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WATER SUPPLY TO THE WEST BANK AND THE GAZA STRIP

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LIST OF MAPS

LIST OF TABLES

FORWARD

This study comprises part of the Middle East Economic Cooperation Project of the Tel Aviv University Interdisciplinary Center. The Project's general objective was to identify development schemes that would be of mutual economic benefit to the countries and to the peoples of the Middle East. In this paper, the severe water shortage problem of the West Bank and Gaza Strip (WBGS) is discussed, and certain unconventional solutions are proposed. These indicate the feasibility of importing water from neighboring countries (Egypt, Lebanon and Jordan) to ensure that the future basic needs of the inhabitants of the WBGS, - domestic as well as agricultural - are met. If implemented, the scheme(s) could, it is believed, create a basis for cooperation between Israel and several of its neighboring countries and reduce friction and conflict between Israel and the inhabitants of the WBGS. The schemes would thus contribute to cementing constructive politcal relations (through mutual dependence) between Palestinians and the other parties involved in the Arab Israeli dispute. The report was edited by D. Sasson

INTRODUCTION

The West Bank and the Gaza Strip (hereinafter WBGS) differ from all other regions in the area because of their lack of sufficient domestic water resources. The WBGS scarce water resources will not enable these regions to meet both the agricultural and the non agricultural water needs and requirements of its inhabitants in the future.

In contrast, all of the surrounding soveriegn states (Lebanon, Jordan Syria, Israel and Egypt) do have access to water resources that ensure their non agricultural (and to a significant extent also their agricultural) demands in the forseeable future. The reason for the potential water shortage of the WBGS is due to the fact that most of its existing local resources are already being fully utilized. These include the aquifers of the WBGS that are currently being used in the WBGS and in Israel, as well as the southern part of the Jordan River which supplies water to both Jordan as well as Israel.

The WBGS prospective water shortage is not only a socioeconomic drawback for its own inhabitants - in all likelihood it will also, in due course, generate serious political repercussions. Clearly, tension will develop when the local population begins to experience the impact of the shortage.

Under such conditions there is only one solution to the water problem facing the WBGS namely; importing water from external sources. Potential external sources of water include the Yarmouk, Nile and Litani Rivers. Although it is technically and economically possible to transfer water from these external sources to the WBGS, politically such a scheme does not appear feasible under present conditions. However, any progress toward regional peace should make this possible and in view of the critical importance of the subject should in effect form an integral part of an overall peace plan.

This report describes possible ways of importing water to the WBGS, including the estimated costs of such potential projects. Several key assumptions form the basis for the proposals :

First, it should be noted that water shortages in the WBGS will prevent full agricultural development and will create unmet demand for non-agricultural water. Importing water from external sources could remedy this.

Second, the proposed projects cannot be used as a basis for large scale refugeee settlement. The projects would not significantly change the relatively small role agriculture plays in the economy of the WBGS areas - which contributes only one-fifth ($300 million) of these areas' total GNP.

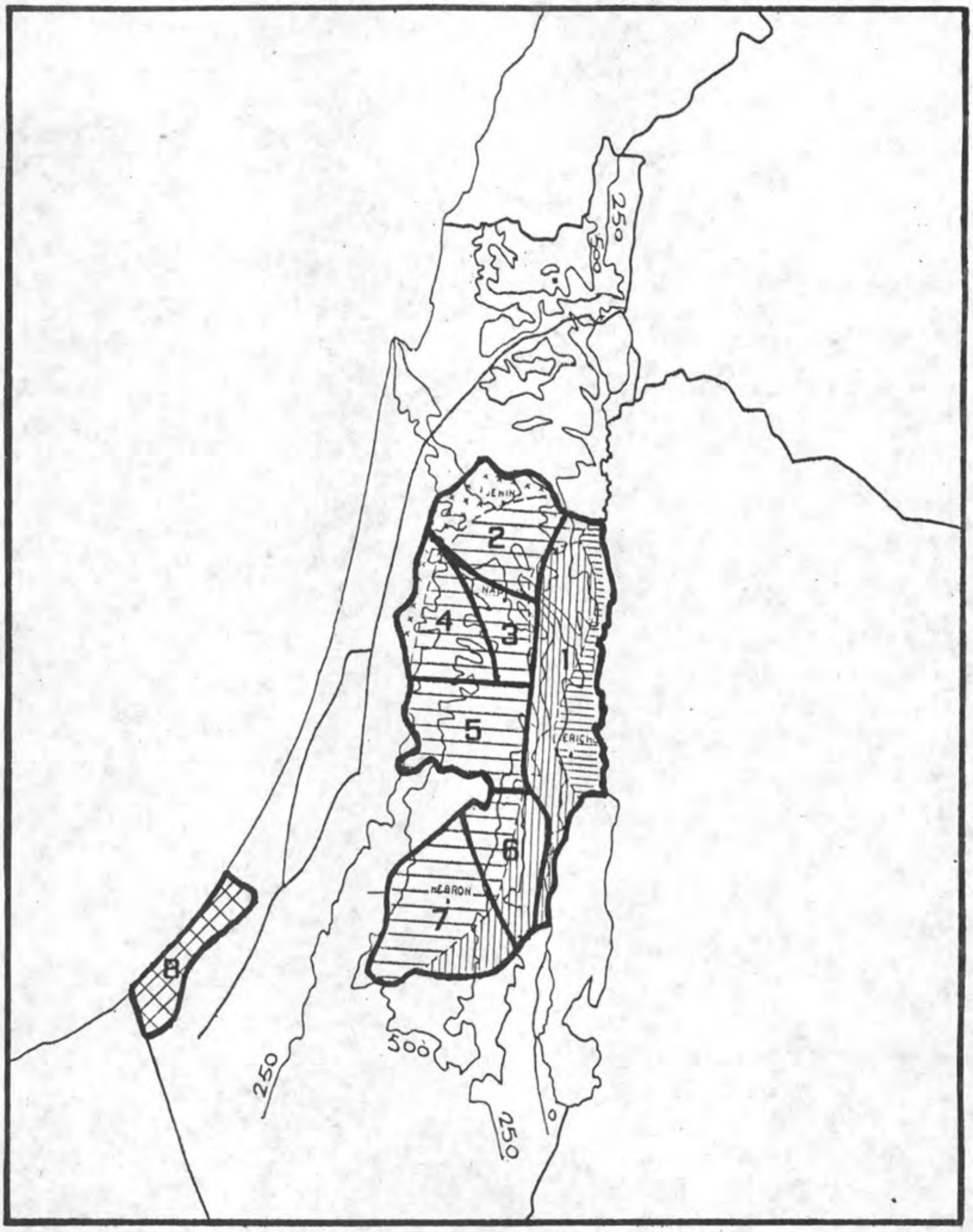
Thus, the economic value of agricultural development in the WBGS is limited. However, expanding the agricultural sector would have a positive social effect, because of the population's traditionally strong links to the agricultural employment and village life.

Third, continued water scarcity will increase tension between Israel and the WBGS, since they presently share joint water resources. This indicates that additional water has a political value which is separate from its economic value.

For use in irrigation, raising water to the highland areas of the West Bank region - which is hundreds of meters higher than the potential water sources - would be uneconomical. Yet, due to the political and social benefits of such a project, international aid may be available (under suitable political conditions) to finance the construction and operation of the whole scheme.

Nevertheless, alternative proposals that provide partial solutions and do not involve supplying irrigation water to the higher zones of the West Bank - and which are, therefore, more economical - are also analysed.

