Powder Keg in the Middle East
AAAS (Forthcoming?)
Sept/Oct. 1995

12

SOURCES OF POTENTIAL CONFLICT IN THE PERSIAN GULF: THE WATER FACTOR

Thomas Naff

Even in the earliest sources of antiquity, water was consistently a key factor of security and conflict among the inhabitants of the Euphrates River basin. Hammurabi, in his code of laws, made what was perhaps the first known attempt to set legal rules for the ownership and use of water in order to avoid strife among the basin's polities. Later, very early in the Muslim era (at the battle of Siffin [657 A.D.] on the lower Euphrates, which pitted the fourth caliph Ali against the insurgent Mu'awiyya—a conflict whose outcome changed the course of Islamic history) water played an important strategic role for both sides.[1]

Today water continues to be an issue of serious contention in the Euphrates basin and in other parts of the Persian Gulf region. But the cause of most current tension is not an actual shortage of water. The Euphrates basin does not yet suffer from scarcity—although it looms—except in a few highly localized situations, and southward the states of the Arabian Peninsula have so far been able to produce enough desalinated water to supplement their dwindling groundwater resources, at least for the short term. Rather, potential water-related conflict in the Persian Gulf region lies in an intricate web of problems: maldistribution, mismanagement, poor planning, unsustainable population growth, overexploitation, pollution, serious inadequacies of supply projected for the near future, and the complicated hydropolitics among the Euphrates' riparians—Turkey, Syria, and Iraq—that not only share the river but mutual hostility as well.

Further complicating the picture is Turkey's recently acquired ability to exercise complete control over the Euphrates, 96 percent of which rises

in the Anatolian Peninsula and whose total average annual flow is about 30 billion cubic meters (bcm) per year. Ankara demonstrated this power in January 1990 when, for the first time in history, it cut off the entire flow of the river for two months* during the first phase of filling the reservoir behind the Ataturk Dam. Despite Turkey's assurances that it would not abuse its superior hydrogeological position, its downstream neighbors remain troubled, especially Iraq, which was acutely aware that during the Gulf War Turkey came under pressure to cut the flow of Euphrates water to force Iraq into quick submission. Nor were the strategic implications of this power lost on Syria.

Compounding Iraq's vulnerability is the extent to which the Turks and Iranians have potential control of the Tigris River as well: over 60 percent of that watercourse, whose annual average flow is about 32–33 bcm, originates in the mountains of eastern Anatolia, while another 10 percent of its source rises in Iran. Both Turkey and Iran clearly possess the capacity to reduce the flow of the Tigris River into Iraq. In these circumstances, without some kind of negotiated agreement with Turkey, Syria, and Iran, Iraq cannot safely rely on utilizing the waters of the Tigris to mitigate anticipated losses from the Euphrates, nor can Syria, in the absence of a firm agreement with Turkey, be assured of its supply of Euphrates water.

Thus far, the aquifers that Iraq shares with Saudi Arabia and Jordan have not been a source of friction but could become so very quickly (Amman has for some years complained informally that the Disi aquifer in southern Jordan, which is shared with Saudi Arabia, is being harmed and diminished on the Jordanian side through overpumping by the Saudis). Should water supplies from the two rivers be decreased significantly, then Iraq will have to exploit all possible groundwater resources as fully as possible. That development could bring competition from those neighbors with whom it shares aquifers, who are themselves already facing imminent water shortages.

The climate of the Arabian Peninsula is for the most part arid to hyperarid. The great bulk of its natural, undesalinated fresh water comes from very limited underground sources—many of which are nonrenewable—with very little more from precipitation in areas of higher elevation. The average annual rainfall for the seven nations of the peninsula is only 81 mm, ranging from a low of 70 mm in Kuwait and Bahrain to 122 mm in Yemen. The average annual rate of evaporation for all the peninsula's countries is 43 times the rate of precipitation.[2]

Relative to its demographic growth rate—plus the pace and patterns of water consumption, certain unsound policies, and the current limits of desalination technology—the Arabian Peninsula may well be at the threshold of chronic shortages that will only grow more acute unless

* The actual cutoff time might have been as short as 27 days.

these patterns of usage are altered. Although it will become necessary for those peninsular states who desalinate their water to invest even more in the technology, it will not suffice simply to put more money into desalination in order to solve their water problems (almost 50 percent of the world's total desalination capacity is already centered in the peninsula). For the technology to produce enough additional fresh water fast enough to keep abreast of the increasing demand and to make cost effective the very large investment required, an affordable major scientific breakthrough in desalination processes and engineering would have to occur in the near future. Presently, no such technological advances are projected in the next decade.[3] It is possible that such dramatic progress could be made, but in a highly arid climate, it is an extremely risky gamble to formulate water policies on the basis of anything but current reality. Even if the needed technological advances were made, the lead time it would take to reap their benefits on the required scale would probably be too long to avoid a crisis if present trends of consumption and management are not radically changed.

Except for the Caspian littoral and a few parts of the northwest, all of Iran's 1,650,000 square kilometers of land are semiarid, arid, or extremely arid. Only 5 percent of this area is cultivated, requiring large amounts of water for irrigation. Most of Iran is in a constant process of desertification. Thus, exploitation of its arid lands by dryland farming and other means is of great importance to Iran, particularly since the production of its qanats has been declining steadily.[4]

Toward the end of the 1950s, specialized departments were formed in Iran's Ministry of Agriculture and at Tehran University for the development of programs of watershed management, conservation, and desert research. It was not until 1967 that the country's water resources were nationalized, and this was followed in 1974 by the establishment of a Department of the Environment in the Prime Minister's Office.[5] Iran, which is environmentally similar to Iraq, faces water problems that are on the whole probably a little more serious, though of a different nature.

While Iran is a potentially important player in the hydropolitics of the Persian Gulf, two factors mitigate against including Iran significantly in this analysis. First, the mullahs have tended to neglect Iran's water problems. Iran's hydrological infrastructure, like most of its economic bases, has suffered badly since the revolution, particularly in the wake of the war with Iraq.

In April 1995, domestic water shortages became so severe that thousands of Iranians in Islamshahr, a working-class district south of Tehran, took to the streets to demand adequate supplies of fresh water. The demonstrations grew so large and violent that the Revolutionary Guard was called out to quell them by force, resulting, it was reported,

in hundreds of dead and wounded.[6] It would take considerable expenditure to improve the water sector to the point where it could serve the needs of a population that is expected to double by 2010, numbering some 100 million. Given such urgent domestic needs, the deteriorating state of the economy, and the high loss of professional human resources in the war with Iraq, it is unlikely that Iran would choose to initiate a policy of aggressive hydropolitics against Iraq. Iran is not dependent on any Iraqi sources of water, would have no legitimate claims on Iraq's surface waters, and so far as is known, does not share aquifers with Iraq.

