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The Shatt al-Arab Basin

George B. Cressey

Three Rivers

THREE unique rivers converge near the head of the Persian Gulf to form the Shatt al-Arab. These are the Euphrates, Tigris, and Karun. Together they drain 808,000 square kilometers, or 312,000 square miles. A third of this basin lies in the mountains of Turkey and Iran. Most of the rest is in the deserts of Syria and Iraq.

In the highlands, the rivers have normal valleys and conventional hydrology, growing larger as they flow onward. Across the desert, evaporation removes much of the water before it reaches the sea. As the flow diminishes, the river's carrying power is reduced and silt is deposited. The bed is thus built higher and higher, so that after the rivers enter their delta, the channels must be controlled by dikes. As the water in the rivers diminishes, its chemical load is concentrated and may be precipitated. Southern Iraq is a vast subaerial delta in which are accumulating both sediments and salts.

The Euphrates proper begins at the junction of the Kara Su and the Murat Su in central Turkey and ends at Qurna, where it joins the Tigris and enters the Shatt al-Arab. An alternate lower end may be placed at Garmat Ali, where another mouth joins the Tigris. It has a length of about 1,700 miles; to this may be added some 400 miles to the source of the Murat Su. The Euphrates drains a basin which covers 101,950 square miles above the head of the delta at Hit.

The Tigris rises amid the snow-covered Taurus Mountains of eastern Turkey. Mountains and foothills each account for half of its basin of 43,110 square miles above the head of the delta near Samarra. The overall length to the Shatt al-Arab is 1,270 miles. Whereas the Euphrates receives no tributaries in Iraq, the Tigris is augmented by a number of major streams. These are the Khabur, the Greater Zab, the Lesser Zab, the Adhaim, and the Diyala. Farther south the Karkheh loses itself in the swamps of lower Iraq, but most of its water eventually enters the Tigris.

The third contributor to the Shatt al-Arab is the longest river in Iran, the Karun, about 511 miles in length. While the basin measures only 26,090 square miles, the Karun drains a mountainous area of moderately heavy precipitation so that it carries a large volume of water.

The combined length of the Shatt al-Arab, Euphrates, and Murat system is about 2,200 miles, enough to place it among the sixteen longest rivers in the world.

Salt accumulation is a critical problem in the irrigated lands of the lower Tigris and Euphrates. The chemical content of the two rivers averages 250 and 445 parts per million, respectively. Not all of this is sodium chloride, for there are considerable percentages of lime and gypsum. So much water is withdrawn for irrigation and then lost by evaporation that the Shatt al-Arab eventually carries 746 parts per million. Since evaporation losses on the irrigated lands of Iraq amount to 30,000,000,000 cubic meters or 30 cubic kilometers of water per year, this means an annual addition to the agricultural areas of 22,000,000 metric tons of dissolved chemicals. The total accumulation of soluble salts has been estimated at over a billion tons.

Toward their mouths, the Euphrates and the Tigris pass through marsh and lake areas which absorb much of the flow. These water bodies change with the season, reaching a minimum of 3,200 square miles in the fall and increasing

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n the spring to 10,900 square miles. During the 1946 flood the total inundated area in all of Iraq amounted to 35,000 square miles.

All the rivers carry large amounts of sediment. The Diyala, a left bank tributary of the Tigris, is the most silty for its size, with some 11,500,000 cubic meters of material a year (Richards, see biblio.), derived from a catchment basin of 29,678 square kilometers. The Tigris itself annually moves 40,000,000 cubic meters of sediment past Baghdad but only a tenth of this amount reaches the Persian Gulf. The silt content in flood may rise to 20,000 parts per million by weight. This is five times the flood load of the Nile. On the Euphrates, the silt content at Hit has reached 6,100 parts per million, but the annual contribution is less than that of the Tigris. To this the Karun adds 29,700,000 cubic meters per year.

Most of the sediment from the Euphrates and Tigris is deposited in the Inland Delta above Basra, so that the water from these rivers which enters the Shatt al-Arab is relatively clear. The Karun, however, pours its full load of mud into the main river.

Since the three tributaries of the Shatt al-Arab carry sediment amounting to millions of tons, it is natural to assume that the river is building new land at the head of the Persian Gulf, and that in earlier centuries the sea extended much farther inland. Some of the monuments at Ur, now 150 miles from the Gulf, portray boat life and it has been assumed that the city once lay near the sea, although river navigation is an equally plausible interpretation. Many articles on the history of early Mesopotamia are accompanied by maps which draw shore lines even north of Baghdad, implying a land advance of ume 400 miles.

The evidence for this delta growth is questionable; in fact, geological conditions as cited by Lees and Falcon (see biblio.) indicate that at the dawn of history the head of the Gulf may even have been seaward of its present position. They conclude that "there is no acceptable historical evidence that the head of the Gulf was ever very far up-country from its present position." Wilson writes, ". . . the position of the seashore can have altered very little during the last sixty centuries, though no doubt very large areas formerly covered by brackish lakes have been reclaimed."

Within the basins of the Euphrates, Tigris and Karun, the mean annual rainfall varies widely. If spread evenly over the entire basin, there would be an average of about 12 inches, or one acre foot. In reality many areas south and west of Baghdad receive but five inches, while the higher mountains have 70 inches and more.

Not only is the precipitation unevenly distributed in space, but there are also wide variations from year to year. Thus Basra, with an annual average of 5.7 inches, has ranged from 2.1 to 13.9 inches. Likewise, Baghdad, with an average of 5.5 inches, has had a minimum of 2.0 and a maximum of 17.5 inches in one year. Two and a quarter inches have been recorded at Baghdad within one day, and six inches were reported in a February day in 1894.

The source of this precipitation has a bearing on the maximum rainfall which may someday be expected, and the ensuing flood heights. If an unusually humid air mass should move into Iraq in the spring and be fed by a continuous stream of moist air, as in the case of a slowly moving low pressure area with an active front, and, if some of this air were continually pushed against the mountain wall, a large area of the Tigris basin might receive 10 or even 20 inches in a week. It is not impossible that this might be repeated a few weeks later. While it is unlikely that flood peaks on the various tributaries would be simultaneous, this is a possibility which must be considered. The Euphrates is less likely to receive such a rainfall, and its floods from Turkey are usually "ironed out" before reaching Iraq.