Map 1: <u>Water Supply Districts on Ecological Areas Background</u>



<u>Water Supply Districts</u>

1. Jericho District
2. Samaria - Jenin District
3. Sameria - Nablus District
4. Sameria - Tul Karem District
5. Judea - Ramallah District
6. Judea - Bethlehem District
7. Hebron District
8. Gaza Strip

<u>LEGEND</u>: Ecological Areas

Jenin Area -

Jordan Vally -

Eastern Foothills -

Upland -

Costal Plain (Gasa area only) -

II. BACKGROUND DATA

A. Geo-Hydrographical Data

The WBGS comprises nearly 6,000 sq. km. in the West Bank (Judea and Samaria), and approximately 360 sq. km. in the Gaza Strip. The area in question surrounds the following five ecological zones : The Jenin-Tulkarem plain, the Judea and Samaria Hills; the eastern slopes of the hills of Judea and Samaria; the Jordan Valley, and the southern coastal area of the Gaza Strip. (See Map 1)

At present the areas irrigated in the WBGS are approximately as follows: 10,000 out of 53,000 irrigable hectares in the West Bank, and 15,000 out of 20,000 irrigable hectares in the Gaza Strip.

Underground water is the main source of water in the WBGS. In the West Bank underground water is stored in the Kenoman - Turon aquifers that act as a drain for the regional rainfall. Most of the rain water (over half a billion cu. m. per annum) flows into these aquifers and is pumped out, mostly in Israel - in the Bet-Shean and Jezreel Valleys, and in the coastal plain for agricultural and other purposes. Only one-fifth of the water drains eastward to springs and aquifers in the West Bank and is (or can be) used locally.

In the Gaza Strip, the sandy aquifers of the coastal plain are overused - supplying 140 million cu.m. per annum while natural replenishment is only some 60 million cu.m. per annum.

B. Expected Water Demand in the WBGS

For the purpose of this report future water demand, both agricultural and non-agricultural, is divided according to the following zones :

- The Gaza Strip
- Samaria (subdistricts : Jenin, Tulkaren and Nablus)
- Judea (subdistricts : Ramallah and Bethlehem)
- Subdistrict of Hebron
- Subdistrict of Jericho

Non-agricultural water demand (domestic, municipal and industrial) forecast for the year 2000 was estimated according to population, and GNP estimates for that time. Agricultural demand for the end of the century was estimated according to total irrigable land availability as well as assumed future crop types and the amounts of water needed for their cultivation.

1. Non-Agricultural Demand

The population of the WBGS is estimated at between 2-3 million by the beginning of the next century (one-third of those in the Gaza Strip).[(1)] For the purpose of this paper a population of 2½ million is assumed.

Per capita GNP in the WBGS for the year 2000, is estimated to be $1,700 per annum.[(1)] Non-agricultural water consumption per capita for these areas is assumed to be similar to that of Israeli areas with similar features and the same level of GNP - i.e. the per capita GNP level that prevailed in Israel in the early 1950's. Non-agricultural consumption in Israel in regions lacking water (such as Jerusalem) was then approximately 50 cu.m. per capita per annum (2). Thus, one may expect an annual water consumption of some 125 million cubic meters for the WBGS - with one-third of this amount allocated to the Gaza Strip.

It is also assumed that by the beginning of the next century, non-agricultural water demand in the WBGS will reflect the present population distribution.[(3)] (see Table 1)

2. Agricultural Demand

Expected water demand for the agricultural sector of the WBGS is estimated on the basis of the following :

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(1) See Reference (1).

(2) See Reference (2).

(3) This was estimated by the birth distribution data, See Ref. (9)

Table 1 - Non Agricultural Water Demand

In The Year 2000

District	Estimated Non Agricultural Water Demand (million cu.m./annum)
1. Gaza Strip	42
2. Samaria (subdistricts of Jenin, Tulkarem, and Nablus)	41
3. Judea (subdistricts of Ramallah and Bethlehem)	17
4. Subdistrict of Hebron	23
5. Subdistrict of Jericho	2
TOTAL	125

(a) Potential irrigable land in the West Bank is in the range of 50,000 hectares (compared with 10,000 hectares presently irrigated)[(1)]

(b) Potential irrigible land in the Gaza Strip is in the range of 20,000 hectares compared to 15,000 hectares irrigated at present, and 8,000 hectares that should be irrigated if overpumping (which must cease in the future)[(2)] is discontinued.

(c) The proportion and pattern of WBGS crops would (it is assumed) be similar to that obtained in Israel at present - one-third perennial (mainly plantations), and two-thirds annuals (vegetables and field crops), with the exception of the Jordan Valley and the Gaza Strip where the proportion would be one half perennial and one half annual crops (in light of the present concentrations of citrus in the Gaza Strip).

(d) Irrigation efficiency has also been assumed to be similar to that obtained in Israel (with the exception of the Gaza Strip which has a deep rooted tradition of inefficient surplus irrigation). This is reflected in Table 2, where estimates of the quantities of irrigation water demand are made accordingly.[(3)] These are between 500 m.m. per annum in the hills, and 1050 m.m. per annum in the valleys. This quantitive difference is due mainly to the perennial crops, since the amount of irrigation water needed each year for the annual crop is fairly uniform and rises from 400 to 500 millimeters (annual crops will be concentrated in the dry areas during the winter and in the humid areas in the

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(1) Based on References (3), (4), (5). The area distribution among the various ecological zones (table 2) is according to Reference(3).

(2) Based on References (4), (5).

(3) Based on Reference (2) adjusted for ecological differences.

Table 2 - Division of Potential Water Demand for Irrigation

According to Ecological and Water Supply Districts

Ecological Area		South Coastral Strip	North Coastal Plain (Jenin-Tulkarem)	West Bank Hills	Eastern Slopes	Jordan Valley	Total
Water Supply District	Average Water Demand cu.m. per dunam	650	600	500	700	1050	
Gaza Strip	Area (thousands of dunam)	200	-	-	-	-	200
	Water Demand (million cu.m. per annum)	130	-	-	-	-	130
Subdistrict of Nablus, Jenin & Tulkarem)	Area (thousands of dunam	-	100	128	61	18	307
	Water Demand (million cu.m. per annum)	-	60	64	42	19	185
Subdistrict of Ramallah & Bethlehem)	Area (thousands of dunam)	-	-	52	4	-	56
	Water Demand (million cu.m. per annum)	-	-	26	3	-	29
Hebron District	Area (thousands of dunam)	-	-	100	-	-	100
	Water demand (million cu.m. per annum)	-	-	50	-	-	50
Jericho District	Area (thousands of dunam)	-	-	-	-	77	77
	Water Demand (million cu.m. per annum)	-	-	-	-	81	81
TOTAL	Area (thousands of dunam)	200	100	280	65	95	740
	Water Demand (million cu.m. per annum)	130	160	140	45	100	475

summer). Map 1 shows the different water supply areas against the background of the different ecological zones.

(e) It is assumed that unlimited demand for agricultural produce will exist, so that no restrictions (preventing full utilization of land suitable for irrigation) will be experienced. Although fruit and vegetable output will exceed local WBGS demand (assuming yields similar to Israeli levels), demands for these products from external countries would absorb any surplus.

3. Overall Demand

Overall water demand forecast for the beginning of the next century is shown in Table 3. In this table, the figures in brackets represent the lower values of what hereinafter is described as a "limited scheme". The "limited scheme" is one in which irrigation water is not supplied to the elevated or higher WBGS regions. In such a scheme, the only irrigation water available to the higher regions will have to come from reclaimed sewage water.