But Iraq is dependent to a degree on waters that originate in Iran. For the past few years there has apparently been serious discussion in Tehran about developing the Lesser Zab for irrigation and hydroelectric energy. The Lesser Zab provides 17 percent of the Tigris's flow in Iraq. Should Iran's development plans for the Lesser Zab be fully implemented—depending on Turkish and Syrian activities on the Euphrates and upper Tigris—tensions with Iraq could be engendered by possible reductions in the flow of the Tigris into Iraq. There may be an element of malice toward Iraq in this scheme, but if there is, it must be secondary; plans for hydrologically developing the Lesser Zab preceded the revolution by some years. Otherwise, there is no clear evidence that water has played a significant role in Iran's strategic planning or relations with its Arab neighbors. Reinforcing this conclusion is the fact that during the war with Iraq, Iran made no effort to cut off water from either the Lesser Zab or the Diyala River, which also feeds the Tigris. The second reason for giving Iran only limited attention in this chapter is that it has been not been possible to collect reliable data on hydrological conditions and other water-related issues in Iran since the revolution, making any authoritative statements all but impossible.[7]

Water has become a factor in an interesting security relationship that is evolving between Iran and Qatar, one of Tehran's smaller Arab neighbors. Should Qatar's approach succeed, it might presage a general strategy that could be profitably employed with local adaptations by other smaller peninsular actors who are proximate to Iran. Since early spring of 1994, the Qataris and Iranians have been holding serious talks about the possibility of Iran selling Qatar water from the Karoun (or al-Karun) River, which originates in Iran and flows into the Shatt al-Arab with a flow of 27 bcm—not an insignificant body of water. The water sought by the Qataris would be delivered by means of a pipeline that would serve a dual purpose. It would be run along the southern Iranian littoral deliberately routed through a string of impoverished, water-short villages, and then over into Qatar, thus benefitting needy Iranians and simultaneously providing a source of hard currency from water sales to Qatar. Qatari authorities stress that this water would not be used for such

"strategic" purposes as drinking or for industry, which would tie Qatar's water security to Iran. Rather, it would be used to recharge fossil aquifers whose water would then be used for such nonstrategic functions as gardening or recreation.

This is only one of many overtures that Doha, for the sake of its security, has made to Tehran in quest of positive ways to engage its powerful, bellicose neighbor. Qatar prefers cooperation and friendship to confrontation. The underlying assumption of this policy is that given the issues of potential dispute that could erupt between the two neighbors—e.g., possible expansion of Iranian claims to the northern segment of the oil field that lies along the median Qatari-Iranian oil line in the Gulf—the best strategic option is to base relations with Iran on friendship and good neighborliness. Water, a resource even more vital than oil but presently less controversial, is perceived as a positive link. While such a policy is fraught with risks, it is believed to be less dangerous than any other approach that could antagonize the Iranians. Qatar is sensitive to the fact that it has very little sympathetic standing in American or European public opinion and therefore cannot count on being defended by the West from Iranian aggression.[8]

Irrespective of region or conditions, solutions to water problems must always be commensurate with the complex nature of water—that is, solutions must necessarily involve several simultaneous approaches on many linked salients: technological (including biotechnology), economic, managerial (including demand management), political, demographic, educational, and ideological. The parched nations of the Persian Gulf are particularly susceptible to this dictum. With a sharper focus on the major issues of water, security, and conflict in the Persian Gulf region, the picture becomes at once clearer and more troubling. For purposes of analysis, a distinction needs to be made between the hydropolitical situations in Iraq and the Arabian Peninsula. Although the two cannot be disaggregated in geopolitical and strategic terms, their hydrological conditions are sufficiently different to warrant separate treatment.

The Arabian Peninsula

Despite shortages, there is not yet a water crisis either collectively or singly among the nations of the Arabian Peninsula serious enough to create conditions that could erupt in water-related conflict. The problems that exist are more hydropolitical than purely hydrological, but serious nonetheless. There are among all the actors of the Peninsula shortsighted policy and behavioral trends that are moving them in the direction of possible water-based conflict. What makes this situation disturbing is

that in the arid climate of the region, where fresh-water supplies receive so little replenishment and consumption is rising so rapidly, crisis conditions could develop very quickly, before effective means for managing them could be mobilized. In those circumstances, water scarcity could combine with other factors to contribute significantly to political and economic dislocations, which could, in turn, lead to state weakness and potential conflict.

Although there are no surface river systems among the nations of the Arabian Peninsula, they are not entirely free from possible transboundary water disputes. Border oases, for example, have a long history of contention, and some states, such as Saudi Arabia, Yemen, Iraq, and the United Arab Emirates, share aquifers. Several countries have in recent years undertaken systematic audits of their water supplies—e.g., Saudi Arabia, Oman, and Qatar. Despite some very good individual national hydrological surveys, there has been no comprehensive, integrated, accurate mapping and analysis of all the peninsula's underground water resources to determine not only quantities, quality, and systemic and hydrogeological interconnections, but how much is renewable or nonrenewable (i.e., fossil). These data are essential for effective management, especially demand-management, of water and for determining the safe-yield of groundwater sources. Aquifers are of a certain delicacy. Because the effects of misuse are hydrologically cumulative, aquifers can be seriously harmed or destroyed in a relatively short time, especially in the absence of good data for managing them; most aquifers cannot be recovered once they are ruined.

Consumption Trends Among the GCC Nations

It is apparent from some available data[9] that the nations of the GCC are using up their fresh-water resources at a rate that, if unaltered, will place them on the precipice of a very serious crisis within a generation. For instance, Qatar's groundwater reserves are under extreme pressure because of overexploitation: withdrawals of water exceed by five times the natural annual recharge of the aquifers. Between 1972 and 1993 Qatar accumulated a water deficit of about 850 million cubic meters (mcm), which amounts to one-third its total estimated supply. Water levels have been dropping between 0.05–1.0 meters each year, with a commensurate rise in salinity and deterioration of quality. Given Qatar's climate, geology, and environment, such depletion rates are simply unsustainable. Unsalinated Saudi groundwater reserves are estimated to be between 300 and 500 bcm. This estimate is almost certainly too high, as the Saudi kingdom is known to have increased its consumption of water for agriculture alone more than tenfold in the past fifteen years.[10] The aquifers

underlying the Khuff Formation in central Saudi Arabia have been drawn down by about 14 meters in the last 15 years.