Should these conditions follow a winter of heavy snow in the mountains and coincide with a period of rapid snow melt, the resulting stream flow might set an all-time record. The freezing isobase over the mountains of eastern Turkey in early spring usually lies around 3,000 feet. On one occasion this freezing level rose to 10,000 feet and remained there for a week. This resulted in the melting of great masses of snow, with consequent run off. Such a change in the elevation of the isobase, rather than warm rain, is probably the major factor in rapid snow dissipation.

In an area of variable and little understood rainfall, one cannot safely predict without a long period of observation. It has been suggested that 80 years are required here in order to achieve the same measure of reliability as given by 30 years of records in humid lands. Even this is not enough, since once in a century, or once in a thousand years, there are exceptional rains. The only certainty is that the known rainfall data are an inadequate guide.

Stream Flow

Many desert rivers have a régime which is in the reverse of those in humid lands. Since they flow through arid regions which fail to nourish them, losses by evaporation may exceed contribution by run off. Subtraction is thus greater than addition.

Normal rivers carry fresh water, but in the desert some of these shrinking rivers lose so much water by evaporation that the remaining flow becomes brackish or even saline.

Rivers the world around are subject to flood, but the range in flow is greater in dry lands, especially in areas of seasonal rain and with snow melt in the surrounding mountains. The St. Lawrence has a difference between low and high water of 1:2; with the Mississippi the fluctuation is 1:25; this increases on the Columbia to 1:35. In comparison, the Euphrates at Hit has a range of 1:28, while the low and high water in the Tigris at Baghdad fluctuates between 1 and 80.

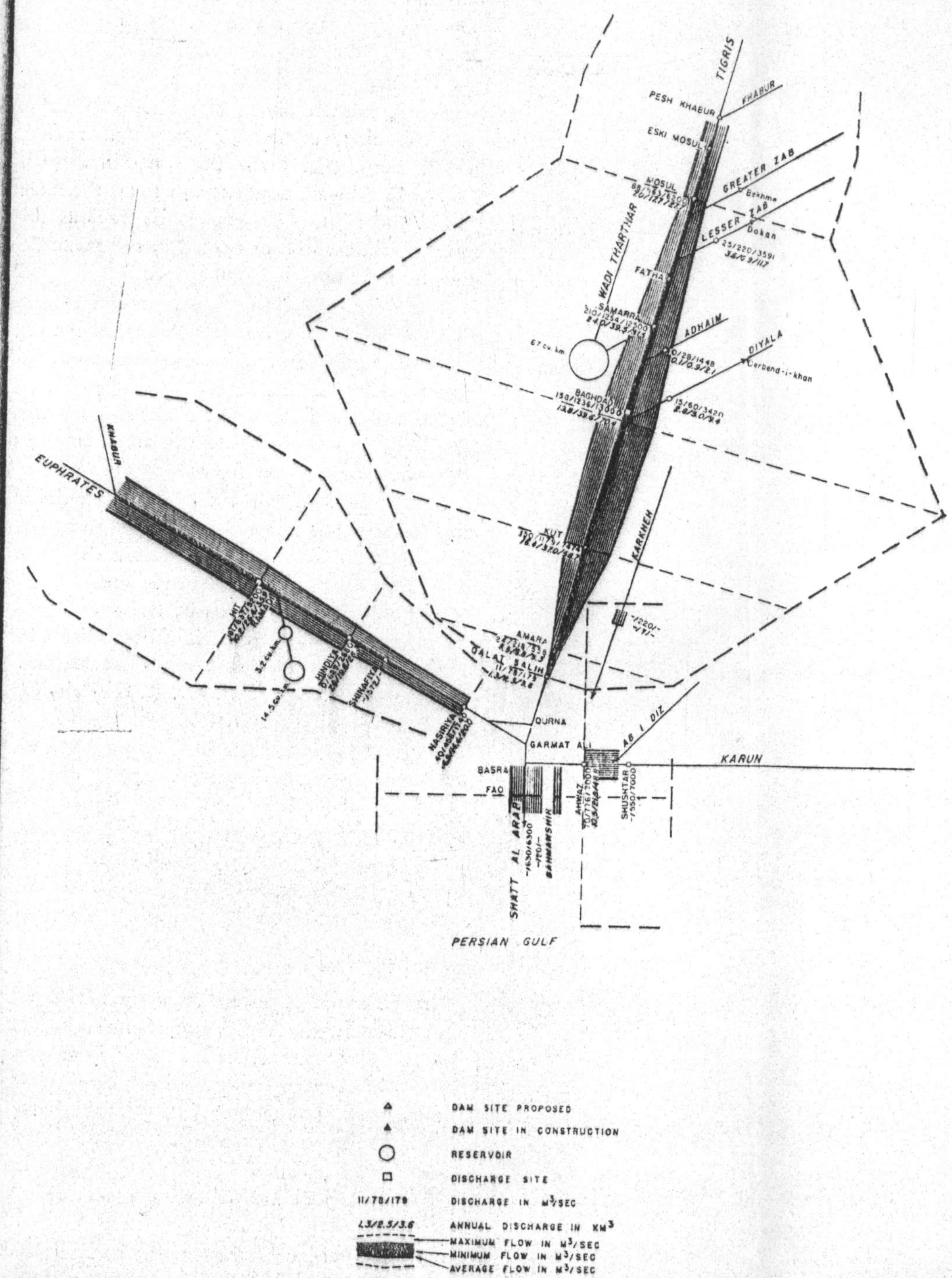
The account of Noah's flood may lack statistical data, but its magnitude is not surprising for a basin such as that of the Shatt al-Arab. Measurements of river levels at Baghdad have been kept for only a few decades, and it is highly probable that future flood flows will be larger. Even Noah may need to be updated.

Peak floods at intervals of a decade, or a century, are best described as 10 per cent, or 1 per cent, possibilities. It is equally likely that there are once-in-a-millenia floods; and the fact that they have only a .001 probability does not mean that two of them may not occur within a decade. In terms of flood control, this indicates that there is no such thing as assurance of complete protection against future conditions. All that man can do is to guard against calculated risks and reduce them by diversional and retentional works.

The three tributaries of the Shatt al-Arab experience low summer flow due to the almost complete lack of rainfall in their basins. With the arrival of winter rains, the flow increases but the maximum floods usually occur in the spring, due to a combination of heavy rain and the melting of snow in the mountains. Floods on the Tigris are made especially serious by sudden contributions from its left bank tributaries; when these are in simultaneous flood the combined run off becomes serious indeed.