Within the framework of the proposal water demand is to be used from two principal sources: (a) local and (b) imported water.

C. Available Water Sources

1. Local Sources

It is not possible to quantify exactly the future output of local water sources in the WBGS. This is due to the fact that more water could be obtained through overpumping (i.e. pumping out more than the annual average natural replenishment of the resources). Overpumping in the West Bank - especially in the west drainage area of the Turon-Kenoman Aquifer, which is already fully utilized - would harm existing Israeli users. In the Gaza Strip continued overpumping will lead to salination of the aquifers. It must therefore be assumed that overpumping will cease in the future and that additional ground water eastward drainage sources will have to be developed.

Table 3 - Water Demand in the WBGS in the Year 2000

DISTRICT	Agricultural(1) Water Demand (millions cu.m./an.)	Non Agricultural(2) Water Demand (millions cu.m./an)	Total Water Demand (millions cu.m./an.)
Gaza Strip	130	42	172
Subdistricts of Jenin, Nablus and Tulkarem	186 (100)	41	227 (141)
Subdistricts of Ramallah & Bethlehem	29 (8)	17	46 (25)
Subdistrict of Hebron	50 (12)	23	73 (35)
Subdistrict of Jericho	81	2	83
Total Area	476 (331)	125	601 (456)

SOURCE : (1) Table 2

(2) Table 1

Sinai Canal and

Map 2: Regional Main Rivers and Water Conduites

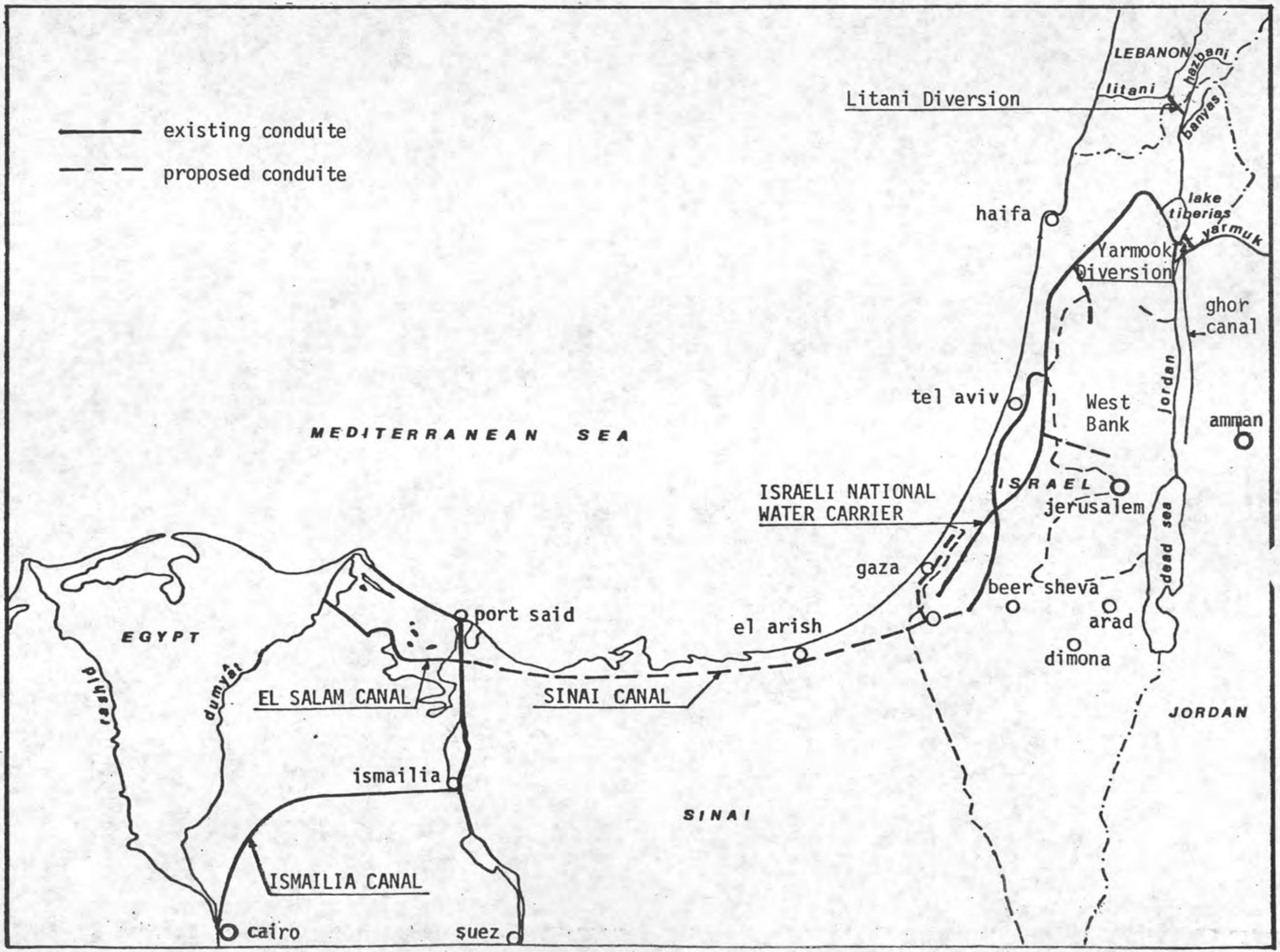

Table 4 - Expected Demand and Supply Sources in the Year 2000

(million cu.m./annum)

District	Utilization at present (198)	Expected Demand	Natural Domestic Source	Reclaimed Sewage Water	Demand to be met by imported water
Gaza Strip	140	172	60	21	91
Samaria	44	227 (141)	35	21	171 (85)
Judea	5	46 (25)	13	8	25 (4)
Hebron	6	73 (35)	17	12	44 (6)
Jericho	64 (a)	83	55	1	27
Total	259	601 (456)	180 (b)	63	358 (213)

(a) Not including 10 million cu.m. from the Jordan River which is not considered to be a natural domestic source.

(b) At present 110 million cu.m. per annum is utilized.

Non-utilized potential of such eastward drainage sources is estimated at 60 million cubic meters per annum (in addition to the 60 million cubic meters per annum already obtained from the East Drainage Aquifer by drilling and springs). Terminating overpumping in the Gaza Strip would limit local resources usage there to 60 million cubic meters per annum compared to the 140 million cubic meters pumped at present. An additional local water resource consists of reclaimed sewage water. It is reasonable to assume that this source will be utilized for irrigation in WBGS at some point of time in the future, though to what extent is unclear as even in Israel sewerage water is not as yet fully reclaimed.

Table 4 shows the supplies of water that could be imported to the WBGS through the proposed scheme, to meet the expected demand. Figures of the limited scheme are given in brackets.

2. <u>External Sources</u>

Each of the Nile, Yarmouk and Litani rivers is feasible (technically and economically) as an external source for the supply of water to the WBGS. Suitable bilateral water agreements will of course have to be negotiated with the countries involved (Egypt, Jordan, Lebanon and possibly even Syria) as the scheme involves their water rights. Some of the institutional and legal issues pertaining to the schemes are mentioned in the final section of this report.

The following is a survey of economic and engineering data relating to utilization of each of these potential sources within the framework of the project. The likelihood of agreement being obtained on the use of these different external sources is also discussed.