In 1965, inhabitants of the GCC states used water for domestic purposes at the rate of 165 litres per capita per day (lcd). In the decade of the 1980s, that figure increased to 300 lcd and presently stands at 400 lcd, a rate of consumption comparable to Israel's and some smaller industrialized states of Europe who have exponentially more water. By far, the largest consumer of water for all the peninsular countries is the agricultural sector, which was collectively using some 3.1 bcm/yr in 1980. That rate is projected to rise by the year 2000 to 24.8 bcm/yr. The largest single country increase for the same period will occur in Saudi Arabia, where the agricultural sector's share of water will surge from 1.8 bcm/yr in 1980 to 20 bcm/yr by the turn of the century. Bahrain's consumption in the same period will have almost doubled, from 70 mcm/yr to 130 mcm/yr, while Qatar's will have quadrupled, from 40 mcm/yr to 160 mcm/yr. The projected total water requirements of the peninsula in the year 2000 are expected to be 31.6 bcm rising to 35.4 bcm by 2010. Of those amounts, agriculture is expected to consume 27 bcm in 2000 and 29 bcm in 2010, leaving only 4.5 bcm and 6 bcm respectively for all other purposes. Compounding these figures is the fact that between 25 percent and 30 percent of water used in GCC agriculture is lost every year to waste and inefficiency.[11]

Such consumption trends make it easier to understand why desalination alone, particularly in light of present technical limitations, cannot within the foreseeable future solve the peninsula's looming water scarcity problems. Underlying this situation like a grumbling volcano is the collective rate of population growth among the GCC nations, one of the highest in the world. Between 1970 and 1990, the total peninsular population increased from 18 million to 31 million.[12] At an overall average growth of 3.6 percent per annum, the current number of inhabitants of the peninsula will double in about 25 years. This is a region, it should be recalled, that is already the largest importer of food per capita on earth.

Water and Oil

In nature, water and oil are geomorphologically closely affiliated; technologically, water plays a key role in the production of oil. This relationship raises a weighty question: Do these natural and technological connections mean that the shortage of fresh water in the Persian Gulf area and the growing demand on it for human consumption ultimately constitute a serious limitation on the continued high level of oil production, with the obvious concomitant socioeconomic and political implications? If the comprehensive role of water in oil production is taken at face value,

the short answer would be an apparent yes; closer scrutiny of the facts, however, yields a more complicated no. Oil and water, as we shall see, do (metaphorically) mix in the Middle East.

The production of oil, and all other forms of energy from fossil fuels and nuclear power, requires the use of relatively substantial amounts of water—preferably, but not always necessarily, fresh water. Reciprocally, the movement of water necessitates the expenditure of significant quantities of energy in the form of oil or gas. Israel, for example, uses about one-fifth of its total national energy supply just to move water. While the oil resources among the GCC countries are collectively huge, they are finite and unevenly distributed. More to the point, their water resources are only a fraction of their petroleum-based energy supply, which, considering the role of water in oil production, gives the appearance of being a limiting factor in the production of that vital commodity.

Water is necessary for almost all of the processes of oil production—for the exploration and drilling of oil and gas (which requires far less water than oil) and, for the extraction of oil, including drilling, flooding, and treatment. For example, in the United States, where oil reserves are all but exhausted and wells need to be flooded or injected with water to build enough pressure to pump up the remaining oil, the production of 500 million tonnes of oil per year requires about 45 mcm of water—that is more than three times the useful water available from the Jordan River.[13] A by-product of oil production is saline water, which is brought up simultaneously with the oil and must somehow be eliminated safely. Ways for pumping oil out of nearly used-up or low-pressure wells have had to be devised. The most common techniques for secondary and tertiary recovery of residues involve a significant input of water by flooding under pressure or the injection of steam. Most of the water used for the various means of producing oil is completely consumed or is unusable for other purposes. Once the oil is extracted, its refinement entails large volumes of water too, 96 percent of which is entirely used up. The generation of energy by the burning of oil or gas (or the production of nuclear power) also involves large amounts of water for cooling purposes.[14]

Given the essential role water plays in the extraction and refinement of oil, it would seem that the continued high rate of exploitation and production of the region's enormous oil reserves (Saudi Arabia alone pumps eight million barrels a day) could simply overwhelm the Gulf's meager water supplies, or, the very slightness of the latter vital resource could severely limit the production of oil. Either way the result would be water-based problems that could cause conflict, most probably if combined with other destablizing issues. However, that scenario is very unlikely to occur.

Generally speaking, it takes a barrel of water to produce a barrel of oil.[15] However, because each reservoir has its own peculiarities, each has its own water-to-oil ratio. Moreover, if a faster rate of production is desired, then the ratio changes to more water per barrel of oil, whatever the features of the reservoir. In most of the Middle East, especially the Persian Gulf region (except for the Neutral Zone between Saudi Arabia and Kuwait), oil is free flowing. That is, there is enough natural hydrogeological pressure to keep the oil flowing once it is tapped, obviating the need for constant insertions of water at each well or field. There is so much oil that the draw-down rate to the point of requiring water is not inordinately high. But the rate of production is high enough to require the injection of water around the edges of the fields to keep the wells free flowing. In Saudi Arabia if an oil well produces fewer than 5,000 barrels per day, it is shut down to preserve the pressure.

Oil in the Persian Gulf region was originally formed in an environment of water. It is found in the same rocks that also captured water. In fact, most of the oil in the region is of that type; it is underlaid by huge reservoirs of very deep, highly saline water that provides much of the pressure that makes the oil free flowing. The Wassiyya aquifer that underlies eastern Saudi Arabia, Kuwait, and Iraq is estimated to be over 4,000 feet deep and to contain between 800 bcm and 1,600 bcm (or five to ten trillion barrels) of very saline water. At its shallowest end as it approaches Riyadh in the west, it gradually becomes fresh water, only a small fraction of the total.

Fresh water is preferred for use in oil operations. However, salt water will perform the same function in drilling, though the resulting saline muddy slush must be disposed of, which adds to the cost. Water is used in this function to enable the drill to move faster and to make it easier to pull the drill up. When an oil field is drilled without the use of water, the usual average yield is about 25 percent of the actual supply in the rock. The gas that is produced with the oil can be compressed and reinjected to increase the yield, but it is not as effective or as cheap as water, which produces a 30 to 35 percent recovery rate. Because saline water from sea or ground sources can be used in the drilling and pumping stages of oil production, water is therefore not a limiting but rather an efficiency and cost factor. In other stages of refinement, modification, and transformation into other products, it is mostly fresh water that is needed—some of which can be reused—but not as yet in such great quantities as to be a limitation. Enough desalinated water is presently being produced to satisfy the fresh water needs of industries in the peninsula associated with oil without cost to the other economic sectors. That situation is expected to continue without serious problems in the short term.

