FINE TUNING THE FUTURE EUPHRATES-TIGRIS SYSTEM

John Kolars
University of Michigan

Presented to the Council on Foreign Relations, 17 June 1992

Introduction

The size and complexity of the Euphrates-Tigris River Basin system obviate any attempt to present an actual management scenario in the time and space of this discussion. Furthermore, the contemporary management of any river system entails such a massive array of skills, programs, and hardware that it would be presumptuous for a solitary practitioner to attempt or to suggest such a task. Therefore, the purpose of this presentation is not to tell people how to manage the twin basins which encompass parts of five countries, but rather to provide an overview of the system and some of its details which may be of importance to such management. Emphasis will be placed on pressure points within the system that, while easily overlooked, may be essential to the larger, more obvious elements now attracting both headlines and negotiators in the Water and Peace process.

This discussion will avoid excursions into the realm of abstract theory. While I recognize the need for such considerations, I have recently read a paper in which the entire complexity of the sharing of the waters of the Euphrates -- including hydrological, environmental, political and economic parameters -- was reduced to a single two digit number, and another which solves all the problems that international river management entails but mentions the Euphrates system on only the first page of a twenty-two page paper. In both cases I was left -- like the little old lady in the add -- with the feeling "Where's the beef?"

In order to avoid such a question myself, I have chosen what I feel are the best data available. The values used in no way represent an ultimate data set. However, the magnitudes and proportionalities indicated by them serve to illustrate the problems involved in the rational use of the Euphrates-Tigris basin's water resources.

The Euphrates-Tigris System

The Euphrates River is the longest river (2,700 km) in southwest Asia west of the Indus. It has an estimated average annual natural flow at Hit, Iraq of 33.457 billion m^3 (Bm^3) (Kolars and Mitchell, 232-235). Approximately 6.6 percent (2.21 Bm^3) of this originates from the Balikh and Khabour Rivers in Syria. The remainder (31.247 Bm^3) comes from Turkey with the exception of some 80 million m^3 which the Sajur (Turkish: Sacir) adds from the right bank after beginning in Turkey before debouching in Syria.

The Euphrates is formed by the Karasu and Murat Rivers which join 45 km northwest of Elazig. From that point to the Syrian border the river flows through a series of mountain valleys, canyons and narrow plains. In Syria its path is traced across a tableland in an entrenched valley which has limited Syrian use of its waters until recent times. The river reaches its alluvial delta in Iraq near Hit 360 kilometers downstream from the Syrian-Iraqi border. From there to the Gulf the Euphrates drops only 53 additional meters, and by the time it reaches Nasiriya it has become a tangle of channels some of which drain into Lake Hammar. Near Qurna it joins the Tigris River whence the combined waters, the Shatt al-Arab, reach the Gulf 179 kms downstream. The Karun River, flowing westward from the Zagros Mountains in Iran, converges with the Shatt in this segment bringing an estimated 27 Bm^3 annually from the Zagros Mountains in Iran (Naff, 1991, 33).[1]

---

1. Cressey, 1958, reports an annual flow of 48.8 billion m^3 at Ahwaz but the derivation of this value is uncertain.

The Tigris River to the east of the Euphrates gains more then half its flow from Turkey. The remainder derives from streams in the Zagros Mountains bordering its left bank in Iran and Iraq. The Tigris is 1,840 km in length, with a reported annual natural flow ranging from 43.0 Bm^3 to 49.2 Bm^3.* The river rises in northeast Turkey near Lake Hazar. It flows southeast to the Turkish

---

*It should be noted at this juncture that I speak with less assurance about the volume of the Tigris river and the timing of events relating to it than I do regarding the Euphrates, for I have studied the latter in detail and must rely upon the conflicting reports of others for the former.

city of Cizre where it marks the border between Turkey and Syria for 32 km before entering Iraq. Approximately 37 percent of the total discharge (18.5 Bm^3) comes directly from Turkey while the Greater Zab with its headwaters in the latter country contributes an additional 26.6 percent (13.1 Bm^3). North of Samara in Iraq the Tigris enters its delta and thereafter forms the eastern portion of the interactive Euphrates-Tigris system.

An unusual and important aspect of the morphology of the two rivers is that the Euphrates is higher in elevation in the north than the Tigris, but to the south the bed of the Tigris is slightly higher than that of the Euphrates. This allows water to be exchanged between the two rivers through canals connecting the Tharthar depression with both streams. At present the exchange is from the Tigris to the Euphrates; a second canal that will bring water from higher up the Euphrates to the Tharthar and thence to the Tigris is planned.

Other left bank tributaries -- among them the Lesser Zab, the Adhaim, and the Diyala -- swell the stream in this stretch with an additional estimated 15.4 Bm^3. Eighty kilometers north of Qurna great swamps border the Tigris and extend south to the confluence of the river with the Euphrates, thereafter the Shatt al-Arab.