1) <u>The Nile</u>

a. <u>Techno-Economic Data</u>

Egypt plans to irrigate part of northern Sinai by means of a canal running the length of the coast and conveying water from a point in the Eastern

Delta up to the Gaza Strip (see Map 2). The plan calls for supplying about a billion cubic meters of water per annum. Expanding this system to supply the WBGS with 100-250 additional million cubic meters of water would lower the per unit cost of the planned system, due to economies of scale.

Furthermore, an expansion would not constitute a burden on Egyptian water resources,since:

(1) The proposed quantities are less than 0.5% of Egypt's present share of the Nile waters (55 billion cubic meters per annum);

(2) Currently, Egypt enjoys a surplus of water and is expected to continue to do so in the future. The future surplus is inter alia expected to result from improved irrigation efficiency and from Egypt's expanded share of Nile waters, which implementation of the Jonglei Canal Project (for reclamation of swampland in the Sudd area of Sudan) will produce.

Conveying water from the Nile to the Gaza Strip could be implemented directly. However, direct conveyance to the West Bank regions is not economic, except through an exchange with the Israeli water system, whereby Nile waters supply the Negev, and, in exchange, water from Lake Kinneret is supplied to the West Bank.

An exchange of this type would be cost effective since conveyance of Nile water to the Negev is cheaper than to the West Bank, and the cost of conveying water from Lake Kinneret to the West Bank is lower than supplying it to the Negev.

The transfer of water from Lake Kinneret to the West Bank will be accomplished by means of a conveyance system branching off from the Israel national pipeline system, east of the supplied consumer zones. Alternatively, water could be transferred from Lake Kinneret to the aquifer by artificial recharge near the Israel national pipeline and, in exchange, water would be supplied to the West Bank from this aquifer by drilling near the consumer zones.

The cost of Nile water in the West Bank areas is estimated at 19 cents per cubic meter.(1) A breakdown of the cost is shown in Appendix 2.

b. Political Considerations

Sale of Nile water to Israel has been considered by Egypt, and was even agreed to by President Sadat just after the Camp David agreements.

Transferring water from Egypt to the WBGS (either directly or indirectly), on the other hand, was never discussed with Egypt and may be acceptable to it if it is seen to support and aid the Palestinians and to contribute to regional peace and stability by removing a source of potential tension.

2. The Yarmouk

a. Techno-Economic Data

The Yarmouk river flows along the border between Israel and Jordan and between Jordan and Syria providing water to the three riperian countries. About ninety percent of the Yarmouk waters are allocated to Jordan, for whom the Yarmouk is the main water source. Although Jordan suffers from serious water shortages, the Yarmouk is not fully utilized by it due to the lack of storage facilities in which the river's winter floods can be retained.

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(1) See Reference (6)

There are two possibilities for storing these winter floods: either constructing a dam on the Yarmouk River, or diverting the river to Lake Kinneret where the water could be stored (see Map 3). The cost of constructing a dam on the Yarmouk is estimated at between nearly half a billion to nearly one billion dollars. This high cost is one of the reasons that impeded the implementation of any such project till now.

In contrast to the dam construction plan that would provide water at too high a cost for agricultural use, storage in Lake Kinneret would be comparatively inexpensive and water from this source could be used economically for irrigation.

The cost of a system that would divert Yarmouk waters to the Kinneret, including the necessary diversion and pumping installations as well as increasing Lake Kinneret storage capacity (from half a billion cu.m. to three-quarters of a billion) is estimated at approximately 35 million dollars. No other scheme can produce greater quantities of relatively inexpensive water than this.[1]

The storage of Yarmouk River waters in Lake Kinneret would not only provide Jordan with an additional 100 million cu.m. of water per annum (compared with the present supply of 100 million cu.m.[2]) but would also benefit Israel and the WBGS.GS

Due to the Kinneret's limited storage capability, part of the Yarmouk River water stored there would be available only in the winter (if this water is not pumped from the Kinneret in the winter, it will spill southward and will be wasted). Jordan does not have a large winter demand for the winter water but Israel and (to a lesser extent) the West bank do. T he West bank and Israel could use the winter water for urban consumption as well as for winter replenishment of aquifers. Thus, the storage of the Yarmouk waters in Lake Kinneret could provide the West Bank and Israel with large quantities of usable winter water.

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(1) See Reference (7)

(2) Not including recent utilization of the river draining aquifers.

By diverting water from the Yarmouk to Lake Kinneret, the salinity in the Lake (at present 250 mg. chlorine per liter) would be significantly reduced to the benefit of Jordan and the West Bank and Israel alike.

The Yarmouk waters stored in Lake Kinneret would be supplied to the West Bank in two ways :

(1) via the Israeli water system (to the western parts the West bank)

(2) via a system to be constructed for conveying water from the Kinneret southward (to the eastern parts of the West bank)

The costs of conveying water by these methods are shown in Appendix 2.

b. Political Considerations

Despite the official state of hostility that exists between Israel and Jordan, for many years the two countries have "agreed" on a formula for sharing or allocation of the Yarmouk waters. However, building a dam on the Yarmouk or diverting the Yarmouk to Lake Kinneret would depend on closer collaboration.

Diverting the Yarmouk to Lake Kinneret is economically feasible, and therefore could be politically viable.

Prior to the Six Day War, plans were drawn up to supply water to the Jordan Valley and the western part of the West Bank (then belonging to Jordan), from the Yarmouk River. More recent Jordanian plans do not include such options. However, Jordan's professed commitment to the inhabitants of the West bank could produce a change in attitude.

In addition Jordan has considerable economic and social incentives to implement a program for storing Yarmouk water in Lake Kinneret because at present, there is no other practical, long-range solution to Jordan's own water shortage problem. In the context of regional peace these incentives could be harnessed in support of such a scheme.

3. The Litani

a. Techno Economic Data

On average about 500 million cu.m. of water flow in the Litani River per annum. Most of this flow is used to produce electricity subsequent to its storage in the Karoun Lake and its westward diversion from the Litani Basin. The portion of winter flood waters that is not yet utilized (mainly the winter floods downstream of Lake Karoun) is planned for use in irrigation and production of electricity as part of the planned Khardale Dam Project (see Map 4).