Other Persistent Factors of Potential Conflict

Nevertheless, a superordinate reality remains: The fresh water reserves of the peninsula are being consumed at a faster rate than they can presently be replenished. Those peninsular nations presently desalinating water have been driven by need to increase production significantly within the next decade. For example, Saudi Arabia, which desalinates the most water at 800 million gallons a day, plans to lift the daily volume to one billion gallons over the next five to ten years. Unless there is a significant breakthrough in purification technology soon, however, even the oil-rich nations of the Gulf, which have the necessary cash and surplus energy, cannot rely on desalination alone cannot to keep abreast of their projected water demand in the short run, and perhaps into the intermediate future.

Salinated and desalinated water can probably provide the oil industry with its needs, but for the other economic sectors, the prognosis is less certain owing to several factors already adumbrated: foremost, a population growth rate unsustainable in relation to rising demand for decreasing supplies of water, unacceptable levels of inefficiency and waste, and defective planning and policy decisions. The persistence of these circumstances could rapidly create destablizing, conflict-prone hydropolitical conditions. Any significant domestic conflict in any of the key actors in the peninsula could have large regional and international repercussions.

An obvious prerequisite for conflict avoidance in those circumstances is far better planning and management of water resources. The problem lies not so much with the technocrats as with the decision makers. Unnecessarily (some critics say wantonly) wasteful policies continue in the face of alarming shortages. Some actors in the peninsula persist in water mining—i.e. withdrawals from a depletable, nonrenewable reserve of water such as a fossil aquifer. This practice is often carried on in order to grow water-guzzling, highly subsidized crops in the hopeless pursuit of food security, Bedouin demands, or worse, to demonstrate for reasons of prestige that despite the aridity of their environment, governments can export agriculture—paying no heed to the fact that the export of agriculture is tantamount to the export of water. As one expert has argued, ". . . crops produced with mined water contribute to a false sense of food security, since the harvest cannot be sustained over the long term."[16] That same wheat grown in certain parts of the peninsula can be purchased from abroad for one-tenth its price in subsidies and water. There is not a single peninsular nation (with perhaps the exception of Yemen) that cannot afford to import all of its agricultural

needs at far lower cost in money, water, and energy than its own irrigated food crops.

Saudi Arabia is a good example. Three-quarters of Saudi Arabia's water supply sits in groundwater reserves, most of which are fossil. Saudis have been pumping that water at a rate more than five times the estimated recharge. By 2010, the nation's aquifers are projected to hold 42 percent less water than they did in 1985.[17] Some of that water is used for oil-related purposes, but large quantities are drawn for growing irrigated crops like wheat, which is then subsidized and exported. Saudi Arabia, it is reported, continues to use vital water reserves in a hopeless endeavor to become self-sufficient in certain food types. The only way that could be done even on a relatively small scale (and for the short term only) is through intensive irrigation at great cost to the nation's very limited supplies of water and with very high subsidies to the farmers.

For climatic reasons, Saudi Arabia will always be dependent on food imports, which will perforce grow steadily as the population increases. (Reports from the Saudi Kingdom indicate that water policies are being reassessed with a view to greater conservation and efficiency.) As stated, the nations of the Gulf region already import more food proportionately per capita than any other part of the world. Climate and hydrogeology dictate that the nations of the Arabian Peninsula cannot simultaneously carry on irrigated agriculture on any significant scale and oil production with its related industries for very long without ruining their vital water resources. The consequences would be unbearable.

But these problems are not without possible solutions. The most difficult and longest term approaches would be to stabilize population growth at sustainable levels, cease irrigated agriculture except in those very few areas where renewable water resources can be sufficiently recharged, invest heavily in water technology (including purification and conservation technology), and improve water planning and management, including a shift to demand management. There are indications that progress along these lines is in the making. Demand management is receiving serious attention among policy makers, more water experts are being trained, and their advice is being heeded more often. Conservation measures have begun, as in the United Arab Emirates, where a series of water harvesting dams was built with a total storage capacity of some 70 mcm to supplement the recharge of groundwater aquifers that receive an inadequate 120 ~~mcm~~ mm of annual rainfall. Water supplies and quality are being more closely monitored. The public is being educated (with varying degrees of effort) about the need for conservation. The recycling of waste water is being studied, and members of the Gulf Cooperation Council (GCC) are calling for cooperative endeavors in attacking the

peninsula's water problems.[18] Various proposed alternative sources of water and technological solutions are also receiving consideration.

Other than desalination, the most prominent among the bruited technological solutions to the peninsula's water problems is water importation. Proposals range from icebergs towed from the antarctic to "medusa bags" (huge nylon or polyester bags capable of carrying hundreds of thousands of cubic meters of water towed by ocean-going tugs) to long-range pipelines. While it is hypothetically possible to tow an iceberg from Antarctica to, say, Saudi Arabia, it would have to be of enormous dimensions for a sufficient portion of it to survive the trip to be useful. But because of its immensity and the consequent slowness of its movement, it would have to circumnavigate the lower latitudes of the Earth about four times to escape the strong ocean currents of that region, leaving very little of its original volume by the time it reaches its destination. Medusa bags, on the other hand, are a practical possibility—they would not constitute a solution per se, but could provide an important marginal supply of fresh water especially in emergency situations. Presently, successful experiments have been conducted with bags that hold about a quarter of a million cubic meters of water. These bags are still too small to be cost effective, but there are bags with a 1.5–2 mcm capacity in the planning stages. They can be used in conjunction with pipelines. It has been calculated that medusa bags would cost more than one-third less for the transport of water than using converted oil tankers.[19]

The most publicized proposal for water transfer is the "Peace Pipeline," vigorously promoted by the late Turkish prime minister, Turgut Özal in the 1980s.[20] The original proposal called for the construction of dual 1,600-mile pipelines. These pipes would carry fresh commercial water from two rivers in Turkey, the Seyhan and Ceyhan, presumed to have some 16 mcm surplus per day that flows into the Mediterranean. The delivery of this water would be intended as a supplementary rather than a primary source. The "western" conduit would deliver water to Syria, Jordan, and the western coast of Saudi Arabia, while the "Gulf" pipeline would provide water to Kuwait, Qatar, Bahrain, the United Arab Emirates, and Oman. Preliminary feasibility studies paid for by Turkey were completed in 1987; on the basis of those studies, Turkey received, in 1989, $1.9 billion in loans from the United States and Britain to complete the necessary studies preparatory to building the pipeline. The final plans produced an estimated cost of about $13 billion for the Persian Gulf pipeline and about $9 billion for the western pipeline, with a completion time of about a decade. The pipes would be buried two meters below the ground except for mountainous stretches, where they would be run through tunnels.

