	..	..	..	..	b/
Basin &	..	..	1 267	134	1 133	..	..	..	..	c/
Al-Awaj,	10,670	..	..	..	..	3 200	580	820	483	d/
as of	..	..	1 338	200	1 138	..	518	..	..	e/
1986)	..	..	700	..	..	..	..	..	..	f/
	..	..	850	..	..	..	50	..	430 Irrigation only	g/
	8 560	268	850	..	..	2 297	..	..	..	h/
	8 630	266	850	..	..	2 297	272	578	..	i/
	8 596	268	850	..	..	2 659	..	..	475 Exploitation by wells only	j/
Orentis	16 900	372	2 000	..	..	6 350	200	1 800	490	a/
	16 900	372	2 863	2 507	..	356	..	..	..	b/
	..	..	2 405	1 066	..	1 339	..	..	..	c/
	13 830	..	..	..	..	6 600	405	2 000	309	d/
	..	..	2 623	1 060	1 563	..	423	..	..	e/
	..	..	2 000	..	..	..	..	..	..	f/
	..	..	..	..	..	..	..	..	..	g/
	20 150	431	2 454	890	1 564	6 389	..	..	..	h/
	21 624	316	2 717	1 110	1 607	6 833	..	..	..	i/
Al-Sahel	5 100	950	1 900	..	..	4 850	275	1 625	159	a/
	5 100	950	..	..	..	..	..	..	..	b/
	..	..	2 515	1 495	1 020	..	..	..	..	c/
	5 100	..	..	..	..	6 500	209	2 300	125	d/
	..	..	2 608	1 800	808	..	290	..	..	e/
	..	..	2 500	..	..	..	..	..	..	f/
	..	..	..	..	..	..	..	..	..	g/
	5 100	1 294	2 335	1 557	778	6 603	..	..	..	h/
	5 049	1 307	2 335	1 557	778	6 599	..	..	..	i/
Aleppo	12 250	276	725	..	..	3 400	325	400	697	a/
	21 050	276	1 191	888	303	..	..	..	..	b/
	..	..	764	285	479	..	..	..	..	c/
	19 200	..	..	..	..	6 100	330	450	306	d/
	..	..	434	100	334	..	288	..	..	e/
	..	..	725	..	..	..	..	..	..	f/
	..	..	..	..	..	..	..	..	..	g/
	11 605	330	966	571	395	3 829	..	..	..	h/
	11 155	304	649	303	346	3 391	..	..	..	i/

Source: Syrian Arab Republic, "Population growth and water security in the Syrian Arab Republic", by W.R. Agha, a professor at Damascus University, (Damascus, 1991).

Table 31. (continued)

Basin name	Area (km^2)	Average annual rainfall (MCM)	Total water resources (MCM)	Surface water (MCM/a)	Ground water & springs (MCM/a)	Volume of annual rainfall (MCM)	Annual ground-water inflow (recharge) (MCM)	Stream flow: rivers, wadis, springs (MCM/a)	Exploitation of ground water (MCM/a)	Source
Euphrates	64 100	278	28 500	..	..	17 850	400	2 100	560	a/
	64 100	278	28 700	..	..	..	..	..	..	b/
	..	..	13 092	11 500	1 592	..	..	..	..	c/
	64 100	..	..	..	..	17 900	1 000	2 200	400	d/
								Except Tigris and Euphrates		
	..	..	2 700	800	1 900	..	400	..	..	e/
			Except Tigris and Euphrates inflow							
	..	..	1 300	..	..	..	..	..	..	f/
	..	..	..	..	..	..	..	..	..	g/
	40 830	178	26 200	26 175	25	7 295	..	..	..	h/
	40 083	182	25	..	25	7 295	..	..	..	i/
			Except Euphrates inflow							
Tigris Khabour Al-Jazira	23 270	358	2 388	788	1 600	8 493	..	..	..	h/
Tigris & Khabour	21 129	402	2 388	788	1 600	8 493	..	..	..	i/
Yarmouk	9 300	263	900	..	..	3 450	50	850	1.7	a/
	5 700	263	445	181	264	..	..	..	..	b/
	..	..	562	298	264	..	..	..	..	c/
	5 700	..	..	..	..	2 000	230	430	16	d/
	..	..	450	180	270	..	20	..	..	e/
	..	..	900	..	..	..	..	..	..	f/
	..	..	..	..	..	..	..	..	..	g/
	5 665	340	445	180	265	1 930	..	..	..	h/
	6 724	287	447	182	265	1 930	..	..	..	i/
Al-Badia	70 500	125	600	..	..	8 850	175	425	45	a/
	70 500	125	600	..	..	..	..	..	..	b/
	..	..	42	25	17	..	..	..	..	c/
					Springs only					
	65 600	..	..	..	..	8 200	100	100	15	d/
	..	..	210	100	110	..	100	..	..	e/
	..	..	600	..	..	..	..	..	..	f/
	..	..	..	..	..	..	..	..	..	g/
	70 000	140	356	163	182	9 800	..	..	..	h/
	70 786	138	354	174	182	9 768	..	..	..	i/