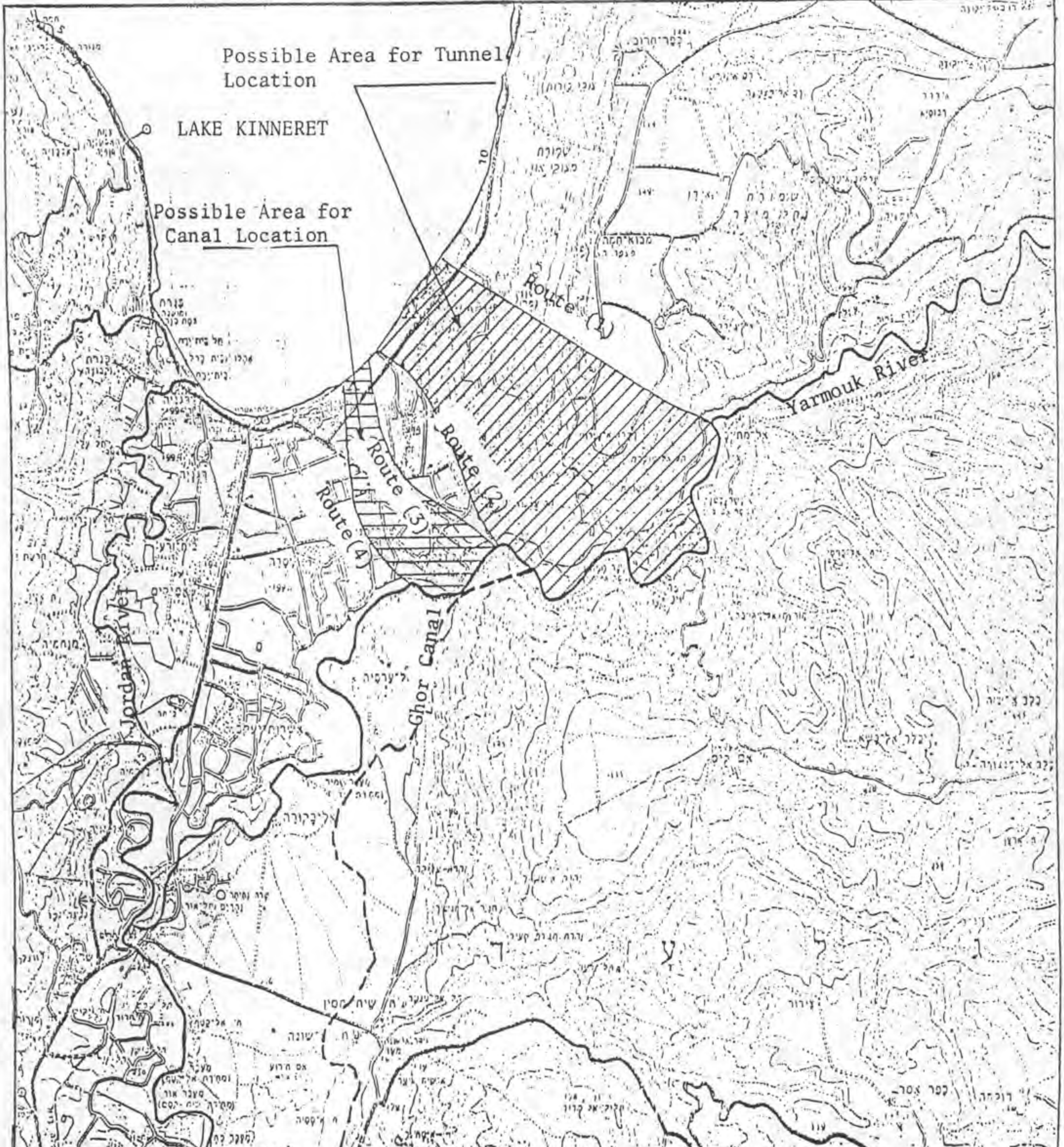
The Litani could be used by diverting part of its flow to the Hasbani River (or the Ayoun River) which flow to Lake Kinneret. From there, the water would be transferred to the West bank (as described in relation to the Yarmouk waters above).

Since full local utilization of the Litani River (by southern Lebanon) may be planned for the future, the following consideration and limitations will affect use of the Litani waters for the proposed project :

(1) The quantity of water to be used for the proposed project constitutes only a small part of the total quantity of water supplied by the river (about 15%).

(2) Special compensation should be paid for the transferred water which will significantly increase its cost.

Map 3 : Yarmouk ~~to Kinneret~~ Diversion ~~Area~~ to the Lake of Galilea



Source (7)

(3) Local (Lebanese) projects should be undertaken to produce water that would replace the water transferred under the scheme including :

- construction of the Khardali Dam and the connected water system;
- development of alternative water sources, primarily of (i) the tributaries that flow into the Litani from the south and (ii) of subterranean water which drains into aquifers north of the river.

The investment required for a system diverting water from the Litani to the Kinneret is around US$25 million.(1) This investment could be very attractive if the water was used to produce electricity.

A hydroelectric plant located on the diversion system, together with the planned Israeli Almagor plant could produce about one KWH of electricity (worth some 7 cents) for each cubic meter of water that is conveyed. It should be noted that local Lebanese production of electricity presently generates only 0.6 KWH per cu.m. water.

This power production would cover the diversion investment but still the cost of the water diverted from the Litani to the Kinneret would not be negligible due to the price of the water at its source.(2)

b. Political Considerations

The political context in which the engineering and economic data presented above should be viewed, must take into account that in Lebanon, as in Egypt, such a project may give rise to objections to exporting water, a national resource. However, payment for the water, development of local water resources and the opportunity to gain more electricity than Lebanon could produce itself by the same water(3), are desirable benefits that may encourage Lebanon to agree to such a project.

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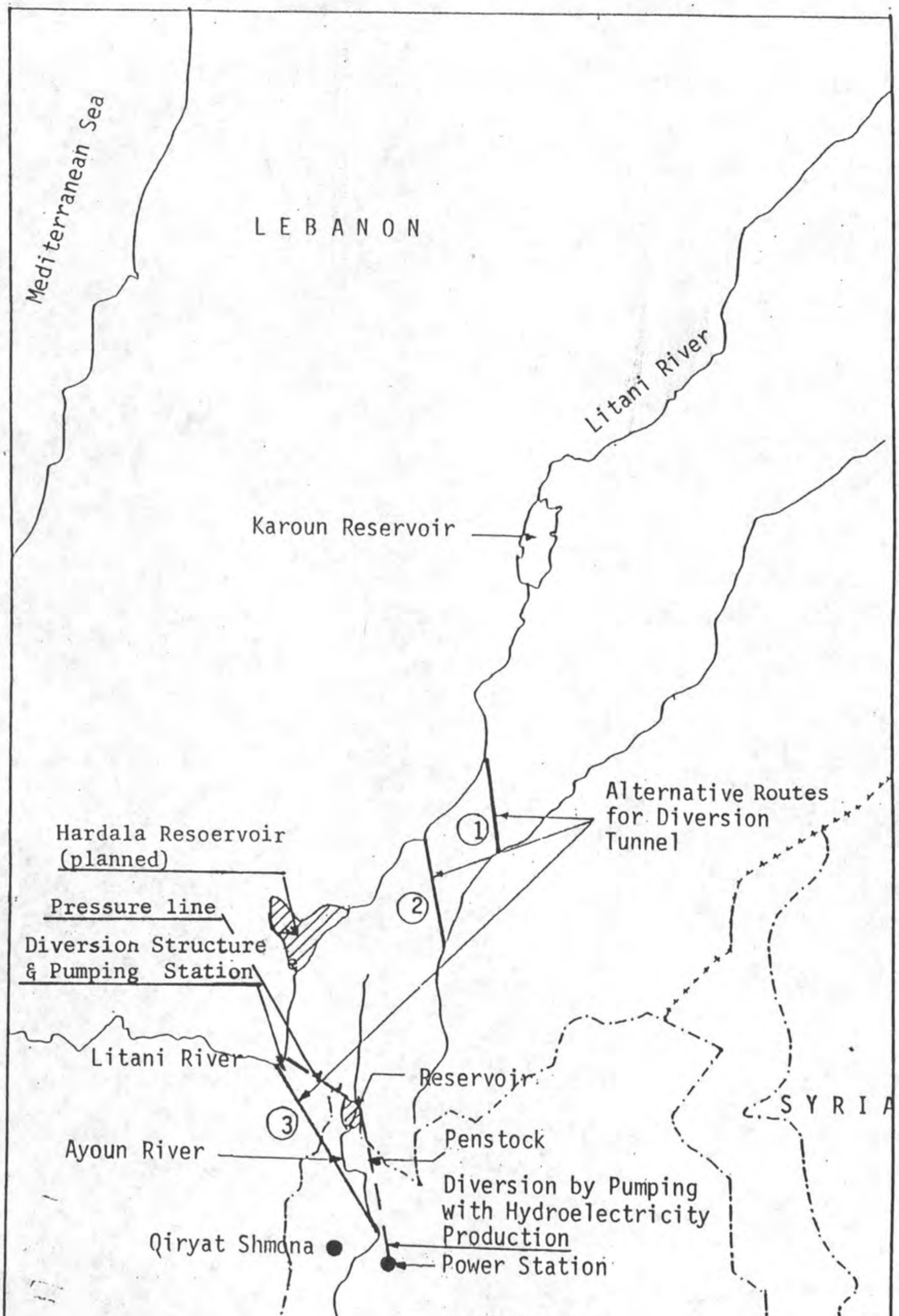
(1) See Reference (8)

(2) See Appendix 2

(3) Since Lake Kinneret is 210 meters below sea level.