The proposal has not yet advanced beyond the planning and discussion phase and is, in fact, dormant. The reasons for its dormancy are not technical—in that respect, the project is quite feasible—rather they stem from a combination of security and economic considerations. The chief constituents of the main target, the Gulf nations, have not bought into the plan, nor have other key actors such a Syria. All fear dependency on Turkish water and all believe the pipeline would be easily susceptible to sabotage and the cost of the water would be very high. The countries through whose territories the pipelines must pass, especially Syria, have not responded enthusiastically. Because the negotiations required must involve so many actors, these states believe the discussions will be complex, long, and difficult with no assurance of success. Another serious potential problem that acts as a brake on the project is the belief that Turkey's own increasing water needs over the next half century will require the use of all of its water resources, leaving no surplus for the pipelines.[21] Although quiescent for the present, the idea has not yet been rejected outright by the Persian Gulf states, and in conditions of extreme shortage, could be revived. Moreover, such states as Saudi Arabia and Kuwait could use a piped supply to recharge some of their fossil aquifers annually to create a strategic reserve of water.

Prognosis for Water Conflict in the Peninsula

In sum, under the prevailing hydrological and political circumstances among the states of the Arabian Peninsula, it is unlikely that water, in and of itself, will be the source of acute international conflict in the near future, although the longer term is less assured. Several influences combine to reduce the probability that a single factor—even one as significant as water scarcity—will precipitate serious conflict in the short run. Such influences include the existence of the GCC, which serves as a matrix for common policy among the most important peninsular actors; the friendly relations among most of the peninsular states; the strategic and economic importance of their collective oil reserves to themselves and to the rest of the industrialized world; their shared fear of the military and ideological designs of Iraq and Iran; and their collective wealth, which will allow at least a marginal increase of supplies from desalination. In addition, policy makers are, incipiently, taking a more rational view of their nations' water problems, which is beginning to translate into positive actions.

But it should be stressed that the states of the Arabian Peninsula are not altogether immune from water-related conflict, particularly of the domestic genre. Given the demographic growth rates in the peninsula, increasing water scarcity, if unmitigated, could be a cause of domestic

economic, social, or political destablization. This is true especially if water shortage combines with other factors of conflict, which often occurs in arid regions. The repercussions of water-related conflict could quickly become international. For example, assume hypothetically that a major oil producer—e.g., Saudi Arabia—suffers a severe, prolonged water shortage in combination with serious civil unrest stemming from the agitations of a radical religiopolitical group, or from poor leadership. Each causal factor of unrest, including water, would tend to intensify reciprocally all of the other factors of potential conflict, and the probability of strife would rise accordingly.

The Euphrates Basin

There exist many historical, hydropolitical, and ideological reasons for conflict among the riparians of the Euphrates basin where the consequent possibilities of dissension are much higher. Animosity and mistrust have tainted Turkish-Syrian relations since June 1939, when Turkey, with French collusion, annexed the Syrian district of Alexandretta, renaming it Hatay. On the other hand, Turkish-Iraqi relations have been largely cordial since the establishment of the Turkish Republic, even though Turkey cooperated with the UN coalition in the Gulf War of 1990. The Turks are anxious, for economic reasons, to reestablish good relations with Iraq. Between Iraq and Syria, there is a deep ideological divide that appears to be unbridgeable so long as presidents Hafiz al-Assad and Saddam Hussein remain ensconced as heads of their respective regimes. The chasm was created by several forces: a power rivalry between the two presidents, each perceiving himself and his nation as the natural leader of the Arab world and, until recently, the most uncompromising anti-Israeli rejectionist; an angry ideological split between the Syrian and Iraqi branches of the Baath Party; and, not least, by a personal contempt and hatred that each leader harbors toward the other. However, in arid lands, water is a superordinate interest and has often overridden many divisions between neighbors for the sake of survival. As will be evidenced shortly, Syria and Iraq for precisely this reason have held technical talks—albeit infrequently—about sharing water and even discussed specifics of allocating the Euphrates' flow after it leaves Turkey.

But there is one significant common ground on which Iraq and Syria stand—that is, their mutual concern over whether there will be sufficient flow in the Euphrates to satisfy their long-term needs when Turkey fully implements the Greater Anatolia Project (GAP). As indicated, about 96 percent of the flow of the Euphrates rises in Turkey and about 65 percent of the waters of the Tigris originate there as well. GAP encompasses both river basins, though, because of insufficient finances, work has been

undertaken only on the Euphrates. When completed and fully operational, the projected cost of GAP will have been upward of $32 billion (up from earlier estimates of $20 to $24 billion), and the project is expected to account for 22 percent of Turkey's total hydroelectric energy production and 19 percent of the country's irrigable land (about 1,500,000 new hectares).[22] It is clearly a huge undertaking that will consume enormous amounts of water. Furthermore, unless Turkey is persuaded to clean up the water it sends downstream, Syria and Iraq will have to contend with water polluted by salts and chemical residues from fertilizers and insecticides carried back to the main river channel by return flows from the massive irrigation involved.

Although Syria and Iraq share common concerns, the field is not level. Syria is an upper riparian to Iraq. Some reputable analysts (e.g., Kolars) have estimated that once GAP is completely implemented on the Euphrates, Syria could lose about 40 percent of its supply of Euphrates water, and Iraq as much as 70 percent. Unlike Iraq, Syria does not have the current advantage of Tigris waters flowing over its territory and thus depends more heavily on the Euphrates. But if and when Turkey develops the Tigris on its side of the border—and if Iran decides to use more of the feeder streams that supply the Tigris after it leaves Turkey—Iraq could face a hydrological crisis of very large dimensions, losing up to 75 percent to 80 percent of its supply from surface waters. Furthermore, Iraq's demographic growth rate will double its population within about 25 years (so will that of Syria), and Iraq does not have a considerable sea coast from which to derive any substantial amounts of desalinated water.

It is improbable that Iraq's groundwater sources could make up enough of the prospective losses from surface flows to allow Iraq to avert a crisis—should those losses transpire. What is presently known about Iraq's aquifers—most of which have been located but are incompletely mapped, unevaluated, and known to be fossil—indicates that groundwater could supply no more than 30 to 40 percent of Iraq's needs. This would still leave a 60- to 70-percent potential shortfall in total supply, even when reckoned only on the basis of usage projected for the next decade. The shortfall could be larger, depending on population growth and whether Iraq adequately improves management and usage efficiency and conservation. (These conservative estimates are subject to error, because it has not been possible at this stage to determine the safe yields of most of the aquifers.)

There are other serious deficiencies in the groundwaters of Iraq that limit their usefulness. They lie very deep and are generally of poor quality; they are very brackish and would require desalination. The necessary technology for extraction and purification would require considerable on-going expenditures. In addition, most of Iraq's soil is of such

poor quality that the cost of drainage and reclamation to leech out the salts would be another persistent high expenditure of money and water. Because of the poor grade of Iraq's soil, great amounts of irrigation water are needed to grow crops. Thus, farming such land would require continuing water and agricultural subsidies to farmers to make the cost of the food produced affordable.