A Matter of Variance

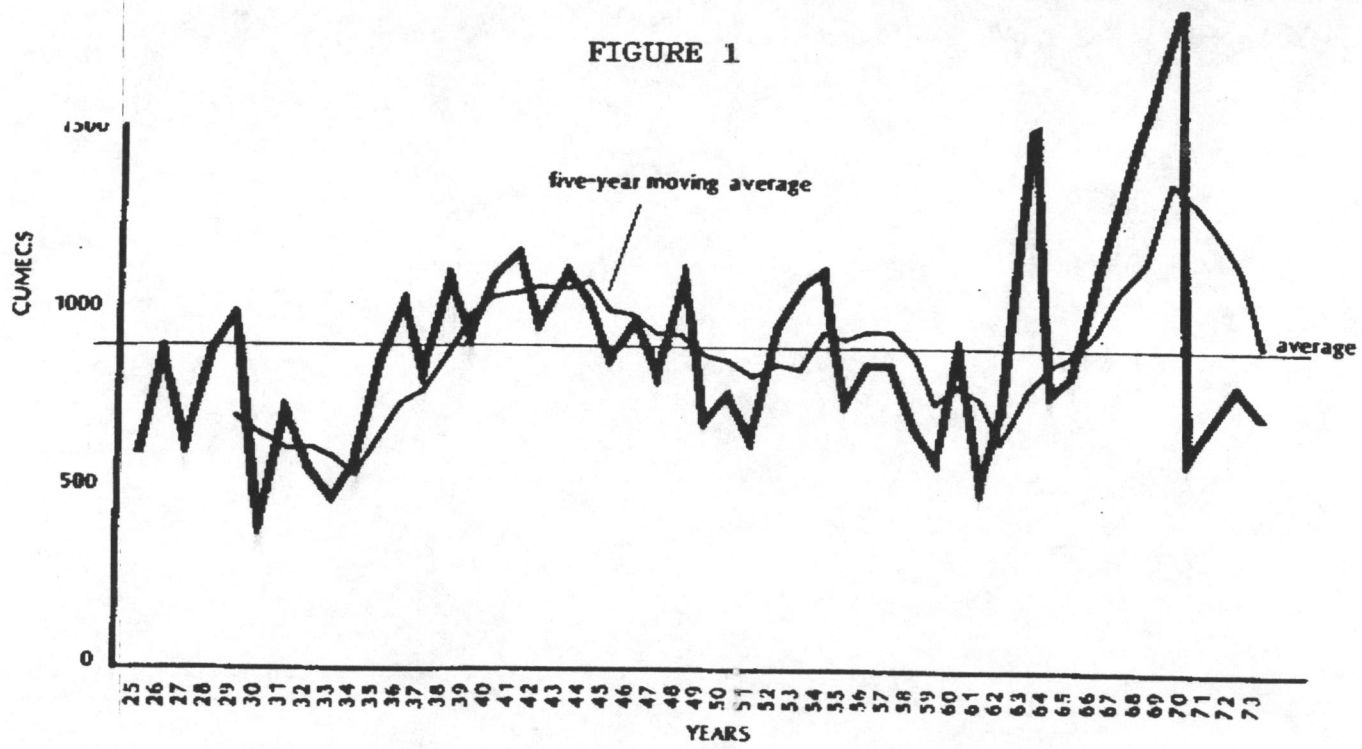
Climatic variability throughout the headwaters of the Euphrates and Tigris Rivers results in extreme variance in the flow of the two streams. This is true not only on a monthly basis but also from year to year, and makes planning and management of the rivers for agriculture and flood control difficult. While there is usually enough water for domestic use, including industry, in the cities located on the rivers' banks, in extremely dry years even this use may be threatened. Variation in the flow of the Euphrates is shown in Figure 1.

The maximum annual flow recorded at Hit, Iraq during the period 1924-25/1972/73 was 63.24 Bm^3 (2005 mcs) [2] in 1968-69. This was nearly six times greater then the minimum annual flow

---

2. These and the following values do not take *natural* flow into account.

FIGURE 1



Discharge of the Euphrates River at Hit, Iraq, 1924–25/1972–73. Source: Hadithi, Appendix E [Ministry of Irrigation]; five-year averages computed for present study.

Source: John Kolars & Wm A Mitchell, The Euphrates River and the Southeast Anatolia Development Project, Southern Illinois University Press (1991), p. 121.

in 1929-30 of 10.66 Bm^3 (338 mcs) (al-Hadithi, 1978, 4, Table 5-1). Such extremes were respectively 123 percent greater and 62 percent less then the average flow of 28.4 Bm^3 (900 mcs) for the same period. The 50 year record for the flow of the Euphrates River at Hit shows a maximum peak of 7,390 mcs in 1969, and a minimum peak flow of 850 mcs in 1930. The average for the period 1924-1973 was 900 mcs. The average annual maximum and minimum flows for the period 1937-1961 were 2,509 mcs in April and 288 mcs in September respectively (Kolars, 1992, 106).