Litani Diversion Sites

Map 4: Diversion of Litani Water to the Jordan River Basin~~-Possible Diversion Installations~~.



III. DESCRIPTION OF THE PROJECTS

Against the background of the water demand and supply data presented in the preceding sections, the various alternative projects will now be described in somewhat broader detail. Alternative possibilities for meeting water demands in the WBGS by making full use of available resources will also be analyzed.

Possible alternative basic schemes include the following :

(1) "An Egyptian Alternative" - using a large Egyptian supply and a smaller Lebanese supply ;

(2) "A Lebanese Alternative" - in which Lebanese water provides the major supply, supplemented by a smaller Egyptian supply.

For both alternatives two different quantative options must be considered :

(1) A larger quantity to meet all agricultural demand; and

(2) A smaller quantity to meet agricultural demand in the low-lying zones only but not in the high zones.

Tables 5 and 6 show the allocation of water associated with each of these alternatives.

A. Potential Water Supply Sources:

The components of the projects, according to source, are as follows :

1. Direct Supply from the Nile

    (1) Expansion of the Egyptian Delta-Sinai System and its adaptation for conveyance of larger quantities of water.

Map 5: Water Supply (Full Egyptian Alternative)

Source and Destination in Full Egyptian Alternative

All Areas	Gaza	Samaria	Judea	Hebron	Jericho	Destination / Source
91	91	-	-	-	-	Nile (Directly)
149	-	102	25	22	-	Nile (exchange with Israeli water system)
59	-	32	-	-	27	Yarmook
59	37	-	-	22	-	Litani
358	91	171	25	44	27	All Sources

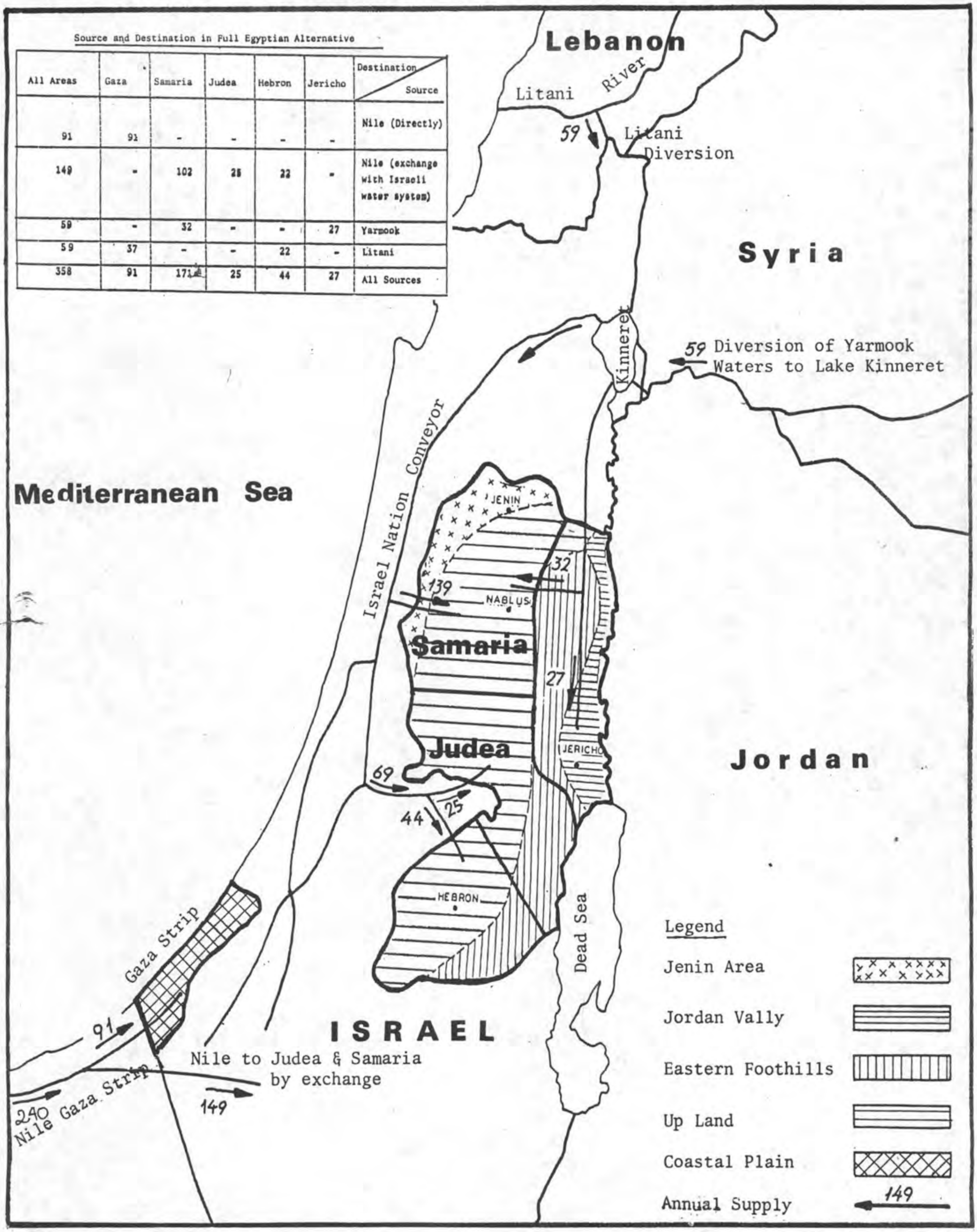


Table 6 - Source and Destination of Annual Supply Under the "Lebanese Alternative" (million cu.m./annum)

Source / Destination	Gaza Strip	Samaria	Judea	Hebron	Jordan Valley	All Areas
Nile directly(1)	91 (91)	-	-	-	-	91 (91)
Nile in exchange for Israeli water (1)	-	64 (0)	-	-	-	64 (0)
Yarmouk	-	97 (35)	-	-	-	97 (35)
Litani	-	10 (50)	25 (4)	44 (6)	27 (27)	106(2) (87)
All sources	91 (91)	171 (85)	25 (4)	44 (6)	27 (27)	358 (213)

Engineering data of the project will be based on the above format of source and destination.

(1) See section II.C.2.1 for explanation of the two types of supply systems from the Nile.

(2) This quantity reaches the consumers. An additional 25% should be obtained from the source but not reach the consumer and will be wasted due to lack of seasonal storage.

(2) Extension of the Egyptian Delta-Sinai System and construction of a conveyance system (canal) that would pass through the Gaza Strip. This alternative would provide for artificially replenishing the aquifers during the winter months.