Gauge and discharge records along the Euphrates are available from several stations in Turkey, from Deir ez-Zor in Syria, and at three dozen sites in Iraq. In Iraq, discharge measurements are available at Hit, just above the head of the delta (since 1924), at the Hindiya Barrage, at Shinafiya, and at Nasiriya. At Hit the river elevation has ranged from 51.98 in Sept. 1930 to 58.26 in May 1929. This corresponds to a flow of 181 cubic meters per second, or cumecs, on the former date, and 5,200 on the latter; the mean annual flow is 837 cumecs. Downstream at the Hindiya Barrage the discharge has varied between nearly zero and 2,880 cumecs, with a mean of 629 cumecs. At Nasiriya, farther south, the range is from 40 to 1,740 cumecs with a mean of 458 cumecs. The progressive downstream shrinkage reflects losses due to evaporation, especially in the rice-growing areas, plus flood diversion into the Habbaniya Lake.

The regime of the Tigris can only be plotted within Iraq since Turkey has gauge readings but no discharge measurements. At Mosul, where the lowest and highest gauge readings have varied between 212.6 in 1925 and 218.3 meters in 1935, discharge records in cumecs range from a minimum of 88, through a mean of 563, to a maximum of 6,200 cumecs. At Samarra, at the head of the delta, after the addition of the Greater Zab and the Lesser Zab, the corresponding discharge figures are



210, 1,254 and an estimated 12,500 cumecs. The records at Baghdad, extending back to 1906, show a minimum discharge of 158 cumecs, a mean of 1,236, and an estimated extreme high of 13,000. The latter includes the total flood flow after the dikes were breached and large areas east and west of the city were inundated. River velocities in flood may reach 10 knots.

Downstream from the junction of the Diyala below Baghdad, irrigation diversions by canal and pump are large, and the river flow diminishes greatly. At the Kut Barrage the minimum, mean and maximum discharge figures are 150, 1,179 and 7,474 cumecs. At Amara, the corresponding data are but 24, 218 and 558, and still farther downstream near Qalat Salih, after much of the river is lost in the marshes, the figures are only 11, 78 and 179. One may wonder whether any other river in the world shrinks so greatly.

Some of the irrigation canals withdraw so much water that they become rivers themselves. In fact, both the Hilla Canal below the Hindiya Barrage and the Gharraf Canal below the Kut Barrage were formerly the main channels of the Euphrates and Tigris, respectively. Each of these canals, in turn, feeds many distributaries. The Hilla Canal supplies water to 1,735,000 *mesharas*[1] by gravity flow, plus 500,000 *mesharas* by pump lift, while the Gharraf contributes water by gravity to 1,400,000 *mesharas*. The total area of Iraq irrigated by gravity flow, as contrasted to pump irrigation, amounts to 6,840,000 *mesharas*, about equally divided between the Tigris and Euphrates basins.

Since much of this irrigation water has no proper drainage channel through which to rejoin the main rivers, vast areas are waterlogged. This is especially true near the head of the Persian Gulf where water accumulates in the Hammar, Suniya, and Sadiya lakes, and in the surrounding marshlands. This is the home of the unique Marsh Arabs. Flying from Basra to Baghdad, the plane takes an hour to cross this water landscape.

The Karkheh River flows between the Tigris and the Karun. It may once have entered the latter but now loses itself in swamp lands east of Amara. Its flow is comparable to that of the Diyala.

Less is known about the Karun. Where it enters its delta at Shustar, the mean discharge is 550 cumecs and the flood maxima reaches 7,000. At Ahwaz, downstream from the mouth of the Ab-i-Diz Cut above the various delta mouths, the minimum reads 70, the mean 766, and the maximum is 7,000 cumecs.

All of these discharge figures, minus evaporation, should add up to the Shatt al-Arab. A third of the Karun reaches the sea through the Bahmanshir Channel rather than the Shatt al-Arab, and the Karun also receives some water from the marshes which mark the terminus of the adjoining Jarrahi River.

Discharge data for tidal rivers are difficult to compute, but it appears that the mean figure for the Shatt al-Arab at Fao, near the mouth, is 630 cumecs with an extreme flow of 6,300 cumecs. On an annual basis, the discharge has been placed at 19.6 cubic kilometers (1947 preliminary data) by the Basra Port Authority. In a personal letter from Mr. R. C. Kelt, Chief Engineer of the Port Directorate, dated December 21, 1955, it is stated: "In general terms it is estimated that the mean annual discharge of the Shatt al-Arab at Fao is 20 milliard cubic meters. During flood periods, however, the rate of discharge may be very much greater, in some opinion to the extent of up to 10 times the average."

Flood Control

The Euphrates enters its delta between Hit and Ramadi, the Tigris near Samarra, and the Karun at Shushtar. Below these points it is generally necessary to construct dikes in order to protect the countryside. When these are breached by erosion or overtopped by high water, vast areas of farm land are inundated, communications are interrupted, and cities endangered.

Since flood levels of the rivers lie at elevations above the surrounding plain, breaks in the dikes give rise to shallow lakes, marginal to the

1. One *meshara* equals 0.612 acre.

City	Low Water Elevation in Meters	Catchment Area sq. km.	Discharge in Cubic Meters per Second: Minimum	Mean	Maximum	Annual Discharge in Cubic Kilometers: Minimum	Mean	Maximum
Discharge Data for the Euphrates								
...ir ez-Zor	......	......	......	......	......	......	24.	......
[illegible]	52.0	......	181	837	5,200	10.2	26.4	35.9
...ndiya Barrage	23.9	......	0	629	2,880	7.6	19.8	28.3
...siriya	1.7	......	40	458	1,740	4.9	14.4	20.0
Discharge Data for the Tigris								
...sul	212.6	54,898	88	563	6,200	7.0	17.7	27.7
...marra	......	......	210	1,254	12,500	24.0	39.5	51.5
...ghdad	27.6	134,259	158	1,236	13,000	19.8	39.6	70.4
...junction of the Diyala	......	166,155	163	1,339	14,000	18.9	42.3	63.5
[illegible]	9.5	......	150	1,179	7,474	16.4	37.0	58.7
...nara	4.6	......	24	218	558	4.3	6.8	9.5
...lat Salih	......	......	11	78	179	1.3	2.5	3.6
Discharge Data for the Karun								
...shtar	......	......	......	550	7,000	......	......	......
...waz	......	67,579	70	766	7,000	10.5	21.8	48.8
Discharge Data for the Shatt-al-Arab								
[illegible]	0	808,000	......	630	6,300	......	20	......