Source notes for table 31

a/ Syrian Arab Republic, Ministry of Public Works and Mineral Resources, "The water resources of the Syrian Arab Republic" by M.S. Safadi, (Damascus, 1974), (in Arabic).

b/ Arab Center for the Studies of Arid Zones and Dry Lands, the Arab Fund for Economic and Social Development, and the Kuwait Fund for Arab Economic Development, "Water resources and their utilization in the Syrian Arab Republic", a paper by Q. Miqdad, B. Hadid, and M. Al-Amir presented at the Symposium on Water Resources and their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

c/ Syrian Arab Republic, University of Damascus, "Water and irrigation projects and food security in Syria", Damascus University Magazine, vol. II, periodical 8, (Damascus, 1979), (in Arabic).

d/ Syrian Arab Republic, Ministry of Irrigation, "The water resources of the Syrian Arab Republic" by S. Qadamani (Damascus, 1986), (in Arabic).

e/ B. Hadid and S. Qadamani, "Assessment and administration of water resources in Syria", a paper presented at the Symposium on Planning for the Exploitation of Water Resources in Syria, Aleppo University, 1987, (in Arabic).

f/ Syrian Arab Republic official papers, 1987 (in Arabic).

g/ Syrian Arab Republic, Ministry of Irrigation, "Water resources administration and their optimum utilization in Barada and Al-Awaj Basin in the Syrian Arab Republic", by A. Shehadat, J. Falluh and L. Serdikov, (Damascus, 1987), (in Arabic).

h/ B. Hadid, "Water resources development strategy and long-term planning", a paper presented at the Workshop on Water Resources Development Strategy in Arid Conditions, Damascus, 25-27 October 1989, (in Arabic).

i/ Majid Daoud, "Euphrates River water in Turkey, the Syrian Arab Republic and Iraq", a study presented at the Thirtieth Scientific Week, Damascus, 3-8 November 1990, (in Arabic).

j/ M.N. Al-Mir (1990); A. Shehadat and J. Falluh (1990); M.N. Al-Amir and M.R. Murtada (1990).

Table 32. Estimated water resources in the Syrian Arab Republic

Rainfall: Annual average (mm) Minimum	Rainfall: Annual average (mm) Maximum	Rainfall: Total volume (BCM/a) Minimum	Rainfall: Total volume (BCM/a) Maximum	Rainfall: Total volume (BCM/a) Average	Rivers, floods & springs, except Euphrates and Tigris (BCM/a)	Rivers, except Euphrates and Tigris (BCM/a) Seasonal	Rivers, except Euphrates and Tigris (BCM/a) Perennial	Floods (BCM/a)	Springs (BCM/a)	Ground-water resources (BCM/a)	Euphrates river (BCM/a) at Jarablis: To the country	Euphrates river (BCM/a) at Jarablis: Country share	Tigris river (BCM/a) at Syrian part	Total water resources available (BCM/a)	Remarks
				46.66		← 4.69 →			3.061	5.075	31.4		18	9.765 Except Syria Syria's share from Euphrates and Tigris rivers	Figures related to Tigris & Euphrates rivers; it refers to flow of the river at Syrian-Turkish borders a/
Less than 100	More than 1 000			45	8.7	← 6.7 →			1	1.903	28		18.300	9.603 Except Tigris and Euphrates rivers	Figures related to the rivers; refers to average annual water flow b/
Less than 100	More than 1 000			46.636									18	35.994 Except Syria's share from Tigris river	c/
				45		4.950		1.500	1.200	1.600		11.5		20.750 Approximately 21	d/
														17	e/
100	1 000	35	60	50	8.324	2; 6.86 Seasonal and perennial main rivers	- 2.8 Inland rivers	4.084	2.039	26.8		18.3		+10.363 Euphrates inflow	f/
				45								11.5		20.5	Water resources for each basin g/
				50			4.350	7.3	1.25	2.006		26			h/
											25.228	13		20.425	Water resources for each basin i/

Table 32. (continued)