B. Exchange Supply from the Nile

(3) Expansion of the Delta-Sinai System (as in (1))

(4) Installation of a distribution system for conveying water from the Delta-Sinai system to several central reservoirs of the Negev's water supply system.

(5) Branching off from the Israeli water system to reservoirs in the West bank.

(6) Subterranean storage installations (wells and well attachments) for storing winter water to be pumped from Lake Kinneret in order to supply the West bank in the summer.

C. The Yarmouk River

(7) Proportional share of the cost of the system diverting Yarmouk waters to Lake Kinneret.

(8) Pumping water from Lake Kinneret to the Israeli water system (includes participation in pumping installations, as well as energy consumption).

(9) Conveyance system from the Kinneret southwards, through the Western Jordan Valley.

(10) Subsystems branching out from the aforegoing system to various consumption points in the subdistrict of Jericho.

D. The Litani River

(11) Diversion from the Litani to the Ayoun River.

(12) Pumping from Lake Kinneret (as in (8)).

(13) A conveyance system from the Kinneret, southwards (as in (9)).

(14) Subsystems branching out to various consumption points in the subdistrict of Jericho (as in (10)).

The capacity of the various installations will be determined according to the peak requirements (in August). Supply in the peak month is approximately 15% of the yearly supply (an average of 5.6 cu.m. per second for every 100 million cu.m. per year in continuous operation installations).[1]

(1) Cost of these are based on data found in References (6),- (7), (8) and in Appendix 1 and Appendix 2.

IV. PROJECT INVESTMENT AND WATER COST

The investment necessary for the entire project is estimated at around $575 million. A limited, and less expensive alternative requires an investment of only $320 million (see details below).

The cost has been calculated to take account of the following :

A. Cost of the Water at Source

Water imported from Egypt and Lebanon has alternative potential uses that will be foregone and must be paid for. The estimated price is much higher in Lebanon than in Egypt, due to the higher marginal product value of agricultural water in Lebanon. Despite the fact that both countries will enjoy a water surplus for long periods into the future (when the marginal product value of the transferred water is zero) price will be calculated for the entire life of the project.

B. Energy

This has been estimated at 7 cents per KW hour.

C. Operational Costs

Estimates for each scheme or project are to be found in Appendix 2 and are summarized on the following page in Table 7.

Table 7 - Annual Supply, Investment and Water Costs of Various Parts of the Project in the "Egyptian Full Capacity Alternative"

(see Appendix 2 for source of data and detailed calculations)

Source	Destination	Gaza Strip	Samaria	Judea	Hebron	Jericho	All Areas
Nile Directly	Annual Supply (million cu.m.)	91	-	-	-	-	91.0
	Investment ($ million)	114	-	-	-	-	114.0
	Water Cost (cent/cu.m)	19.2	-	-	-	-	19.2
Nile in exchange for Israeli water	Annual Supply (million cu.m.)	-	102	25	22	-	149.0
	Investment ($ million)	-	185	56	50	-	291.0
	Water Cost (Cent/cu.m.)	-	19.5	25.1	25.4	-	21.3
Yarmouk	Annual supply (million cu.m)	-	32	-	-	27	59.0
	Investment ($ million)	-	35	-	-	50	80.0
	Water Cost (cent/cu.m)	-	17.5	-	-	14.9	16.3
Litani	Annual Supply (million cu.m.)	-	37	-	22	-	59.0
	Investment ($ million)	-	51	-	39	-	90.0
	Water Cost (cent/cu.m)	-	28.8	-	36.5	-	31.7
All Sources	Annual Supply (million cu.m)	91	171	25	44	27	358.0
	Investment ($ million)	114	266	56	89	50	575.0
	Water Cost (cent/cu.m)	19.2	21.1	25.1	30.9	14.9	21.6

The following conclusions can be drawn from Table 7:

(1) The total investment required for the entire project will be approximately $525 million.

(2) The cost of project water ranges from about 15 to 37 cents per cu.m., based on a capital cost of 5% per annum.[1]

(3) This price variation means that some of the project's schemes can supply relatively inexpensive water, suitable for use in agriculture, while the cost of other water is too high for use in irrigation.[2]

(4) If stored in Lake Kinneret, water from the Yarmouk River is relatively inexpensive. Water from the Nile River is expensive, while the most expensive water is from the Litani due to the high cost at source.

(5) The location of different consumption areas in the WBGS also influences the cost of project water. Water supplied to low lying areas (the Jordan Valley and the Gaza Strip) will be relatively cheap, while water supplied to the high areas of the West bank and in the following would be relatively expensive :

Samaria - lowest
Judea
Hebron - highest

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(1) This is based on the assumption that relatively cheap investment capital can be obtained in light of the political contribution the project could make to regional peace.

(2) Marginal product value of agricultural water is estimated at 10-20 cents/cu.m. based on Israeli agricultural data. Water costing more than 20 cents/cu.m. is here regarded as too expensive for irrigation use.

(6) The foregoing indicates that a more limited scheme providing agricultural water to low areas only is a less costly option. Under this alternative, water would be supplied to the low areas for both agricultural and non-agricultural purposes, whereas the high areas would only be supplied with water for non-agricultural consumption. In high areas only reclaimed sewage water would be used for irrigation.

(7) This is the basis of the less expensive and more limited alternative mentioned above (see Table 8) which would cost \$318 million (as opposed to \$575 million required for providing the high regions with irrigation water)[1]. The average cost of water under this less expensive alternative would be 18.9 cents per cu.m. (compared with an average of 21.6 cents per cu.m. water in the more expensive plan). Also, water supplied for agricultural purposes would cost less than 20 cents per cu.m.

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(1) The more limited and less expensive option is more flexible in terms of available external water resources (it can be carried out without the Litani or, alternatively, without supplying Nile water to the West bank It may thus also be politically more flexible.

Table 8 - Annual Supply, Investment and Water Costs of Various Parts of the Limited Project Under the Egyptian Alternative

(See Appendix 2 for data source and detailed calculations)

Source	Destination	Gaza Strip	Samaria	Judea	Hebron	Jericho	All Areas
Nile Directly	Annual supply (million cu.m.)	91					91
	Investment ($ millions)	114	-	-	-	-	114
	Water Cost (cent/cu.m.)	19.2	-	-	-	-	19.2
Nile in Exchange for Israeli Water	Annual supply (million cu.m)	-	71	4	6	-	81
	Investment ($ million)	-	129	9	3	-	141
	Water cost (cent/cu.m.)	-	19.5	25.1	25.4	-	20.2
Yarmouk	Annual Supply (million cu.m.)	-	14	-	-	27	41
	Investment ($ million)	-	13	-	-	50	63
	Water cost (cent/cu.m.)	-	17.5	-	-	14.9	15.7
All Sources	Annual Supply (million cu.m.)	91	85	4	6	27	213
	Investment ($ million)	114	142	9	3	50	318
	Water Cost (cent/cu.m.)	19.2	19.2	25.1	25.4	14.9	18.9

V. CONCLUSIONS

The WBGS areas are likely to experience water shortages in the magnitude of one-quarter to one-third billion cubic meters by the beginning of the next century. If water is not supplied from external sources, these shortages will probably give rise to the following problems :

(a) In the West bank, irrigation will have to be reduced in order to provide water for the higher-priority, non-agricultural uses such as domestic, industrial and municipal.