...vers, which may remain until evaporated. ...e city of Baghdad, surrounded on all sides ... dikes, has several times been seriously ...reatened. If the dikes should be overtopped ... a high flood, parts of the city would be ...bmerged to depths of 15 feet.

Floods rise quickly on the Tigris and Karun ...d more slowly on the Euphrates due to its ...nger course below the mountains. Thus the ...gris may double its volume in two days. ...ood warnings are generally possible, for it ...quires some ten days for the water to move ...om the mountains to the sea.

During the period from 1945 to 1957, the ...gris broke its banks below Baghdad in every ...ar except two, and above Baghdad in four ...ars. In March 1954, Baghdad was saved ...om disaster only by great efforts and good ...rtune. Most of the Tigris flood broke through ... right hand bank farther downstream and ...entually entered the lower Euphrates. The ...phrates was also in flood, but a part of its ...k was reduced by the Habbaniya Reservoir; ...thout it much of Iraq below Ramadi and ...marra would have been under water.

To reduce the hazard, the Iraq Development Board has developed a series of flood control works on the Euphrates and Tigris, and on the tributaries of the latter. Since the maximum flow is unpredictable, these dams will not entirely prevent floods, but they will greatly reduce the hazards.

Along the Euphrates a low dam, or barrage, at Ramadi, completed in 1956, raises the river level a few feet so that a part of the flood flow may be diverted southward through the Warrar Inlet Canal into the natural basin of Lake Habbaniya. The rated capacity of both the Ramadi Barrage and the Warrar Inlet Canal is 2,800 cumecs, or a total of 5,600 cumecs. Dikes around the Habbaniya basin have enlarged it into a reservoir which provides a storage capacity of 3.2 cubic kilometers. If this is insufficient, the Mujarra Escape Regulator will pass water southward to a similar natural depression at Abu Dibbis, with a potential capacity of 14.5 cubic kilometers if new dikes are built to close the gap toward the Euphrates. There is also an arrangement whereby surplus water in Habbaniya may return to the Euphrates, via the Dhibba Regulator, once the flood has passed, for subsequent irrigation use.

Additional dams have been proposed upstream at Khan, Baghdadi, Rawa and Hit, but their reservoirs would inundate good farm lands. Still other sites exist at Yusif Pasha in Syria, and at Keban in Turkey where a large dam is now under construction near the junction of the Kara Su and the Murat Su.

Conditions along the Tigris are even more favorable for flood storage. To the west is the Wadi Tharthar, which terminates in a dry *playa* whose floor is below sea level. A barrage at Samarra, and a 60 kilometer canal, or escape way, finished in 1956, can divert water into this depression whose capacity is 63 cubic kilometers. No return flow is yet available.

Two dams along Tigris tributaries, the Dokan Dam on the Lesser Zab and the Derbend-i-Khan Dam on the Diyala, have storage capacities of several cubic kilometers. Each of these dams, and the Samarra Barrage as well, are designed for flood control and irrigation, and eventually for the generation of hydroelectric power as well. Such multi-purpose objectives raise problems as to whether the reservoirs should be kept empty until the end of April, in readiness to absorb the spring floods, or full in order to provide the maximum storage for power and irrigation. Tigris dams are under consideration in Turkey and in Iraq at Eski Mosul and at Fatha; also at Bekhme on the Greater Zab.

The Samarra Barrage is designed to pass a flood flow of 9,000 cumecs, although for the safety of the lower valley the maximum should not exceed 7,000 cumecs, and the Wadi Tharthar diversion canal will carry 8,000 cumecs safely. This total of 17,000 cumecs is only 3,000 cumecs larger than the recorded flow of the Tigris at this point, so that the safety margin is low. A high water mark at Samarra, which occurred during the memory of the present inhabitants, even suggests a flow of 20,000 cumecs. With the development of storage on the tributaries, and later on the main river, the peak flow will be reduced so that the floodway of the Tharthar Canal should only be needed a few days a year.

The problem lies in what to anticipate on rare occasions. Hydrologic estimates for Samarra by Thomas (see biblio.), based on 25 years of records, place the flood expectations as follows:

11,680 cumecs	5 per cent frequency
15,350 cumecs	1 per cent frequency
18,990 cumecs	0.2 per cent frequency
20,550 cumecs	0.1 per cent frequency

These figures are smaller than for fan-shaped basins in other parts of the world since the Tigris has no right bank tributaries. Experience tables for basins of this general character forecast a theoretical peak of 41,000 cumecs. Since there is abundant evidence, both geologic and historic, that the observed discharge during the past 25 years has been greatly exceeded in the past, the expectations of Thomas may be too low. Thomas thus adds, "It is possible that the flood risk may be greater than estimated, due to available flood data being unrepresentative. A failure of the Barrage or breach of the retaining banks might lead to catastrophic disaster."

While great floods are rare, they do occur, and since Baghdad, with its 650,000 people, lies downstream, the risk must be recognized. The city is surrounded on all sides by dikes, and has many times been threatened. The new dams will greatly reduce the flood menace, but it should not be said that Baghdad is now "safe." Since man cannot safely gamble with nature, no complete security is possible.

If the Tigris and its tributaries were simultaneously each at their maximum recorded flood, without reservoir control and without allowance for storage capacity of the channel and its flood plain, the combined flow at the Diyala junction near Baghdad would have reached 23,750 cumecs. This has never been the case in recent history, and the total would now be reduced by Dokan and Derbend-i-Khan storage, plus Wadi Tharthar diversion. But the prospect should not be overlooked.

The problem of Baghdad is complicated by the constricted channel, for the city has gradually encroached on the river. The safe capacity is around 5,300 cumecs, at a gauge level of 34.7 meters. Prior to Tharthar development, floods were apt to exceed this limit four times within a decade. When the river reached a higher level, the dikes were cut upriver and part of the flow diverted across country to the east of the city. This area, "outside the city Bund," is gradually being built up with homes and factories which will restrict the discharge capacity of the flood channel. Most of the city lies below flood level. The absolute maximum capacity of the river and the escape channels at Baghdad is 8,000 cumecs, provided the Diyala, which joins the Tigris just below the city, is not also in flood; if it too is in flood the maximum capacity at Baghdad is 7,000 cumecs.