The Tigris River shows variance in volume along its length as the result of numerous tributaries as well as its water's being diverted to Lake Tharthar and for irrigation. Peak flows can vary between 14,000 mcs near the entry of the Diyala to 179 mcs near Qurna. The minimum recorded flow at Baghdad is 158 mcs and the maximum 13,000 mcs, the average being 1,236 mcs. The Euphrates has a more regular regime with a minimum flow of 181 mcs and a maximum of 5,200 mcs at Hit, Iraq. Because of the proximity of the sources of the left bank tributaries to the main stream of the Tigris compared to the lack of perennial side streams in the lower reaches of the Euphrates, the former river is famous for its floods while the latter is not.

The smoothing of such annual and multi-annual variance in the flow of the two rivers through the use of upstream reservoirs is a major argument presented by the Turks to rationalize their use of the rivers. General information and estimates of the natural flow and possible uses of these two streams are shown in Tables 1 and 2.

Actual and Proposed Use of the Rivers

Iraq

The above description of the Euphrates and Tigris rivers makes little reference to the human use of these streams. Mesopotamia, the southerly land between the rivers, has been for millennia the site of irrigation projects dependent upon their waters. In modern Iraq an estimated 1,294,000 hectares of land use the Euphrates for irrigation. It is further estimated that as much as 52 percent of the natural flow of the river entering Iraq may be used for irrigation (Kolars, 1991 B, p 11). One estimate places the Iraqi water requirement for irrigated agriculture based on the Euphrates in the year 2000 at 16.1 Bm^3. Because much of such irrigation depends

TABLE 1

Sources and Uses of the Euphrates River
(Mm³/yr)

Natural Flow			
	Observed at Hit, Iraq	29,800	
	Removed in Turkey (pre-GAP)	820	
	Removed in Syria (pre-Tabqa)	2,100	
	Natural flow at Hit	32,720	
Pre-Keban Dam (< 1974)	Flow in Turkey		30,670
	Removed in Turkey		− 820
	Entering Syria		29,850
	Added in Syria		+ 2,050
	Removed in Syria		− 2,100
	Entering Iraq		29,800
	Added in Iraq		—
	Iraqi irrigation		− 17,000
	Iraqi return flow (est.)		+ 4,000
	To Shatt Al-Arab		16,800
Full Use Scenario (ca. 2040)	Flow in Turkey		30,670
	Removed in Turkey		− 21,600
	Entering Syria		9,070
	Removed in Syria		− 11,995
	RF & Tributaries (Turkey / Syria)		+ 9,484
	Entering Iraq		6,559
	(Removed in Iraq)		(− 17,000)
	(RF in Iraq)		(+ 4,000)
	(Deficit to the Shatt Al-Arab)		(− 6,441)

TABLE 2

Sources and Uses of the Tigris River
(Mm³/yr)

	Pre-project	2000 +	Natural Flow
Flow from Turkey	18,500	18,500	18,500
Removed in Turkey	—	− 6,700	
Entering Iraq	18,500	11,800	
Inflows to Mosul	2,000	2,000	2,000
Greater Zab	13,100	13,100	13,100
Lesser Zab	7,200	7,200	7,200
Other	2,200	2,200	2,200
Subtotal	43,000	36,300	43,000
Reservoir Evaporation	—	− 4,000	
Irrigation (to Fatha)	− 4,200	− 4,200	
Return Flow	+ 1,100	+ 1,100	
Adhaim River	+ 800	+ 800	800
Irrigation (to Baghdad)	− 14,000	− 14,000	
Return Flow	+ 3,600	+ 3,600	
Domestic Use	− 1,200	− 1,900	
Diyala River	+ 5,400	+ 5,400	5,400
Irrigation	− 5,100	− 5,100	
Return Flow	+ 1,300	+ 1,600	
Subtotal	30,700	19,200	49,200
Reservoir Evaporation	—	900	
Irrigation to Tokul	− 8,600	− 8,600	
Return Flow	+ 2,200	(2,700 to Outfall Drain)	
Total to Shatt Al-Arab	24,300	9,700	49,200

Source: "Water Resources of the Middle East," John Kolars, Canadian Journal of Development Studies, Special Issue, 1992, pp. 107-108.

upon gravity flow, an additional 5 Bm^3 would have to be maintained in the stream to create a headwater surge for canal intakes (Naff, 1991, 24-25). (More of this below.)

As much as 17.5 Bm^3 may be extracted from the Tigris River in Iraq for agriculture. An additional 1.2 Bm^3 are used for domestic purposes. Little or no water is removed in Turkey, but sometime after the year 2000 as much as 6.7 Bm^3 may be used there. All in all, the flow to the Shatt al-Arab is currently estimated to be reduced to 24.3 Bm^3 from a total natural flow of 49.2 Bm^3; future flows may be as little as 9.7 Bm^3 (Table 2).