Rainfall: Annual average (mm) Minimum	Rainfall: Annual average (mm) Maximum	Rainfall: Total volume (BCM/a) Minimum	Rainfall: Total volume (BCM/a) Maximum	Rainfall: Total volume (BCM/a) Average	Rivers, floods & springs, except Euphrates and Tigris (BCM/a)	Rivers, except Euphrates and Tigris (BCM/a) Seasonal	Rivers, except Euphrates and Tigris (BCM/a) Perennial	Floods (BCM/a)	Springs (BCM/a)	Ground-water resources (BCM/a)	Euphrates river (BCM/a) at Jarablis: To the country	Euphrates river (BCM/a) at Jarablis: Country share	Tigris river (BCM/a) at Syrian part	Total water resources available (BCM/a)	Remarks
100	1 600	35	60	50.5	8.3	0.893 In coast basin	5.840 Principal		4	2.935	26.8	11.5	18.3	22.7	i/
										2.935				25.035	Total surface water resources amounted to 22.1 BCM/a k/
				45.825		4.106			3.818	2.069	From 25.468 to 32.840 (average 28.899)			84.717	Total estimated river flows 33.005 BCM/a, considering five year (1979-1983) average l/
											25			40	m/
					7.65		4.95	1.5	1.2	1.6		11.5		20.75	Average water year n/
				50 or 53.7715		4.9		3.2	4.1	1.6		26.127		37	Total water resources o/
				46	7.7	5.445		3.6	4.1	1.625 or (2.5)		13			Available water resources
243				45				3.6	4.1	1.625				35.325	p/

Note: Blank entries signify information not available.

a/ Majid Daoud (1990);
b/ Nidal Taqi-Eddin; Abdul Aziz Masri (1989);
c/ Barakat Hadid (1989);
d/ Mohammad Shuker (1987);
e/ M. Wakeel (1987);
f/ B. Hadid; S. Qadamani (1987);
g/ N. Rifai (1987);
h/ Energy and Development No. 341 (1987);
i/ Syrian Publicity (1987);
j/ S. Qadamani (1986);
k/ ACSAD (1986);
l/ Q. Miqdat et al. (1986); N. Al-Mir et al. (1983);
m/ Al-Bath Paper No. 6929 (1985);
n/ N. Rifai (1984);
o/ Food Security in the Arab World (1980);
p/ S. Safadi (1974).

Table 33. Population and water resources vis-à-vis water basins in the Syrian Arab Republic

Basin	Area (km^2)	Beneficiaries in each basin	Average water resources (MCM/a)	Annual per capita share (m^3/a)	Beneficiary percentage in each basin with respect to total population	Basin water resources / Total water resources (Percentages a/)
Barada and Al-Awaj	8 560	3 459 000	850	246	28	2.4
Orentis	20 150	2 560 000	2 454	959	21	6.8
Al-Sahel	5 100	1 429 000	2 335	1 634	11.7	6.5
Euphrates	40 830	880 700	26 200	29 749 b/	7.1	72.8
Al-Jazira and Khabour	23 270	865 000	2 388	2 760 c/	7	6.6
Yarmouk	5 665	792 000	445	562	6.5	1.3
Al-Badia	70 000	250 000	356	1 424	2	1.2
Aleppo	11 605	2 019 900	966	478	16.7	2.5
Total	185 180	12 255 600	35 994	..	100.0	100.0

Source: Syrian Arab Republic, "Population growth and water security in the Syrian Arab Republic", by W.R. Agha, a professor at Damascus University, (Damascus, 1991).

a/ Percentages are variable as they rely on upstream developments in Turkey.
b/ Figure is unconfirmed; believed not to exceed 8,000 m^3/a year, considering present Euphrates water flow.
c/ Value was estimated without considering the Syrian share from Tigris River water.

Table 34. Ground-water resources and ground-water quality of the main basins of Jordan

Basin	Ground-water resources (MCM/a)	Total dissolved solids (ppm) From	To
Yarmouk	53	280	900
Jordan River	14	450	800
Jordan Valley	12	800	3 000
Zarqa	94	400	3 000
Dead Sea	60	500	1 000
Wadi Araba	8	800	2 500
Red Sea	8	700	1 500
Jafr	78	250	3 500
Azraq	20	300	800
Sirhan	5	1 000	..
Hamad	5	1 000	..