There is a certain historical irony in the present situation. Iraq was rich in soil, irrigation, canals, and agricultural production, as late as the 1950s. At times in this century, Iraq was producing enough food—especially wheat and rice—to feed a population of some 35 million people. But the effects of long-term natural changes in the river channels, soil erosion, and salination of irrigated land has caused a steady reduction in per capita agricultural production in Iraq. Since 1958, Iraq has changed from being mainly an agricultural nation that exported wheat, rice, and other foodstuffs to being an oil-producing, semi-industrial country that imports most of it food. Neglect of proper drainage and irrigation practices, worsened by the migration of farmers to the oil fields and cities, led to increased salinity of the soil. The problems of poor-quality water and soil have been compounded by the government's policy of making agriculture and water a matter of military security. Between 1974 and 1984, public investment in the water sector was 15 percent of the agriculture budget; in the decade between 1980 and 1990, that investment dropped to 5 percent when 85 percent of the agricultural budget was transferred to the military sector, reflecting Saddam Hussein's aggressive policies toward Iran and Kuwait.

Some steps have been taken to mitigate these conditions through the construction of irrigation projects equipped with controlled intakes, concrete canals, sluice gates, syphons, and a network of drainage pipes and canals laid down as preventive measures against the further salinization of the soil. The entire drainage network is connected to a single main drain canal that runs between the two rivers for the collection of irrigation wastes that are discharged into the Gulf.[23] But as important and impressive as these technical improvements are, they have been applied to only a small part of the agricultural sector; they will amount to little more than stop-gap measures unless they are introduced nationwide. Presently, most of the nation's irrigation system remains in unsatisfactory condition: water withdrawal is uncontrolled; the distribution system, structures, and canals are inefficient and insufficient; field drainage facilities are lacking; and field irrigation is poorly executed. Endemic water-quality problems have already been exacerbated by the economic embargo imposed on Iraq after the Gulf War, which has caused a severe shortage of chemicals needed for water treatment. This situation has affected the safety of the drinking-water supply, which has produced

concomitant health problems. Most importantly, the larger underlying issue of basinwide cooperation on allocation and usage must be successfully engaged if there is to be sufficient water for drinking, industry, and the maintenance of a significant agricultural sector.

An added political and security complication for Baghdad is the fact that most of the Tigris watershed inside Iraq lies entirely within Kurdistan, the northern area where there is presently an autonomous Kurdish area under UN protection. In the unlikely event there were to be a permanent autonomous or independent Kurdish entity established in the north, Iraq's water supply from the Tigris would be vulnerable to manipulation by the Kurds. Ironically, the Iraqis themselves demonstrated the strategic uses of water in that area by using it as a weapon against the Kurds. Baghdad deliberately located most of Iraq's small dams in the Kurdish north to create a barrier of water to prevent Kurdish rebels from advancing southward against Iraqi forces during anti-Kurdish operations. Before the Gulf War, there were plans for constructing a cascade of 13 dams on the Rawandoz River for just that objective.[24]

If the worst-case scenario of a 70- to 80-percent loss of total water supply were to occur, among the most serious consequences would be a decline in Iraq's ability to produce oil and a loss of the authorities' capacity to deliver vital public services. Unlike the oil producers of the GCC, Iraq does not have a long sea coast where large quantities of water could be desalinated or pumped for use in oil production. Were Iraq to lose that much water, or even 50 to 60 percent (which is quite possible), in a relatively short time span, the socioeconomic and political impact would be devastating. In those circumstances, Iraq would become vulnerable to a mixture of destablizing security hazards: domestic political and sectarian factionalism, civil strife, or dismemberment by civil war or by aggressive neighbors. Alternatively, depending on the nature of Iraq's leadership and other local regional relationships, Iraq could again become aggressive toward its Arab neighbors north or south with the object of gaining more of the flow of the Euphrates and Tigris Rivers or acquiring a longer sea front for the purpose of increasing the supply of water for desalination. If hostilities over water were to develop, the conflict would be international. Moreover, if the cause were presented as water deprivation, the Iraqi public (judging by the results of interviews conducted by the author) would most probably view the issue as a national, patriotic war and give its full support. However, water is infrequently the sole cause of large-scale conflict, rather it is almost always an important element in a combination of factors that contribute to the conflict.

Although it is possible for these conditions to develop fairly quickly from a combination of factors such as prolonged drought (which occurs

relatively often in the area), together with resource mismanagement and failure among the basin riparians to arrive at cooperative arrangements for equitable apportionment, the present situation affords all the basin actors time to avert a crisis if there is a will to do so. This window of opportunity exists because the prospects that Turkey will acquire the financing necessary for completing all the stages of GAP within the foreseeable future are dim. The bases for a successful negotiation are in place, albeit dormant. Much depends on how water plays out in the foreign relations of the Euphrates basin riparians, most particularly in our case, the hydropolitics of Iraq.

International Dimensions of Iraqi Water Problems

Because Iraq's two main rivers both originate outside its boundaries, water for Iraq is an important strategic and international issue involving Turkey and Syria on the Euphrates, Turkey and Iran on the Tigris, and Iran over the Shatt al-Arab, although the last is more of a boundary than a water issue. The aquifers that Iraq shares with Saudi Arabia and Jordan have not as yet caused friction (the flow of these aquifers is northwest to ~~north~~east, thus favoring Iraq). Reinforcing the perception of Iraqi authorities that water is an issue of paramount importance in foreign relations is their awareness that the nation's oil resources will be eventually depleted or that other cheaper, more secure energy sources will be developed as substitutes, but that there is no alternative to water for domestic and agricultural use.[25]

Despite the absence of formal international apportionment and usage agreements among the riparians of the Euphrates and Tigris Rivers, they have yet to resort to military action over water, though in a few instances hostilities have been only narrowly averted. The chief reasons for the successful avoidance of violent conflict have been that none of the principals involved has wanted a war over their shared water supplies; Turkey has been a member of NATO, which meant that an attack on Turkey could involve NATO forces; and, since the Gulf War, the military balance of power has shifted decisively to Turkey (which, of course, is still a member of NATO). The dispute between Iraq and Iran over the Shatt al-Arab has been rooted not in water supply but in control and right of use. Over the past century, there have been several negotiations about the Shatt al-Arab, but in most cases the agreements reached have been unilaterally abrogated by one side or the other. The last accord was reached in 1975 when Iraq agreed to cede half of the Shatt to Iran if the latter would cease its support of the Iraqi Kurds. Saddam Hussein disavowed the agreement when he invaded Iran. After 1979, the issue was not discussed until 1990, when Saddam Hussein gave up his claim to sole

control as a concession to get a quick settlement from Iran in order to free up troops for use against the United States and its allies in Kuwait.