Flood control is of great importance in Iraq, and a proposed canal leading from the al-Baghdad Dam on the Euphrates to Lake Tharthar would allow excess water to be channeled to the Tigris. Euphrates floods are also diverted into Lake Habaniya (from which water can be recovered) and farther west into Lake Abu-Dibis which has no return outlet. Floods on the Tigris are controlled by diversion into Lake Tharthar and by the Sadam Reservoir, the Lower Mosul Regulator Dam and the Badush Dam, all upstream from Baghdad.

Salination and drainage are also particular problems. A Main Outfall Drain beginning just west of Baghdad and leading between the two rivers to the Gulf 550 kilometers to the south should remove unwanted runoff from fields. Nevertheless, poor farming practices in combination with difficult topography cannot be corrected quickly or easily.

Syria

Officially sponsored Syrian use of the Euphrates, as opposed to private entrepreneurship, began with the inauguration of the Tabqa (Ath-Thawra) Dam in 1973. This facility has an generating capacity of 800 MW and a reservoir, Lake Assad, holding 11.6 billion m^3 when completely full. The facility has been criticized for the placement of the penstocks which necessitates high water levels to ensure full power production. The Tishreen Dam upstream from Lake Assad will have a generating capacity of 1.6 MW and a reservoir holding 1.3 Bm^3. Downstream, the Baath Dam which was completed in 1986 generates 64 MW but has negligible storage capacity (90 Million m^3 -- Mm^3).

The Sajur River entering from the right bank, and the Balikh and Khabour Rivers which enter the Euphrates from the left bank provide 80 Mm^3, 190 Mm^3, and 1.78 Bm^3 respectively in Syria. It should be noted, however, that the catchment areas for these streams are within Turkey, a problematic situation which discussed below.

Relatively little water is used for irrigation in Syria at the present time (aprox. 2.6 Bm^3 for private use and 2.3+ Bm^3 official projects and evaporation from reservoirs). If all proposed projects were to be completed, this amount might rise to a total of 6.9 Bm^3 per year, or if additional lands near Aleppo were to be irrigated without return flow to the mainstream, this figure might reach 10.8 Bm^3 loss per year (Kolars and Mitchell, 280-281). A recent paper by a Syrian engineer (Mikhail, 1992) places Syrian expectations of their share of the Euphrates-Khabour system at 13.1 Bm^3 (415 mcs) per year or 39 percent of the natural flow of the river. It should be noted that the planned amounts of irrigated land and the reality of how much is possible given gypsiferous soils and other problems remains a matter of confusion and discussion among those evaluating Syrian use of the river.

Turkey

Turkish planned use of the Euphrates and the eventual use of the Tigris River is by far the most ambitious and controversial issue at present within the combined basin. This is due to the implementation of the Southeast Anatolia Development Project (Turkish acronym: GAP). GAP consists of thirteen major sub-projects, seven of which are on the Euphrates and six on the Tigris. Of these, fifteen dams, fourteen hydroelectric stations, and nineteen irrigation projects are scheduled for the Euphrates.

The first major hydroelectric project completed on the Euphrates was the Keban Dam with a generating capacity of 1,360 MW. Although the Keban Dam completed in 1974 plays an essential role in the management of the Euphrates River it is not included within the GAP, *per se*. The next dam to be completed was the Karakaya hydroelectric project (1,800 MW) in 1988, downstream from the Keban Dam. The third, and largest, (2,400 MW) is the Ataturk Dam, the reservoir of which is now -- June 1922 -- about half full (capacity: 48.7 Bm^3; active reservoir volume: 19.3 Bm^3).

Once GAP is completed about one million ha will be irrigated with Euphrates' waters and another 625,000 ha with those of the Tigris. This will increase irrigated land in Turkey by 50 percent of the total irrigated in 1990 (3.3 million ha). The first of such irrigation projects is scheduled to begin in 1993 on the Harran Plain south of Sanliurfa. In total, about 482,000 ha will be brought on line from the Ataturk Reservoir sometime after the year 2005. If all the projects planned for GAP were to come on line as much as 16.9 Bm^3 might ;be removed from the Euphrates and 6.7 Bm^3 from the Tigris.[4] A more realistic figure for the Euphrates might be removals of 10.8 Bm^3 by sometime after 2010. The difference between the larger and smaller estimates represents possible pre-construction abandonment of some projects because of high pumping costs, poor soils, and a possible lack of market for crops.

The reduction of flow in the two rivers is of great concern to Syria and Iraq. Additional problems which they anticipate are the pollution of the stream by run off from Turkish fields, and the possible use of water cut-offs as a weapon if intractable differences between the countries were to develop. Given the above brief description of the rivers and their use, the issue of sustained, guaranteed flow is a good place to begin the discussion of pressure points in the management of the Euphrates-Tigris basin.