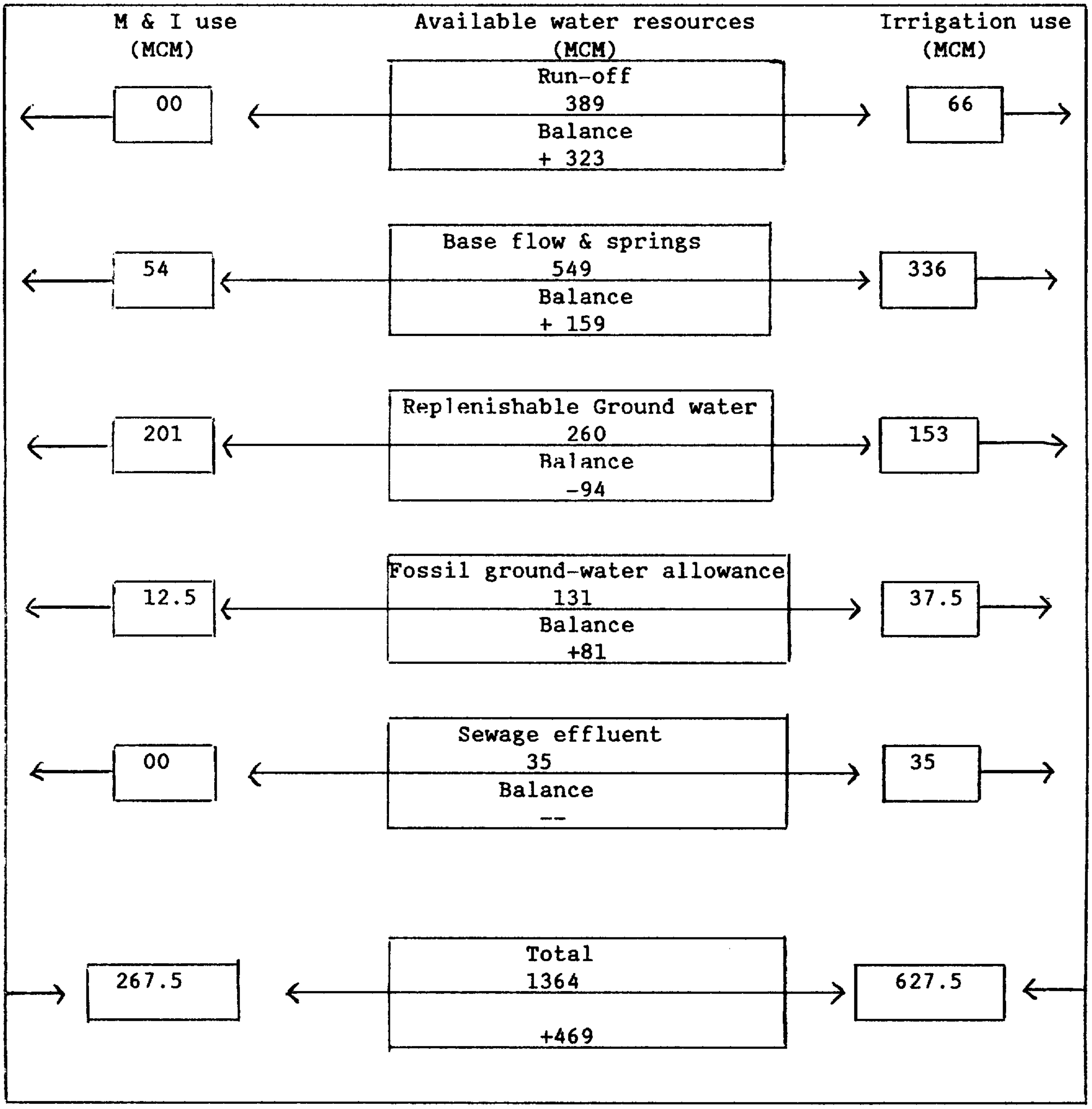
Source: M.M. Bilbeisi and M. Bani Hani, "Water resources and water use in Jordan", a paper presented at the Conference on Water Resources and Their Strategic Importance in the Arab States, Amman, 2-4 April 1989.

Table 35. Replenishable ground-water basins in Jordan, 1988 (Safe yield, abstractions and balance)

Basin	Safe yield (MCM)	Production: Irrigation	Domestic	Industrial	Total	Balance (MCM)
Amman-Zarqa	87.5	82.2	59.1	5.02	146.32	-58.82
Yarmouk	40	39	18.9	--	57.9	-17.9
Azrak	20	15	14	--	29	- 9
Jordan River side wadis	15	--	6.3	--	6.3	+ 8.7
Jordan Valley	21	20	--	--	20	+ 1
Dead Sea basin (including Mujib)	57	29.84	22.55	19.7	72.09	-15.09
Wadi Araba (north)	5.5	1.5	0.03	--	1.53	+ 3.97
Wadi Araba (south)	5	0.9	2.16	--	3.06	+ 1.94
Jafr	9	12.6	5.4	--	18	- 9
Total	260	201.04	128.44	24.72	354.2	-94.2

Source: Economic and Social Commission for Western Asia, "The Jordanian experience in development and planning of water resources", a paper presented at the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region, Damascus, 13-16 November 1989, (E/ESCWA/NR/1990/3).