Two other low dams, one downstream on each river, provide take-off points for irrigation canals. On the Euphrates there is the Hindiya Barrage, completed in 1913, while on the Tigris there is the Kut Barrage, built in 1939. Below these points so much of the flow is diverted for irrigation, or spills over into marsh and lake areas, that the rivers are much reduced. A third dam, built on the Diyala in 1929, distributes the entire summer flow of the river to a large agricultural area.

No dams have been built on the Karun, but many sites are available above Shushtar.

The Water Budget

Within the combined drainage basin of the three rivers the rainfall varies from as little as 100 millimeters in the lowlands to well over 1,000 millimeters in the mountains. The total annual precipitation for the area is estimated at 325,000,000,000 cubic meters, or 325 cubic kilometers. Where the Euphrates, Tigris and Karun enter their flood plains (at Hit, near Baghdad, and at Shushtar), and after they receive the contribution of their last major tributaries, the combined annual flow amounts to 90 cubic kilometers. Thus, out of the original supply of 325 kilometers, 235 cubic kilometers have been lost by evaporation. Only small amounts move out of the basin underground. Much of the precipitation has disappeared before it ever reaches a permanent stream.

Other evaporation losses take place in the lowlands. Subtractions in the irrigated areas of the Tigris and Euphrates account for 30 cubic kilometers. Losses from the lakes and swamps which make up the vast Inland Delta north of Basra average 2 meters per year, and thus amount to 33 cubic kilometers.

The Karun has two mouths; about two-thirds of the water enters the Shatt al-Arab, while the remainder reaches the Persian Gulf through the Bahmanshir Channel to the east of Abadan. As already pointed out, the annual discharge of the Shatt al-Arab proper is 20 cubic kilometers; to this may be added some 7 cubic kilometers for the other mouth of the Karun.

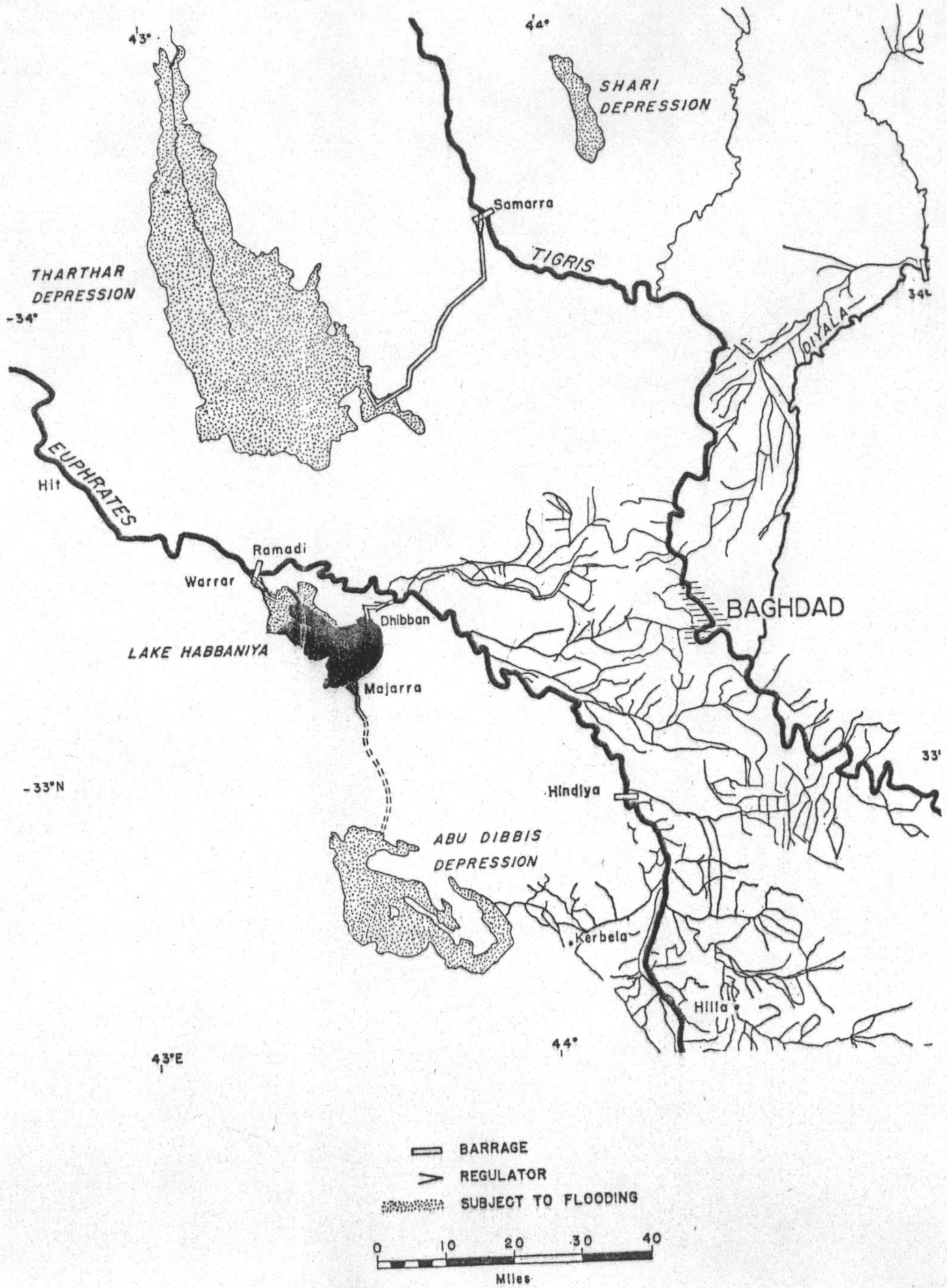
The total water budget of the Euphrates, Tigris and Karun thus reads as follows:

Discharge to the Persian Gulf (from the Karun: 22 from the Tigris and Euphrates: 5)	27 cubic kilometers
Evaporation in the Inland Delta	33 cubic kilometers
Evaporation in the irrigated areas	30 cubic kilometers
Evaporation above the head of the deltas	235 cubic kilometers
Original supply from precipitation	325 cubic kilometers

The above figures suggest that the average drop of rain has but one chance in 12 of flowing to the sea. Were it not for the contribution of the Karun, which loses little water by evaporation en route, the average would be even smaller. Water passing Baghdad has but one chance in 35 of getting to the Persian Gulf.