Ar Aside on Types of Development

The matter at issue in this discussion and in any consideration of the use and sharing of the Euphrates-Tigris basin resources including the waters of its rivers is the type of development that will and/or should take place. Six possible attitudes toward, or conditions of, development are possible. These are not mutually exclusive and can overlap or exist simultaneously in conflict with each other. Nevertheless, they can be viewed as forming a sequence or continuum of attitudes the first five of which in the opinion of this author go from unacceptable to best. Nevertheless, I imagine that my views will be contested by others representing different value systems and points of view.

---

4. These figures include losses resulting from reservoir evaporation.

The first and most pragmatic definition is that of *prior usage*. In this case, the first to come are the first to be served, even at the expense of those elsewhere on the river and regardless of the damage such use may incur.

Similar to the above is the idea of *maximum development or yield*. This can quickly become a matter of *laissez faire* with each party which participates in the sharing defining its own terms to suit its perceived needs.

Equatable or reasonable development approaches the notion of an attempt to share resources among contesting users in such a way that each will feel a sense of justice or fairness in the distribution. With this can be placed schemes for dividing the water according to the populations served, the amounts of available irrigable land, and the amount naturally contributed by each riparian state. What all of these share in common is an exploitive view of the resource with little attention being paid to the environment or the commonweal. Not only is this difficult to attain, but once more the ultimate good of the environment *per se* is not considered.

A step towards a more comprehensive view of development would be some definition of *optimal* development. While this contains the idea of parity or equity among users, it also suggests extension to the resource itself with the inherent idea that the resource will not suffer overmuch from such use.

Sustainable development has become a popular phrase in view of the growing international concern for the environment. The idea here is that the resource will not be depleted to the point where it can no longer be renewed along with the consequence that it will eventually deteriorate and disappear. Such an approach optimizes the use of the resource for future generations and for neighboring sharers. In many ways this would seem to be the desirable aim of all negotiators with the exception the most crass and self serving. Therefore this definition is chosen for the purposes of the discussion which follows.

A further type of development might be called *environmentally correct*. Development following this pattern would attempt to maintain as nearly a natural state as possible with little consideration of inevitable human use. This approach has within it the fallacious idea that humanity exists outside of nature and is

neither dependent upon it nor inextricably involved with it. The concept is therefore considered impractical.

500 Cubic Meters per Second -- Expectations and Reality

Returning to the intention of this paper, it is time to consider some of the realities that underlie the broader considerations of managing the two rivers. Let us consider, for example, the much publicized demands of Syria and Iraq for a guaranteed flow into their countries from upstream.

Concern for sharing the two rivers developed when Syria and Iraq gained their independence. The first available records indicate that Turkey and the two newer nations each put forth demands for water sharing at a tripartite meeting in Baghdad in September 1965 (Naff and Matson, 92-93). Turkey wanted 14 Bm^3/yr; Syria 13 Bm^3/yr; Iraq 18 Bm^3/yr of the Euphrates. The total of 45 Bm^3/yr would be 1.3 times greater then the average annual flow of the river.

In 1975 Iraq called for a meeting of the Arab League Foreign Ministers when the flow of the Euphrates from Syria was reduced to 197 mcs from an expected 920 mcs. Saudi Arabia is credited with mediating this crisis and arranging for Syria to release additional water to alleviate the situation. Although the problem was undoubtedly exacerbated by Turkey's filling of the Keban reservoir, recent examination of precipitation records as well as of the flow of regional streams outside the Euphrates-Tigris drainage area during the same period indicates that precipitation was at an extreme low for the year in question and that the crisis was as much the result of natural conditions as of human interference (Kolars & Mitchell, 89-90).

In subsequent bilateral talks Syria agreed to accept a steady flow of 500 cms across the Turkish border. Iraq apparently also agreed to this although reports also indicate that the latter country also demanded that the amount be raised to 700 cms. In any event, the most recent arrangement between the two downstream riparians is for Iraq to receive 58 percent of the 500 cms and Syria the remaining 42 percent.