Figure XVII. Water resources and utilizations
(Schematic diagram)
1988



Source: Economic and Social Commission for Western Asia, "The Jordanian experience in development and planning of water resources", a paper presented at the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region, Damascus, 13-16 November 1989, (E/ESCWA/NR/1990/3).

Table 36. Jordan water structures

Dam	River/Wadi	Year completed	Capacity (MCM)	Purpose
King Talal	Zarqa	1986	82	Irrigation, power
Wadi Arab	W. Arab	1984	20	Storage, power
Kafrein	Kufrein	1967	4.8	Irrigation
Shueib	Shueib	1964	2.3	Ground-water recharge
Sharhabeil	Ziglab	1964	4.3	Irrigation
Sultani	Mujib	1962	0.3-1.2	Irrigation, livestock watering
Qatrana	Mujib	1962	2.3	Ground-water recharge, livestock watering
Lahfi	Dhuleil	..	0.7	" "
Buweida	Yarmouk	1967	0.7	" "
Ghadeir Al-Abyad	Yarmouk	1967	0.7	" "
Samma Sirhan	Yarmouk	1965	1.7	" "
Agib	Dhuleil	1983	1.4	Ground-water recharge
Burgu'	Ruweishid	1950	1.5	Livestock watering
Sha'lan	Ruweishid	1970	1.0	Irrigation
Deir Al-Kahf	Deir Al-Kahf	1950	1.5	Livestock watering

Source: Economic and Social Commission for Western Asia, "The Jordanian experience in development and planning of water resources", a paper presented at the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region, 13-16 November 1989 (E/ESCWA/NR/1990/3).

In the Syrian Arab Republic, the details of the constructed small dams and reservoirs have not been made available. By 1983, about 84 small- and medium-sized dams had been constructed, with a total capacity of 313 MCM, in addition to the large Euphrates Dam, with a storage capacity of 11,600 MCM.

Syrian Arab Republic, Ministry of Irrigation, "Water Resources in the Syrian Arab Republic" (by S. Al-Qadamani), Damascus, 1986 (in Arabic).

Table 37. Proposed dams and retention reservoirs in Jordan

Dam	Basin	Storage capacity (MCM)	Study conditions	Uses
Wahdeh	Yarmouk	220	Feasible	Multi-purpose
Kufrinja	J.V.* side wadis	5.2	"	Irrigation
Wadi Yabis	J.V. side wadis	5.2	"	"
Karameh	J.V. side wadis	45	"	Irrigation and storage
Rumeil	Wadi Wala	25	Under study	Irrigation
Nukeila	Wadi Mujib	12	"	Multi-purpose
Al-Abyad	Wadi Mujib	12	Pre-feasibility	Irrigation
Tannur	Wadi Hasa	14	"	"
Jurdhan	Jafr Basin	4	Under study	Multi-purpose
Swaqa	Wadi Mujib	2.8	Pre-feasibility	Ground-water recharge
Dabaa	Wadi Mujib	2.8	"	Multi-purpose
Hamam	Wadi Wala	3	"	Ground-water recharge
Abu Safat	Jafr Basin	2.8	Under study	Irrigation
Zatari	Zarqa River	2	Pre-feasibility	"
Ruweishid	Wadi Ruweishid	10.8	Under study	Multi-purpose
Abu Hafna	Wadi Ruweishid	2.5	" "	"
Rajil	Azraq Basin	2	" "	Ground-water recharge
Ratam	Azraq Basin	2	" "	Ground-water recharge
Butum	Azraq Basin	2	" "	Ground-water recharge
Usheishat	Jafr Basin	2.4	Proposed	Ground-water recharge
Mathk	Jafr Basin	2	"	Livestock watering
Fassu'a	Jafr Basin	2	"	" "
Abyad	Jafr Basin	2	"	" "
Uqeiqa	Jafr Basin	2	"	" "
Al-Jahdaniya	Jafr Basin	2	"	" "

Source: Economic and Social Commission for Western Asia, "The Jordanian experience in development and planning of water resources", a paper presented at the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region, Damascus, 13-16 November 1989, (E/ESCWA/NR/1990/3).

* J.V. = Jordan Valley.