The absence of enduring agreements is not due to the failure of the parties to negotiate. Considering the record of animosity among the three riparians, there have been a surprising number of exchanges aimed at developing at least an interim working arrangement during the last thirty years. Negotiations over that time have produced bilateral agreements between Turkey and Iraq and between Iraq and Syria and a Joint Technical Regional Rivers Committee, but as yet no tripartite treaty for equitable sharing. The Turkish-Iraqi accord is an annex to their 1946 Treaty of Friendship and Good Neighbourly Relations and governed the flow regulations of the Euphrates and Tigris Rivers. The annex concerning the Euphrates amounted to little more than a statement of good intentions, because without the participation of Syria, nothing of import could be accomplished. In April 1990, before the Iraqi invasion of Kuwait, Iraq and Syria are reported to have negotiated a tentative apportionment arrangement for Euphrates water. The agreement would give Syria 42 percent and Iraq 52 percent of the flow downstream of Turkey, and would establish a joint technical committee to resolve details of the monthly division of water. If such an accord formally exists, it has obviously been set aside for the time being, although there is no evidence that either party has discarded the agreement since the Gulf War. In 1983, Syria accepted an invitation to participate in the Joint Technical Committee that was formed by Turkey and Iraq in 1980, turning it into the only trilateral body where common water problems are discussed by representatives of all three riparians.[26] But since the trilateral committee's first meeting in November 1983, it has met only sporadically with few productive results. The representatives have been given only restricted authority to agree to anything beyond technical matters—for example, the Iraqi delegate, who had the least amount of authority, never held a rank higher than that of a director-general.[27]

Neither Iraq nor Syria has resorted to litigation under international riparian law as a means of insuring its fair share of water. While they have not gone to court, they have buttressed their claims with a combination of judicial principles that include those of no significant harm, equitable utilization (rational sharing based on real need, economic development, size of population, etc.), and historical or prior use. For their part, the Turks have adopted the legal stance assumed by most upper riparians—absolute sovereignty over all resources within their borders. That is, Turkey asserts the right to do or not to do whatever it pleases with waters originating in its territory. Turkey has paid a serious price for its reticence to adhere to the established law that obliges nations that undertake activities harmful to other riparians to notify and consult with them prior

to initiating such projects. The World Bank has rejected Turkey's requests for GAP loans because of its rule, based on that law, that where development of water resources could affect other users, all the concerned parties must agree to the loan. Thus Syria has successfully blocked Turkey's loan application for years and has made it more difficult for Turkey to obtain capital from other sources. Ankara has been effective in finding alternative resources, but now the failure to obtain large loans from either the World Bank or others in the current restricted international financial market has significantly slowed progress on GAP. An unintended salutary consequence has been the creation of more lead-time for negotiating an apportionment agreement.

Iraq and Syria recognize that because Turkey has invested so much political and financial capital in GAP—which, if successful, would transform the economy of Turkey with commensurate social and political rewards—Ankara cannot be expected either to retreat or make significant changes in its determination to carry through on GAP. They have, accordingly, focused their efforts on the quantity and quality of water sent down from Turkey. The natural flow of the Euphrates River is estimated to be over 900 cubic meters per second (cm/s). The long-term adjusted rate is somewhat less than that figure, about 750–800 cm/s. But because the river's flow varies so much from year to year, and even within seasons of a single year, it has been possible for each party to argue with some justification for its own calculations of the rate. Turkey has guaranteed a minimum flow of 500 cm/s to Syria and Iraq, which in turn have rejected that figure as inadequate, countering with a demand of at least 700 cm/s. This occurred most recently at a ministerial-level meeting in June 1990.

At the same time, Turkish authorities have made strenuous efforts to reassure their riparian neighbors that Turkey would not use water as an instrument of coercion or as a strategic weapon against Iraq and Syria. In 1989, however, then-prime minister Turgut Özal threatened to cut off the Euphrates if Syria and Iraq did not stop the aid he accused them of giving to the Kurdish Workers' Party (PKK) insurgents. Likewise in 1990, the Turkish Minister of State, Kamran Inan, was reported to have stated that Turkey was under no obligation to conform to international stipulations regarding the Euphrates and Tigris Rivers.[28] On the other hand, Turkey has fairly consistently fulfilled its pledge to send down 500 cm/s and during the Gulf War resisted all suggestions that it cut off the Euphrates to force Iraq into submission.

The Prospects for Water-Related Conflict in the Persian Gulf

It would appear that factors of scarcity, security, and conflict combine to produce a higher probability of water-related strife for Iraq and the other riparians in the Euphrates-Tigris basins than do the same factors operating in the Arabian Peninsula. In Iraq, Saddam Hussein's leadership and the effects of the Gulf War are additional destabilizing factors. Warfare and other types of acute conflict among the Euphrates and Tigris basin actors, however, are unlikely in the foreseeable future, if for no other reason than Iraq is debilitated from the Gulf War. Domestic conflict, in which water plays a supporting role to other causes, is a more likely scenario.

Essential to Iraq's economic recovery and stability is the improvement of its water infrastructure, the introduction of advanced water technology, a program of strict conservation, and efficient water management, all of which will require an infusion of foreign capital. Iraq's international credit status was destroyed by the Gulf War but should recover slowly once the economic embargo is lifted and oil sales resume. But financial and technical support from abroad will continue to be difficult for some time owing to prevailing conditions of political and economic instability, Iraq's refusal to provide information necessary to obtain help from the World Bank, and the shrinkage of the international financial market. This situation will have to improve relatively quickly if Iraq is to position itself to avoid the real possibility of a water crisis.

GAP does pose a threat to Iraq and Syria; but since mutual animosity has inhibited cooperation in persuading Turkey to agree to a firm, long-term commitment on an adequate amount of water to be released downstream, each has responded differently to the perceived menace. Syria, the more hostile, has done all it can to block access to financial assistance for GAP, while Iraq, hoping to capitalize on traditional friendship with Turkey, has offered oil and hydroelectric power from its northern dams as part of a negotiated settlement.[29] But little in the way of a sustainable, long-term settlement on apportionment and usage can be accomplished without the full engagement of all three parties in the negotiating process and agreement on the final arrangements. That is unlikely to happen in the short term unless Saddam Hussein is removed or Iraq is able to undertake a full-scale recovery program. Then, because water is such an overriding issue for both Iraq and Syria (and because Hafiz al-Assad is nothing if not a pragmatist), even with Saddam Hussein in office, Syria and Iraq might be able to act in concert if such cooperation appears to promise concessions from Turkey or can avert a serious water crisis.