In February 1990 Turkey reduced the flow of the Euphrates to a trickle for a month in order to begin filling the Ataturk reservoir and to complete construction in the riverbed downstream from the

dam. Syria and Iraq formed a brief detente in order to send their ministers to Ankara to protest Turkey's action. Turkey replied that it had previously increased downstream flow to compensate for the temporary cutoff and that the matter was technical rather than political in nature. It also stated that "since Iraq had already agreed with Syria to take 58% of the 500 m^3/sec of water available no further formula was required." (Beaumont, 1991, 16)

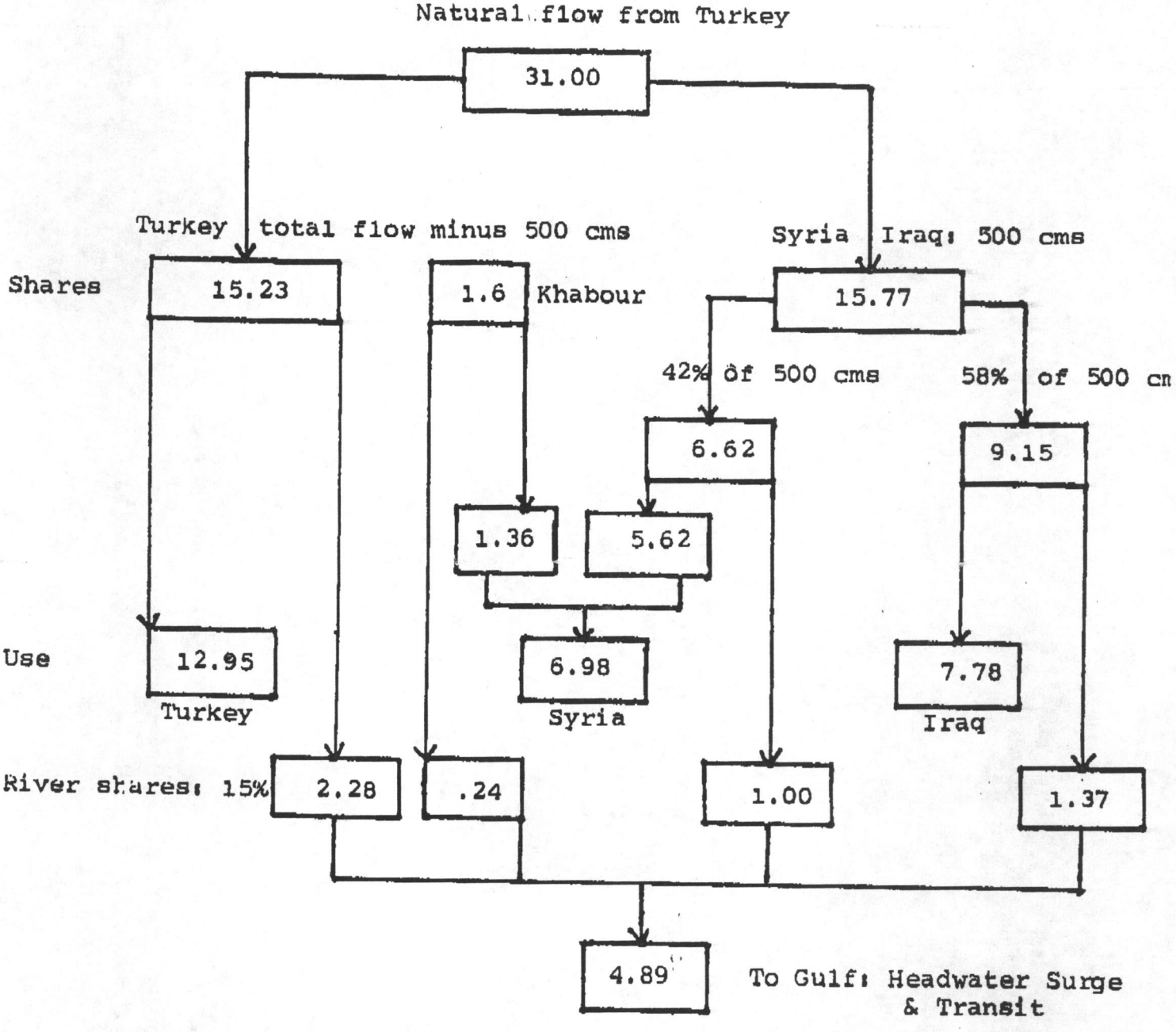
Leaving aside the emotional and political aspects of the situation alluded to above, what does the quantity 500 mcs mean in terms of water availability, sustainable development, and the environmental integrity of the river? Figure 2 presents a partial and heuristic view of this situation. The diagram it presents avoids detail in order to make an essential, and often overlooked, point.

Assuming an average annual natural flow of 31 Bm^3 entering Iraq, this amount is divided between Turkey and the two other riparians according to the "500 cms and remainder" principle, the remainder 15.23 Bm^3 being available in Turkey. The situation, however, is more complicated then at first appears. A certain amount of water must remain in the Euphrates for at least four reasons. 1) The river is the means to carry away waste water, often polluted, from the fields it irrigates, as well as domestic sewage. 2) A headwater surge must be maintained in order that gravity fed canals in Iraq can be serviced. 3)The ecology of the Gulf and its fishing industry and wildlife are dependent upon the flow of fresh water into it. 4) Conservationists would argue that the stream must be kept viable as a special and unique habitat. In order to meet all or even some of these needs an estimated 5 Bm^3 must remain in the river. Using the principle of fair sharing of resources and obligations, the row labeled "Use" on the diagram represents the water remaining for use after prorated shares have been allocated to the river by each country. These shares, figured at 15 percent of each riparian's allotment, are shown in the "River shares" row. The total belonging to the river ends the diagram.