Table 38. Dams and reservoirs in Iraq

Structure name	Designed storage (MCM) Normal storage	Live storage	Reserve storage	Remarks
1. Structures at the Tigris River				
Dokan	6 800	5 500	400	Existing (1959) (for power and irrigation, or P+I)
Tharthar	77 600	38 500	7 800	Existing (1956) Rehabilitated (76) Regulation
Fatha	23 300	19 300	2 700	Planned
Mosul (Saddam)	10 700	9 700	1 800	Existing (1986) (P+I)
Bakhma	8 300	7 800	600	Existing (P+I)
Badouch #1 and #2	..	..	..	Under construction (P+I)
2. Structures at the Diyala River (Tigris tributary)				
Darbandi Khan	3 000	2 500	1 100	Existing (P+I) (1961)
Himrin	3 950	2 300	1 400	Existing (P+I)
3. Structures at the Euphrates River				
Hadithah (Qadisiya)	8 200	7 500	2 200	Existing, irrigation
Habbaniyah	3 300	2 700	..	Existing (1956) Rehabilitated (1970)
Total	145 150	95 800	18 800	

Source: Economic and Social Commission for Western Asia, "Assessment of the water resources situation in the ECWA region", 1981 (E/ECWA/NR/L/1/Rev.1), (table updated).

Table 39. Surface run-off and ground-water recharge in the northern Tehama wadi system, Saudi Arabia

Wadi	Area of basin (km^2)	Annual* flow (MCM)	Recharge to ground water (Percentage)	Recharge (MCM)	Number of wells	Withdrawal (MCM)
Al-Laith	2 700.00	40.80	37.00	15.00	24.00	0.28
Al-Ayer	710.00	10.40	35.00	3.80	..	..
Hyly	4 500.00	88.00	31.00	27.60	160.00	1.00
Al-Shaghaba	200.00	3.00	33.00	1.00	..	..
Yaba	2 800.00	42.30	53.00	22.60	60.00	0.50
Kanouneh	1 800.00	27.20	40.00	10.80	90.00	0.90
Lomah	640.00	9.70	30.00	2.90	32.00	0.22
Ahsubah	1 120.00	16.90	30.00	5.10	51.00	0.12
Nawan	255.00	3.90	31.00	10.20	25.00	0.06
Kourmeh	160.00	2.40	28.00	0.70	42.00	0.06
Dakah	1 126.00	16.90	15.00	2.50	16.00	0.04
Al-Shabab	140.00	14.40	14.00	2.00	5.00	0.10
Al-Shamyah	1 360.00	205.00	10.00	2.00	6.00	0.20

Source: Saudi Arabia, Ministry of Agriculture and Water, "Water and development in the Kingdom of Saudi Arabia", by M.N. Othman, (Jeddah, 1983).

* At a two-year recurrence interval.

Table 40. Annual flow and ground-water development in southern Tehama, Saudi Arabia

Wadi	Area of basin (km^2)	Average annual flow (MCM)	Recharge to ground water (Percentage)	Recharge to ground water (MCM)	Withdrawal from ground water (MCM)	Available additional resources (MCM)
Shaddan	565.0	105.0	9.1	9.6	0.7	6.2
Sabya	696.0	19.1	38.7	7.4	3.8	2.5
Fijeh	65.0	15.4	25.3	3.9	0.8	2.2
Khaloh	5.0	29.4	16.7	4.9	0.9	2.8
Taashar	505.0	68.2	20.0	13.5	2.3	7.8
Bighi	714.0	14.4	32.0	4.6	--	3.2

Source: Saudi Arabia, Ministry of Agriculture and Water, "Water and development in the Kingdom of Saudi Arabia", by M.N. Othman, (Jeddah, 1983).

Table 41. List of dams constructed in Saudi Arabia

Name	Catchment area (km^2)	Type	Storage capacity (MCM)	Length (m)	Height (m)	Location	Purpose
Hanifa	..	Concrete	1.3	390	9.5	Riyadh	
Laban	..	Rock fill	2.0	500	12.0	Riyadh	Recharge
Nammar	..	"	1.5	400	8.0	Riyadh	Recharge
Diriyah	..	Concrete	3.0	380	9.5	Al-Diriyah	Recharge
Hair	..	"	3.8	400	14.0	Riyadh	Recharge
Safar	54	Earth	0.3	325	4.0	Riyadh	Recharge aquifers
Hriqa	19	"	0.08	190	6.0	Riyadh	" "
Ghbeirah	21	"	0.09	170	6.0	Riyadh	" "
Jalajil	..	"	1.75	630	11.6	Sdair	Storage & recharge
Melham	20	Concrete	0.2	100	4.0	Sdair	Storage & recharge
Hreimlah	350	Earth	1.5	1 250	6.0	Sdair	Diversion
Majma'a	100	Rock fill	1.2	360	8.0	Sdair	Flood control and recharge
Thadiq	..	Earth	2.0	850	7.0	Sdair	
Rawdah	..	Earth	3.0	554	14.0	Sdair	
Ghat	..	Earth	1.0	250	11.0	Sdair	
Khalah	..	Concrete	0.2	60	7.0	Baha	
Jozan	1 100	Concrete	71.0	316	41.6	Jizan	Flood control and irrigation
Sa'ab	..	Earth	0.5	290	10.0	Taif	
Abha	58.5	Concrete	2.4	350	33.0	Asir	Water supply
Bathan	20	Concrete	0.8	266	12.5	Madinah	Recharge & control
Akramah	..	Rock fill	0.4	300	8.0	Taif	
Shaqra'a	..	Rock fill	0.2	90	10.0	Shaqra'a	
Marid	..	Earth	1.3	500	7.0	Asyah	Flood control
Ananyah	..	Earth		180	8.0	Qasim	Recharge and diversion
Al-Ainiyah	..	Masonry	1.0	400	5.0	Riyadh	Recharge and storage