Two small corrections need to be made for upstream diversions which take water entirely outside the basin. The city of Aleppo in Syria now receives its domestic supply by pipe line from the Euphrates with a normal withdrawal of 0.7 cubic meters per second. In Iran, a 9,250 foot tunnel leads eastward from the headwaters of the Karun and diverts 110 cumecs in summer for irrigation around Isfahan. Sevian has also proposed the construction of an 80 mile canal for navigation from the Euphrates to the Mediterranean, and of a canal from the Shatt al-Arab to Kuwait, thus removing further amounts of water.

A water budget may also be computed in terms of total area needs, or in the depth of water to be applied. Within much of lowland Iraq, Syria and Iran, the normal rainfall amounts to less than 200 millimeters, as compared with a potential evapotranspiration figure of some 1,200 millimeters. In order to raise crops, this gap must be narrowed. The irrigated area in Iraq thus imports water from Turkey, Syria and Iran. If the entire intake from these countries might be spread evenly within Iraq,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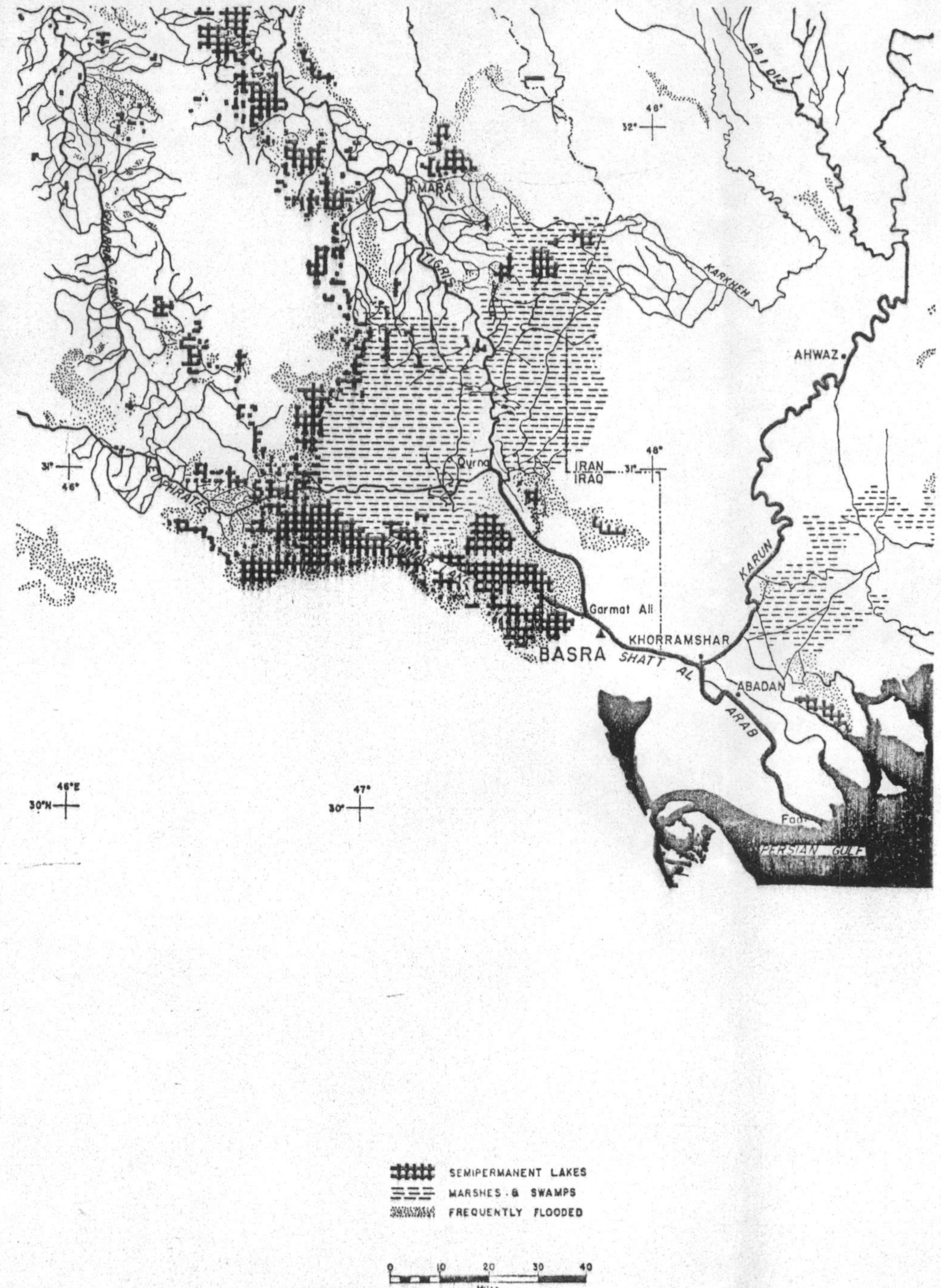
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Annual Water Requirements for Iraq[2]

	Area in Mesharas	Water in cubic kilometers A	Water in cubic kilometers B	Depth in meters	Acre feet
Euphrates Basin, existing projects	4,900,000	6.1)	14.7	0.50	1.5
Euphrates Basin, new projects	2,800,000	6.5)		0.93	3
Tigris Basin, existing projects	8,100,000	11.3)	32.4	0.55	1.5
Tigris Basin, new projects	6,200,000	15.0)		0.97	3
Total	22,000,000	38.9	47.1		

obviously impossible, it would provide an additional 200 millimeters, two-thirds of an acre foot. Since the supply of irrigation water is limited, especially during the summer, only a small part of the valley can be cultivated.

Water needs in Iraq may be seen from the accompanying table. The present and prospective requirements on the Euphrates amount to 12.6 or 14.7 cubic kilometers per year, depending on various schemes as to intensive use. This may be compared with the mean annual flow at Hit amounting to 26.4, or the low water flow of 10.2. On the Tigris the total plan calls for 26.3 to 32.4 cubic kilometers, set against a Baghdad mean annual flow of 39.6 and the low water discharge of 15.2 cubic kilometers. Iraq thus has enough water for its planned needs if it can all be properly used.