The most likely short-term scenario for the Euphrates basin is that little progress will be made toward a negotiated settlement as long as Saddam Hussein remains in power and the situation created by the aftermath of the Gulf War continues. The situation will fester until sustained, sharp shortages are experienced downstream, at which time tensions could erupt dramatically and lead to a regional (and therefore international) crisis. In the meantime, water issues compound other factors that promote domestic conflict in Iraq, intensifying and broadening their impact and contributing to internal instability.

Water crises and conflict are avoidable in the Euphrates basin, and water security is achievable. Scarcity as a determinant of possible conflict in the basin stems not from a dearth of water, but from maldistribution and mismanagement of that water. Though the effects of maldistribution are little different from real shortage, the former type of problem yields to solutions more readily. Despite poor distribution, there is enough water in the Euphrates and Tigris Rivers for all users, provided that there is cooperation in its management, preferably a single, representative, basinwide body with sufficient authority, expertise, and funds to oversee allocation and usage and provided that efficiency and conservation are practiced in all water activities and that the demographic growth rate is aligned with the limits of the water resources. These are very difficult goals to achieve in the best of circumstances but almost impossible without political stability and harmony among the concerned riparians. Nevertheless, they must somehow be attained if conflict is to be avoided.

Notes

1. E. de Vaumas, "Le contrôle et l'utilization des eaux du Tigre et de l'Euphrate," *Revue de Géographique Alpine* 46 (1958): 235–55; J.B. Pritchard, ed., *Ancient Near Eastern Texts Relating to the Old Testament*, 3rd ed. (Princeton: Princeton University Press, 1969), 168; on Siffin: Al-Ya^{c}qubi, Tarikh al-Ya^{c}qubi, 2 vols., (Beirut: Dar Sadir, 1977), vol. II, 187–88.

2. Jamil Al-Alawi and Mohammad Abdulrazzak, "Water in the Arabian Peninsula: Problems and Prospects," in P. Rogers and P. Lydon, *Water in the Arab World* (Cambridge: Harvard University Press, 1994), 176–178.

3. John Keenan, *The Potential and Limitation of Water Technology*, AMER Middle East Water Reports, Parts I and II, Philadelphia, (1986, 1989).

4. A qanat is an underground channel by which water is brought from various sources by means of gravity flow to where it is needed for irrigation. A qanat is built and maintained by a series of wells that give access to the channel every 10 to 50 meters along its course. Qanats take years, sometimes generations, to construct and require considerable, long-term investment.

5. Department of the Environment, Office of the Prime Minister, Case Study on Desertification in Iran: Turan, Tehran, May 1977, 97 pp.

6. *Washington Times*, 5 April 1995, A13.

7. The author has just become aware of a statistical abstract of Iran published in Tehran in 1992 and of a report that the Iranian authorities have published a recent volume on water in Iran. He has not been able to locate copies as of this writing. Depending on the contents of these two volumes, the statement concerning sources might have to be altered.

8. Information on the Qatari-Iranian water talks and their context were provided in a personal communication by Dr. John Duke Anthony, president of the National Council on U.S.-Arab Relations, based on recent discussions Dr. Anthony had with the foreign minister of Qatar. The author wishes to thank Dr. Anthony for sharing his information and insights.

9. Some of the data used in this section are drawn from summaries of unpublished papers delivered at the second Gulf Water Conference (hereafter Gulf Water II), whose theme was "Water in the Gulf: Towards Integrated Management," held in Manama, Bahrain, November 5–8, 1994, under the auspices of the Bahrain-based Water Sciences and Technology Association (WSTA) and the GCC General Secretariat. The summaries are published by the *Gulf Daily News*, Nov. 6, 1994. Other data are drawn from the AMER Middle East Water Database in Philadelphia.

10. Al-mahmoud Abdulrahman et al., Qatari Ministry of Municipal Affairs and Agriculture, and Abdul Latif Al-Mugrin, deputy assistant secretary-general, GCC Secretariat, Gulf Water II.

11. Al-Mugrin, Gulf II; see also Al-Alawi and Abdulrazzak, "Water in the Arabian Peninsula," 177, 186–191.

12. Al-Alawi and Abdulrazzak, "Water in the Arabian Peninsula," 172.

13. One tonne = one long ton = 2,240 pounds or 1.016 metric tons.

14. For an excellent brief treatment of this topic with supporting data, see P. Gleick, "Water and Energy," in Gleick, ed., *Water in Crisis*, (New York and Oxford: Oxford University Press, 1993), 66–79.

15. Some of the information and data contained in the following section was provided in personal communications by various geologists and hydrologists formerly with the ARAMCO Oil Company, for which the author expresses his thanks.

16. Postel, S., "Water and Agriculture," in Gleick, ed., *Water in Crisis*, 59.

17. Ibid., 59.

18. *Gulf Daily News*, Nov. 6, 7, 1994.

19. Water Commission of Israel, Assessment of Medusa Bag technology undertaken by Tahal, 1991; also data provided to the author by James Cran, President of Medusa Corporation, November 1994.

20. Mention has already been made of a proposed transfer of water by pipeline from Iran to Qatar.

21. Turkey's economic development plans are among the most ambitious in the region and its population is growing at about 3.6 percent per annum.

22. The best source in English on the GAP project is J. Kolars and W. Mitchell, *The Euphrates River and the Southeast Anatolia Development Project* (Carbondale, Ill.: Southern Illinois Press, 1991); for a picture of how GAP affects the hydropolitics among the Euphrates riparians, see the respective articles by a Turkish, Syrian, and Iraqi specialist in *Research & Exploration* (A Scholarly Publication of the National Geographic), November 1993, vol. 9, pp. 50–79; see also Naff & Matson, *Water in the Middle East*, 83–110.

23. The information on water-sector investments and water and soil conditions in Iraq is drawn from an analysis of Iraq's water situation in *Water Issues in Iraq*, by A. Hardan and T. Naff, prepared for Associates for Middle East Research (AMER), August 1991, 70 pp., unpublished; the data used is from the AMER Database on Middle East Water.

24. Hardan and Naff, *Water Issues in Iraq*, 40.

25. Hardan and Naff, *Water Issues in Iraq*, 56–60.

26. S. McCaffrey, "Water, Politics, and Conflict," in Gleick, *Water in Crisis*, 95, 100–101; Hardan and Naff, *Water Issues in Iraq*, 57–8.

27. Ibid., 57.

28. McCaffrey, *Water, Politics, and International Law*, 93.

29. Hardan and Naff, *Water Issues in Iraq*, 58

30. This statement is based on private communications to the author by very well-placed authorities in both Iraq and Syria who are involved with the shaping of hydropolitical policies.