Note that Turkey's needs for anywhere between 10.8 Bm^3 and 16.9 Bm^3 would be served with difficulty. Syria's share which includes use of all the prorated waters of the Khabour fall far short of the 13 Bm^3 apparently expected by them, while Iraq comes nowhere near the amount of water it is currently extracting from the river.

FIGURE 2

INTERNATIONAL SHARES OF THE EUPHRATES RIVER
A Partial and Heuristic Examination
(All values in 10^9 m^3/yr)



1. All users contribute proportionately to the River and Gulf which must be environmentally maintained.
2. Transit waters flow unimpeded.
3. Syria and Iraq share 500 cms: 42% & 58%.
4. Turkey uses all but 500 cms.
5. The Khabour is used entirely by Syria.
6. Evaporation from reservoirs is included in each country's share. (See text. A furth er refinement would be for all to share reservoir losses proportionately since all benefit from smoothed variance of flow.)

Given the problems inherent in the 500 cms allotment, it would become an exercise in futility to expect negotiations based on these figures to have any staying power in the years to come. Nor would demanding more water from Turkey, strongly entrenched in its headwater position, be of much utility. Furthermore, this diagram has omitted, for simplicity's sake, further reductions due to evaporation from the dams along the course of the river.

A way out of this impasse would be to seriously consider Turkey's suggestion that a complete inventory of soils and crop patterns be carried out throughout the basin and that those areas best suited to particular crops be given water rights also in accord with the regional need for each crop and compensatory credits (oil/energy/cash/complimentary produce?) be exchanged among the three states. Difficult as such a solution may seem, it is certainly superior to the hostilities and destruction to which the demonstrated sharing of 500 cms would inevitably lead.

A Sampling of Pressure Points

Flow vs. Variance

The maintenance of steady, sustained flow in the case of the Euphrates depends almost entirely upon Turkish manipulation of the River. (The relatively shallow nature of Lake Assad behind the Tabqa Dam in Syria precludes dependence upon that facility. Also, under ideal conditions the Syrians would want to maintain high water levels in the reservoir at all times to ensure uninterrupted hydroelectric production.) The situation in Turkey is complicated by the relatively large volume of dead water storage in the Ataturk reservoir (29.4 Bm^3; 60.4%). The need to maintain high water levels both for power generation and to ensure the gravity flow of water into the Urfa tunnels, which will eventually irrigate 482,000 ha, means that there will be constraints on the amount of storage space to be set aside for floods or for the amount of draw down permissible in times of drought.

Management of a steady flow in light of the above limitations and in combination with the annual and multi-annual variance already mentioned will become a major problem. This will necessitate a full sharing of data and information with the downstream riparians both to enable them to respond to changing

conditions and to avoid suspicions of manipulation of the river for covert reasons.

The provision of data through a Regional Information Clearing House (RICH) should go far to correct any misunderstandings that might arise, as in the case of the "low water misunderstanding" between Syria and Iraq in 1975. By the same token, new satellite technology coupled with Geographical Information Systems (GIS) analytical techniques should be able to provide at least short term (3 to 6 months) prediction of flood and drought conditions in downstream areas.

Rerouting of Return Flow

The usual rough estimate of water necessary for irrigation under conditions found in the twin basins is one meter of applied water for each square meter of irrigated farmland. This refers specifically to the amount needed to replace the deficit (D) between actual evapotranspiration (AE), the amount of water available to the plant from natural sources, and potential evapotranspiration (PE), the water required to maintain the metabolism of the plants involved. Replacement water equivalent to D, however, does <u>not</u> represent the total amount needed for successful irrigation. The total must include water inevitably wasted by system inefficiencies as well as excess water needed to carry dissolved salts, excess fertilizer, herbicides and insecticides away from the fields, which if left in place, would quickly poison the land. Dunne and Leopold (p.162) suggest as a rule of thumb that twice the amount needed for the replacement of D should be removed from the reservoir. In the twin basin area a value 2.5 times the replacement value D is more realistic. Part of the extra water removed from the reservoirs will be lost through evaporation and deep percolation; the remainder returns to the river as return flow (RF).

This return flow is significant. It may be unacceptably polluted which creates a special set of problems for downstream users, but even if it is clean enough for additional farming, it may still pose unexpected problems. In the case of the Turkish Euphrates and that portion of its waters diverted through the Urfa tunnels as much as 2.27 Bm^3 may eventually find its way south by way of RF via the Balikh and Khabour Rivers. This may impact the High Jezirah, one of Syria's most fertile areas, in several ways. The amount of water returned may flood the valleys of the Khabour and Balikh

causing severe drainage problems; the RF may carry with it pollutants which could adversely effect Syrian agriculture in that area; or the RF may compensate for Syrian removals for their own agriculture and thus serve a useful purpose. It is necessary for these alternatives to be recognized and understood in order for a lasting water treaty to be effective.