The problem of increased irrigation within Syria concerns the limited areas of flood plains along the Euphrates. For the most part, the river flows in a valley which lies several hundred feet below the uplands. Only narrow belts of flood plain can be irrigated by gravity canals. Potentially cultivatable areas within 10 meters of river level total 2,500 square kilometers, while areas requiring from 10 to 20 meters lift add 900 square kilometers. Some possibilities exist along the Khabur. If Syria should divert large amounts of Euphrates water, it might seriously affect irrigation prospects within Iraq.

Only scattered information is available for the Karun and Kerkheh. Extensive areas are already irrigated in the limited delta area, known as Khuzistan, but ample water is available for additional cultivation.

Water Policy

Water is one of nature's most valuable assets, unappreciated while abundant. Fortunately, water is a renewable resource, except when we overtap ground water or change the run-off characteristics of a watershed. Ideally, no drop of rain which falls in the basin of the Shatt al-Arab should run off to the Persian Gulf without performing several useful services en route. These may be for domestic use or the watering of livestock, to grow crops, for power, industry, or navigation, or as replenishment for ground water. A comprehensive program will consider many functions, including the relative claims of upstream versus downstream users. This calls for a use policy and an overall water budget.

Any inclusive program for the Shatt al-Arab basin must begin with an adequate inventory. This is not yet available, since we need more data on terrain characteristics, climatic conditions, hydrology, and land use potentials. Excellent studies have been made in Iraq, but none have covered the entire Shatt al-Arab basin. Wise planning calls for an understanding of the complete watershed; country by country planning is impractical.

2. Knappen, Tippetts, Abbett and McCarthy, page 6. Scheme A provides for a continuation of the present practice of irrigation in alternate years on existing projects, thus allowing the land to lie fallow, but for year round irrigation on new land. Scheme B provides for irrigation throughout the year in most of the old areas and in all of the new projects.

In addition to physical surveys, there must be an evaluation of future population and its requirements. If petroleum and natural gas are to provide all the power needed in Iraq and Iran for decades to come, it may not be necessary to install the generators provided for at Dokan, Samarra and elsewhere. Turkey and Syria, however, have power shortages and may wish to develop hydroelectricity on their parts of the rivers.

Whether or not it may prove feasible to irrigate considerable areas in Syria, or perhaps in Turkey, has its bearing on how much water may be left over for Iraq. Power dams on the headwaters will also affect stream flow down river. The full utilization of the rivers for irrigation may reduce the prospects for navigation. The conflict between upstream and downstream competitors for water is an old story. Many of the wars between ancient Assyria, upstream, and Babylonia, downstream, were fought over problems of water. It is obvious that the development of the Euphrates and Tigris calls for long range cooperation between Turkey, Syria and Iraq. The Karun flows entirely within Iran, but the Shatt al-Arab is under Iraqi jurisdiction.

Since climatic unpredictability is certain, what degree of variability should be anticipated? In terms of costs, is it better to plan on the irrigation of a large area, knowing that once in a few decades there will be a major water shortage? Should bridges be designed for all but the one per cent flood? How much should be invested in river control works which may be needed only once in a century? Should major cities be given maximum flood protection? Should settlement be forbidden in certain locations? These are policy decisions which only a government can make; the function of the geographer is to prepare and evaluate the inventory.

Some procedures are relatively clear. It is uneconomic to plan for irrigation without also planning for drainage, and it may be expected that the costs of getting rid of surplus water will equal or exceed that of providing the original supply. No irrigation project is safe where the soils or the water have a high initial content of salts, or where the water table is brought within five feet of the surface. Silt and sand accumulation is another hazard, and canal water should not be withdrawn from the rivers until it has been adequately de-silted.

Only a few control works exist on the Tigris or the Euphrates and there are none on the Karun. Are others needed? The situation is especially serious on the distributory canals where conditions fluctuate widely between shortage and surplus. Thus the Gharraf, main irrigation canal from the Tigris, has 52 regulated offtakes and 959 which are uncontrolled.

Reservoirs may serve various purposes, but it must be recognized that some of the purposes may be contradictory. In order to reduce flood hazards the reserve storage capacity should be kept at a maximum; in other words, the lower the level the better. The economic generation of electric power calls for the highest possible head; in other words, a full reservoir. Irrigation requirements equally call for the maximum storage. These conditions involve conflict between the city dweller who wants flood protection and the farmer who wants to be assured of adequate water for irrigation.

The Iraq Development Board, under the previous régime, felt the necessity of rushing into elaborate water programs, but it had to proceed in advance of full geographic studies. Millions of dollars can be saved and major mistakes avoided if action takes place only after the Shatt al-Arab basin is studied as a whole. Wise planning is impractical until the geographic inventory is reasonably complete.

With proper development, the water of the Shatt al-Arab basin may provide twice as good a livelihood for twice as many people. There are great unrealized assets, but it is also well to recognize the limitations and hazards. Man cannot afford to under-plan when dealing with water in the desert.

BIBLIOGRAPHY

Binney, Goeffrey Morse. "Some Notes on the Karun River and the Shatt al-Arab," *Journal Institution of Civil Engineers*, XXXIII, No. 3 (1950), 204-52, 360-62.

Boesch, Hans H. "El-'Iraq," *Economic Geography*, XV (1939), 325-61.

Cressey, George B. "Water in the Desert," *Annals*, Association of American Geographers, XLVII (1957), 105-24.

Haigh, F. F. *The Control of the Rivers of Iraq and the Utilization of Their Waters*. Baghdad: Directorate General of Irrigation, 1951.

Harza Engineering Company, and Binnie, Deacon and Gourley. *Hydrometeorological Criteria for Design Floods in the Tigris River Basin*. Baghdad, 1957.

Ionides, M. G. *The Regime of the Rivers Euphrates and Tigris*. London: E. & F. N. Spon, 1937.

——————. *The Records of the River Karun*. Baghdad: Irrigation Department, 1932.

Iraq Development Board, Baghdad. Various reports.

Iraq Directorate General of Irrigation, Baghdad. Various reports.

Iraq Meteorological Service, Baghdad. Various reports.