Source: Economic and Social Commission for Western Asia, "Assessment of the water resources situation in the ECWA region", 1981 (E/ECWA/NR/L/1/Rev.1) (table updated).

Table 42. List of dams to be constructed in Saudi Arabia and their characteristics

Name	Location	Type	Length (m)	Height (m)	Storage capacity (MCM)
Okda	Jai'l	Earth	100	7.00	0.10
Salf	Hai'l	Earth	230	6.00	0.10
Okoom	Rabegh	Earth	800	6.00	Diversion
Murat	Murat	Earth	110	12.00	0.40
Tura'a	Al-Madina	Earth	450	15.00	2.00
Rumma	Al-Kaseem	Concrete	700	7.00	1.00
Al-Ghab	Al-Madina	Earth	650	11.00	1.00
Hajla	Aseer	Rock fill	110	12.00	1.00
Safrat	Sadeer	Rock fill	490	13.00	1.00
Saoom	Aseer	Concrete	75	13.00	1.00
Najran	Najran	Concrete	250	60.00	85.00
Shuara'a	Al-Dawami	Concrete	95	11.00	1.00
Lia	Al-Tai'f	Rock fill	190	45.00	10.00
Turba	Al-Tai'f	Concrete	380	21.00	20.00
Al-Hanabej	Al-Dawami	Earth	700	7.00	3.00
Sadoose	Salboukh	Earth	520	7.00	0.70
Al-Akoul	Al-Madina	Concrete	450	11.00	7.00
Houta Bani Tameem	Houta Bani Tameem	Earth	770	13.00	3.50
Samnan	Al-Zulfi	Rock fill	150	21.00	1.50
Al-Ghayl	Al-Aflaj	Concrete	126	11.50	2.50
Al-Sharaye'	Al-Madina	Earth	500	8.50	0.88
Thama	Babilkarn	Concrete	145	15.00	0.32
Surat Obeida	Aseer	Rock fill	170	22.00	1.50
Al-Akeek	Al-Bahah	Concrete	..	..	26.00

Source: Saudi Arabia, Ministry of Agriculture and Water, Seven Green Spikes, by A.B. Al-Khatib, (Saudi Arabia, 1974).

Table 43. Water resources in the interior of Oman (Dakhila)

Wadi	Surface water (MCM)	Ground-water recharge (MCM)	Water use (MCM)
Al-Oula	5.7	2.7	0.8
Sifam	16.4	12.0	8.6
Al-Ghoul	4.4	2.2	0.2
Bahla	45.4	22.7	13.4
Tanuf	9.1	4.5	0.8
Nazwa	25.3	12.6	11.2
Al-Muaidin	13.2	6.6	4.2
Bahla	9.6	4.8	3.0
Halfin	14.1	7.0	6.7
Total	143.2	75.1	48.9

Source: Arab Center for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Economic and Social Development, "Water resources and their utilization in the Sultanate of Oman", a paper presented at the Symposium on Water Resources and their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

Table 44. Ground-water resources and water use in Oman
(MCM)

Area	Surface run-off	Recharge	Water use
Musandam	23.4	18.0	12.0
Eastern and central Batinah	180.2	105.5	147.4
Northern Batinah	168.1	119.0	121.6
Interior Oman (northern area)	121.7	58.8	16.6
Interior Oman	143.2	75.1	48.7
Eastern area	95.9	70.8	29.2
Qurayat and Sour	90.1	36.9	15.4
Salalah and southern area	67.9	52.8	16.3
Zofar and northern wadis	27.3	27.0	..
Total	917.8	563.9	407.2

Source: Arab Center for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Economic and Social Development, "Water resources and their utilization in the Sultanate of Oman", a paper presented at the Symposium on Water Resources and their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

Table 45. Water resources of eastern Oman

Wadi	Surface water (MCM)	Ground-water recharge (MCM)	Water use (MCM)
Indam	23.5	12.0	7.3
Kanet	3.9	2.0	1.2
Samad Al-Aala	5.8	2.9	2.0
Ithle Al-Aala	3.4	1.7	0.9
Fateh	0.5	0.3	0.3
Menjerid	3.3	2.4	0.1
Aghada	10.3	9.7	3.7
Al-Dhaher	2.7	2.5	0.3
Ibra	6.2	5.7	0.1
Tima	2.9	2.8	0.3
Salim	0.1	1.0	..
Al-Kabel	28.3	24.2	13.0
Bani Khaled	4.1	3.4	..
Total	94.4	70.6	29.2