Another, more subtle ramification of the routing of this RF may also occur. The extreme scenario for Turkish use of the Euphrates indicates that as little as 9.4 Bm^3 (299 mcs) might cross the border into Syria via the main stream. Given the RF via the Khabour and Balikh (2.3 Bm^3), it would be technically possible to assert that a total of 11.7 Bm^3 (358 cms) was being sent on to Syria although the placement at the junction of the Khabour and Euphrates near Deir ez-Zor of 73 cms would be of doubtful utility.

The purpose of this exercise is not to criticize Turkish plans but rather to point out that the management and routing of return flow is a critical element in the long term search for stability based on the sharing of the river.

Domestic Water Use - Syria

A small matter, nevertheless of great importance to several million people, is the maintenance of a pure supply of water for the city of Aleppo and its environs. The city now depends upon twin siphons which bring water westward from Lake Assad. Aleppo once drew its water from the Qweik River (Turkish: Balik) which rises in Turkey. That source has long been diverted by both Turkish and Syrian agriculture. The guaranteeing of Aleppo's water supply may well become a small but significant counter in the negotiations concerning the equitable sharing of the river.

Caring for the Gulf

The subtraction of fresh water from the Shatt al-Arab in the quantities already suggested could change and perhaps destroy the ecology and fisheries of the Gulf into which it empties. This issue is one which has already attracted the attention of the GCC and Iran. It may be that the flow of the Tigris, though reduced will suffice to maintain the Gulf's ecology. Needless to say, as major suppliers of petroleum and loans to at least two of the riparians and as

opponents of Iraq in the Kuwati War, such matters will not go unnoticed nor unaddressed by the Gulf States.

By the same token, the flow of the Euphrates when diminished might be restored by a canal across northern Iraq bringing water from the Tigris near the Turkish border to the middle section of the Iraqi Euphrates. Such a suggestion raises questions of the role of the Kurds whose ethnic territory straddles the border between Iraq and Turkey. It would be opening Pandorra's box to pursue these questions in this paper, but as water becomes scarcer such a canal may be the least expensive solution given rapprochement with the Kurds and their sharing in the proceeds of the development of the twin rivers.

Conclusions

The above list of pressure points is not intended to be complete or technically exact to the last detail. Rather, the purpose of this paper has been to alert participants in the ongoing negotiations that a thorough awareness of the complexity and range of the issues involved is essential. One might add at this point that the use of the waters of the Orontes (Asi) River shared by Lebanon, Syria and Turkey is another issue that must be anticipated in order that a regional *Pax Aquarum* may be achieved. Meanwhile, what can outsiders do to help untie or cut this water soaked Gordian Knot? (Have any of you ever tried to untie a wet shoelace?)

A Regional Information Clearing House (RICH) as described above could be financed and managed by objective outside financiers and analysts. Equal access to such information would be a relatively bias free step in the right direction. A second possible action would be the establishment of a world wide cadre of technical experts to work in unison with local professionals in solving management problems. A third effort would be to urge the World Bank and the several national governments which may provide both funds and expertise to proceed slowly with all possible haste. That is, not to be lured by mega-solutions nor to be discouraged by seemingly intractable differences between riparians, but rather to look for possible areas of cooperation and to proceed from those to untying the Knot itself.

REFERENCES

Beaumont, Peter, "Transboundary Water Disputes in the Middle East," Internation Round Table 2 (Ankara: September 1991), pp. 29.

Kolars, John, "The Future of the Euphrates River," A paper presented to the World Bank Workshop on Comprehensive Water Resources Management Policy (Washington, D.C.: June 24/28, 1991), pp. 33.

_____, "Water Resources of the Middle East," Canadian Journal of Development Studies, Special Issue (May, 1992), pp. 103-119.

Kolars, John F. and William A. Mitchell, The Euphrates River and the Southeast Anatolia Development Project, Southern Illinois University Press (Carbondale: 1991), pp. xxix & 325.

Mikhail, Wakil, "Analysis of Future Water Needs for Diferent Sectors in Syria," The Middle East Water Crisis: Creative Perspectives and Solutions, A conference at the University of Waterloo, Ontario, Canada (May 7-9, 1992), pp. 18.

Naff, Thomas, "Water Issues in Iraq," Associates for Middle East Research (Philadelphia: Revised Aug. 1991), pp. 66.

Naff, Thomas and Ruth C. Matson, Water in the Middle East - Conflict or Cooperation?, (Westview Press, Boulder; 1984), pp. xvii & 236.