Jacobson, Thorkild and Adams, Robert M. "Salt and Silt in Ancient Mesopotamian Agriculture," *Science*, CXXVIII (1958), 1251-1258.

Khalaf, Jassim M. *The Water Resources of the Lower Colorado River Basin*. Chicago: University of Chicago, Department of Geography, Research Paper No. 22, 1951.

al-Khashab, Wafiq. *Water Balance of the Tigris-Euphrates Basin*. Chicago: University of Chicago, Department of Geography, Research Paper, 1958. (Not seen.)

el-Kholy, Fouad H. *Hydrology of River Tigris*. Baghdad: Directorate General of Irrigation, 1952.

——————. *Report on Suspended Sediment in River Tigris*. Baghdad: Directorate General of Irrigation, 1956.

Knappen, Tippetts, Abbett, McCarthy. *Report on the Development of the Tigris and Euphrates River Systems*. Baghdad: Development Board, 1952.

Lebon, J. H. G. "The New Irrigation Era in Iraq," *Economic Geography*, XXXI (1955), 47-59.

Lees, G. M. and Falcon, N. L. "The Geographical History of the Mediterranean Plains," *Geographical Journal*, CXVIII (1952), 24-39.

Macfadyen, W. A. *Water Supplies in 'Iraq*. Baghdad: Ministry of Economics and Communications, 1938.

Nelson, Wesley R. "Control and Use of the Waters of the Tigris and Euphrates Rivers." Baghdad: Iraq Society of Engineers, March 29, 1956. [Mimeographed.]

Noble, A. H. *The Subsurface Water Resources of Iraq*. Baghdad: Government Press, 1927.

Ralph M. Parsons Co. *Ground Water Resources of Iraq*. 9 vols. Baghdad: Development Board, 1954-55.

Richards, Edwin Verney, "The Flood Problems in Iraq," *Journal Institution of Civil Engineers*, XXIV, No. 6 (1945), 145-68.

Salter, Lord. *The Development of Iraq*. Baghdad: Development Board, 1955.

Sevian, Vahe J. "Economic Utilization and Development of the Water Resources of the Euphrates and Tigris," *Proceedings*, United Nations Scientific Conference on the Conservation and Utilization of Resources, New York (1949), IV, Water Resources, 148-58; also in *Bulletin de la Societe Royale de Geographie d'Egypt*, XXIV (1951), 177-200.

——————. "Irrigation in Iraq," *Indian Geographical Journal*, 1951, 46-52.

Sousa, Ahmed. *The Hindiyah Barrage: Its History, Design and Function*. Baghdad: Government Press, 1945.

——————. *Iraq Irrigation Handbook*: Part I, *The Euphrates*. Baghdad: Directorate General of Irrigation, 1944.

——————. *The Euphrates Valley and the Habbaniyah Project*, Vol. 1. Baghdad: Government Press, 1944.

Thomas, A. R. *Report on Hydrologic Problems in Connection With Wadi Tharthar Project, Iraq*. Baghdad: Development Board, 1954.

Willcocks, W. *Irrigation of Mesopotamia*. 2nd edition. London: E. & F. N. Spon, 1917.

Wilson, Arnold T. "The Delta of the Shatt al-Arab and Proposals for Dredging the Bar," *Geographical Journal*, LXV (1925), 225-39.

GENERAL

I SAW FOR MYSELF, by Anthony Nutting. New York: Doubleday, 1958. 103 pages. $3.00.

Reviewed by Richard V. Weekes

With Soviet tanks fighting patriots in Budapest streets and British, French and Israeli bullets flying over Egypt, the resignation of Britain's Minister of State for Foreign Affairs in November 1956 over the Suez invasion made little noise in the world. Yet Anthony Nutting's protest over his government's actions, reminiscent of that made in 1938 by Sir Anthony Eden himself, was important. Mr. Nutting, now 38 and since World War II one of the rising politicians in the Conservative Party, demonstrated that along with Sir Edward Boyle, 34 (who resigned a few months later), Reginald Maulding, 41, and Iain MacLeod, 44, some of Britain's "conservative" political personalities are far from being old and tired.

Therefore, *I Saw for Myself*, a short account of Mr. Nutting's 20,000-mile journey through the Middle East following his resignation, has significance if only for the insight it gives into the thinking of a man likely to be on the British scene for some time to come. Mr. Nutting, now an occasional foreign correspondent, did not enter the Muslim world a stranger; he negotiated the Anglo-Egyptian Agreement with Gamal 'Abd al-Nasir in 1954 and played an important role in forming the Baghdad Pact in 1955, an arrangement he still feels has more to than against its credit. This time he listened, not only to the politicians running things, but to opinion leaders out of power.

Mr. Nutting's observations and conclusions are not those of a British socialist nor a British-India sahib. He is outspokenly critical of the French in North Africa, British policy in the Persian Gulf and gunboat diplomacy. His heroes are the Algerian nationalists and King Saud, among others. His chief villain is Nasir, significantly in spite of the circumstances of his resignation.

Mr. Nutting's reports give *I Saw for Myself* a somewhat oversimplified picture of some complex situations, yet such insight as he has is rather refreshing, when most Western leaders seem to have little understanding at all of people and forces in the Middle East. Mr. Nutting's observations establish his reputation as a man of independent perspective. Among them: in Iran the "rich and ruling classes exhibit an indolence and irresponsibility that is really frightening"; Israel is "an armed labor camp, a militarist democracy" which "prefers a grievance to a reconciliation," a "nation of people blinded by their own bravery"; the danger of Britain's oil supplies lies in Great Britain's perpetuating "the present archaic state of relations with Kuwayt, Bahrayn, etc., which satisfies no one except the rulers"; US' arguments on the Baghdad Pact "vary according to which section of the State Department happens to be briefing Mr. Dulles on the day in question"; "the purpose of the Eisenhower Doctrine must be to help our Arab friends to beat the Communist threat, not to demonstrate the power —or the weakness—of the United States in the Middle East."

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THE MIDDLE EAST IN TRANSITION, ed. by Walter Z. Laqueur. New York: Frederick A. Praeger, 1958. xix + 513 pages. $8.75.

Reviewed by Fahim I. Qubain

The book, consisting of two parts, is an anthology of thirty-four articles, each written by a different author. Twenty-six of these articles had already appeared during the past six years in various magazines and journals.

Part I, "Social Reform and Political Change," contains nineteen essays. Seven deal with social