Source: Arab Center for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Economic and Social Development, "Water resources and their utilization in the Sultanate of Oman", a paper presented at the Symposium on Water Resources and their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

Table 46. Water resources of Sour and Qurayat in Oman

Wadi	Ground-water resources (MCM)	Run-off to sea (MCM)	Water use
Mejlas	3.8	0.9	2.2
Bani Bttash	1.3	0.3	2.9
Daikah	26.7	15.1	5.3
Fleit	5.0	1.9	5.0
Total	36.8	18.2	15.4

Source: Arab Center for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Economic and Social Development, "Water resources and their utilization in the Sultanate of Oman", a paper presented at the Symposium on Water Resources and their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

Table 47. Water resources of the Dhahirah area of Oman

Wadi	Surface water (MCM)	Ground-water recharge (MCM)	Water use (MCM)
Sharab	1	0.5	..
Al-Nadira	1.2	0.6	..
Khreimeh	0.4	0.2	..
Mihah	1.2	0.8	..
Semini	3.6	2	..
Sharam	2.7	1.5	1.1
Kahel	0.7	0.5	0.3
Mahoah	3.5	2.5	2.4
Katouh	1.8	0.8	..
Sheek	3.4	1.7	0.7
Lihas	0.3	0.2	0.1
Madabeh	0.7	0.3	..
Ashkan	5.9	2.5	0.5
Sifah	6.6	3	0.3
Sidarat	0.9	0.4	..
Fateh	6.1	3	..
Khubaib	3.9	1.5	..
Dank	27.3	12	3
Bijaleh	1.4	0.6	..
Jafra	5.2	2.6	0.5
Kabir	14.1	8	5.7
Al-Ayn	14.8	7	1.5
Shohayeh	2.8	1	..
Rafhsh	0.9	0.4	..
Aswad	6.4	3	..
Futeihah	0.9	0.4	..
Halid	1.3	0.5	..
Halaj	1.4	0.7	..
Hajar	1.3	0.6	..
Total	121.7	58.8	16.1

Source: Arab Center for the Studies of Arid Zones and Dry Lands, Arab Fund for Economic and Social Development, Kuwait Fund for Economic and Social Development, "Water resources and their utilization in the Sultanate of Oman", a paper presented at the Symposium on Water Resources and their Utilization in the Arab World, Kuwait, 17-20 March 1986, (in Arabic).

Table 48. Proposed dams in the United Arab Emirates

Wadi	Catchment area (km^2)	Storage capacity (MCM)	Maximum height (m)	Spillway (m^3/s)
Tawayeen	198.0	14.0	21.0	1 600
Safad	32.0	0.5	4.5	561
Ashwani	216.0	3.75	12.0	1 100
Gour	302.0	4.0	20.0	960
Zikt	72.0	3.0	20.0	1 000
Naqab	90.0	1.4	9.0	1 035
Wurayyah	130.0	2.0	6.7	2 156
Forfer	68.0	2.0	10.5	692
Hadf	62.0	3.0	7.5	1 210
Khub	64.0	2.25	6.5	1 100

Source: Halcrow Consultants, "Dam and recharge facilities in the United Arab Emirates" for the Ministry of Agriculture and Fisheries, (Dubai, 1989).

Table 49. Expected available water resources in Egypt balanced with water requirements (BCM)

Year	Available water resources (Expected)			Total	Requirements (Projected)		Total	Irrigated land
	Nile	Drainage	Ground	(BCM)	Municipal and industrial	Irrigation	(BCM)	(Feddan)
1992	53.5 a/	7.0	3.5	64.0	10.4	52.8	63.2	600 000 new land
2000	55.5+2.2 b/	7.5	4.9	70.1	10.7	58.3	69.0	1 000 000 additional
2010	55.5+4.0	8.2	4.9	72.6	10.9	61.3	72.2	750 000 additional
2020	55.5+8.2	8.6	4.9	77.2	12.6	64.2	76.8	650 000 additional

Source: Economic and Social Commission for Western Asia, "Water resources planning in Egypt: issues ahead to the year 2020" (Egypt), Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region, Damascus, 13-16 November 1989, (E/ESCWA/NR/1990/3).

Notes: a/ Represents Egypt's share in Nile River water at Aswan Dam.
b/ Represents Egypt's share in the Upper Nile water conservation projects upon implementation.

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