(b) In the Gaza Strip, shortages (with similar results) will probably materialize. These effects will be experienced sooner and with greater intensity, as current overpumping of underground aquifers will have to be curtailed and stopped.

(c) These problems could create more friction and political unrest in the WBGS. Tension over water rights could soon develop into serious conflicts that may stem from the following :

In the West bank the population has direct access to aquifers which supply the Israeli water system. In the Gaza Strip, Israel uses water (eg. from the Bsor River) which might otherwise provide water to the Gaza Strip.

Technically, it is possible to supply water to the WBGS from external sources, such as the Nile, Yarmouk and Litani rivers. Schemes utilizing such waters would be advantageous to both the WBGS and Israel.

Implementation of the proposed water transfer projects depend on reaching a political solution to the problems of the WBGS - acceptable to all parties involved - since implementation is possible only in the context of regional peace. Although such an agreement is a prerequisite to the proposed projects, once implemented, the project itself could act as a strengthening and stabilizing force supporting the agreement.

Each external water source proposed for the project is subject to certain limitations - in terms of availability, cost, and political feasibility. Water from the Litani River is limited in quantity and is relatively expensive due to its potential alternative uses. Water from the Yarmouk River is relatively inexpensive - but is limited in quantity. Water from the Nile carries a medium cost and is practically unlimited, in physical terms, but political objections may limit its availability for the project purposes.

The cost of transferring water from external sources depends also on the geographic features of the consuming areas in question. Conveying water to high areas (in the regions of Nablus, Bethlehem, Ramallah and Hebron) will be too costly for agricultural purposes. In the low-lying areas (the regions of Jericho and the Gaza Strip), however, the transferred water for use in agriculture is likely to be cost-effective.

In view of these factors, it is possible to consider (and implement) alternatives with various technical and economic characteristics. Out of these, two possibilities were reviewed in detail :

(1) Supplying water to meet all demand (a supply of 358 million cu.m. at an investment cost of $575 million).

(2) Water for irrigation purposes would not be supplied to the high zones (those would utilize only reclaimed sewage water

for agriculture). Irrigation water would be supplied to the following zones only : The Jordan Valley, the Gaza Strip and the low regions of the subdistricts Jenin, Tulkarem and Nablus (213 million cu.m/annum at an investment cost of $318 million).

Alternative two would provide a less expensive solution while allowing for greater flexibility in the selection of external water sources. This alternative could be implemented by substituting various sources. For instance, water from the Litani River could be used instead of importing water from the Nile (the "Lebanese alternative") or water would not be imported from the Litani (the 'Egyptian alternative").

Principle allocations of water for three alternatives are shown in Table 9.

Table 9 - Balance of Source and Destination Under Different Alternatives

(million cu.m. per annum)

Source	Destination Alternative	Gaza Strip	Samaria (subdistricts of Jenin, Nablus and Tulkarem)	Judea (Subdistricts of Ramallah & Bethlehem)	Subdistrict of Hebron	Subdistrict of Jericho	All Areas
Nile	Full Supply	91	102	25	22	-	240
	Low Supply (Lebanese Alternative)	91	-	-	-	-	91
	Low Supply (Egyptian Alternative)	91	71	4	6	-	172
Yarmouk	Full Supply	-	32	-	-	27	59
	Low Supply (Lebanese Alternative)	-	35	-	-	-	35
	Low Supply (Egyptian Alternative)	-	14	-	-	14	41
Litani	Full Supply	-	37	-	22	-	59
	Low Supply (Lebanese Alternative)	-	50	4	6	27	87
	Low Supply	-	-	-	-	-	-
All Sources	Full Supply	91	171	25	44	27	358
	Low Supply (Lebanese Alternative)	91	85	4	6	27	213
	Low Supply (Egyptian Alternative)	91	85	4	6	27	213

VI. LEGAL AND INSTITUTIONAL ASPECTS

The various schemes described in this paper can be undertaken in combination (as part of a package forming an integral part of an overall regional peace plan) or they could be undertaken separately and independently as peaceful and closer relations with different countries permit.

Clearly, each scheme or project raises distinct legal as well as institutional and operational issues. A brief description of some of the major issues involved in each of these schemes follows.

A. YARMOUK

The Yarmouk scheme requires, as a precondition, a trilateral agreement or understanding (concerning water allocation and utilization rights) between the three riperian states, namely Jordan, Syria and Israel. In the very least and assuming Jordan and Israel can reach agreement on such a scheme inter se before Syria is also willing to similarly commit itself, Syria's acquiescence thereto will have to be secured. The scheme (once such a trilateral consensus is in place) could be executed as a binational (Jordanian-Israeli) project based on joint ownership and management. In such a case, the allocation of the costs of the project and the revenues derived therefrom (from sale of water to the various consumers) as well as of the respective operational responsibilities between the two parties would have to be worked out in advance. While such a possibility (based on a joint venture model) with both governments directly or by means of appropriate instrumentalities acting as the principals of the enterprise is a theoretical possibility, it is doubtful whether (in light of the inherent difficulties involved in implementation) it is a practical probability. The more likely alternative would be to proceed along the route of two separate (Jordanian and Israeli) sub-projects, with each side assuming responsibility for the part of the project located on its own territory, and with machinery for very close technical and operational cooperation and coordination between them. Assuming that external finance would be required for each of the sub-projects, the loans would be severally raised and guaranteed by Jordan and Israel respectively, though joint guarantees of both governments for both sub-projects could be considered a means of demonstrating a stronger commitment to the entire concept by the two parties. In any event, the terms of the Indus Basin (Indian and Pakistani) sub-projects could perhaps serve, mutatis mutandis, as a model for this as well as for the other schemes considered.

B. LITANI

The Litani project can probably (from a strictly legal point of view) be undertaken without any agreement on water rights being concluded between any of the parties. Lebanon could simply agree to sell water to Israel while Israel agrees to purchase it and/or sell electricity to Lebanon, and/or provide compensating amounts of water to the WBGS and/or to Jordan. A formal contractual link with Jordan could, but need not, be established. If such a link were desirable, it could be done as part of a trilateral agreement, or on the basis of two bilateral (Lebanon-Israel, on the one hand and Jordan-Israel, on the other) agreements . Formal Jordanian linkage (under either alternative) presumes harmonious relations between Jordan and Lebanon. Serious friction between those two countries at a future date though not, ex hypothesi, between Israel and either could generate complications that might not necessarily arise if Jordan were not to become a formal part to any Lebanese-Israeli agreement.

On the other hand, formal Jordanian linkage may have little bearing on this question, execution could be based on a single binational (or, if Jordanian participation were desirable, even trinational) project entity (based on a joint venture model) or on the more likely basis of two or three separate sub-projects (each being the responsibility of an instrumentality of a single sovereign government) with close coordinating machinery. As in the case of the Yarmouk scheme, the sub-project route probably raises fair less implementation problems. The Litani scheme may or may not be combined with the construction of the Khardela dam, though technically the construction of the dam would probably increase the benefits of the project.

c. NILE

The Nile project is (legally and institutionally) similar to the Litani project, and, in addition, enjoys greater physical security (in light of the absence of any other geographically-proximate and potentially hostile state such as Syria maintains in respect to the Litani). WBGS or Jordanian dependence on the Litani project exposes them to risks resulting from tension between Lebanon and Israel, while dependence on the Nile project exposes them to risks resulting from tension between Egypt and Israel. In either case, therefore, WBGS and/or Jordan's interest are to mitigate any such tensions.

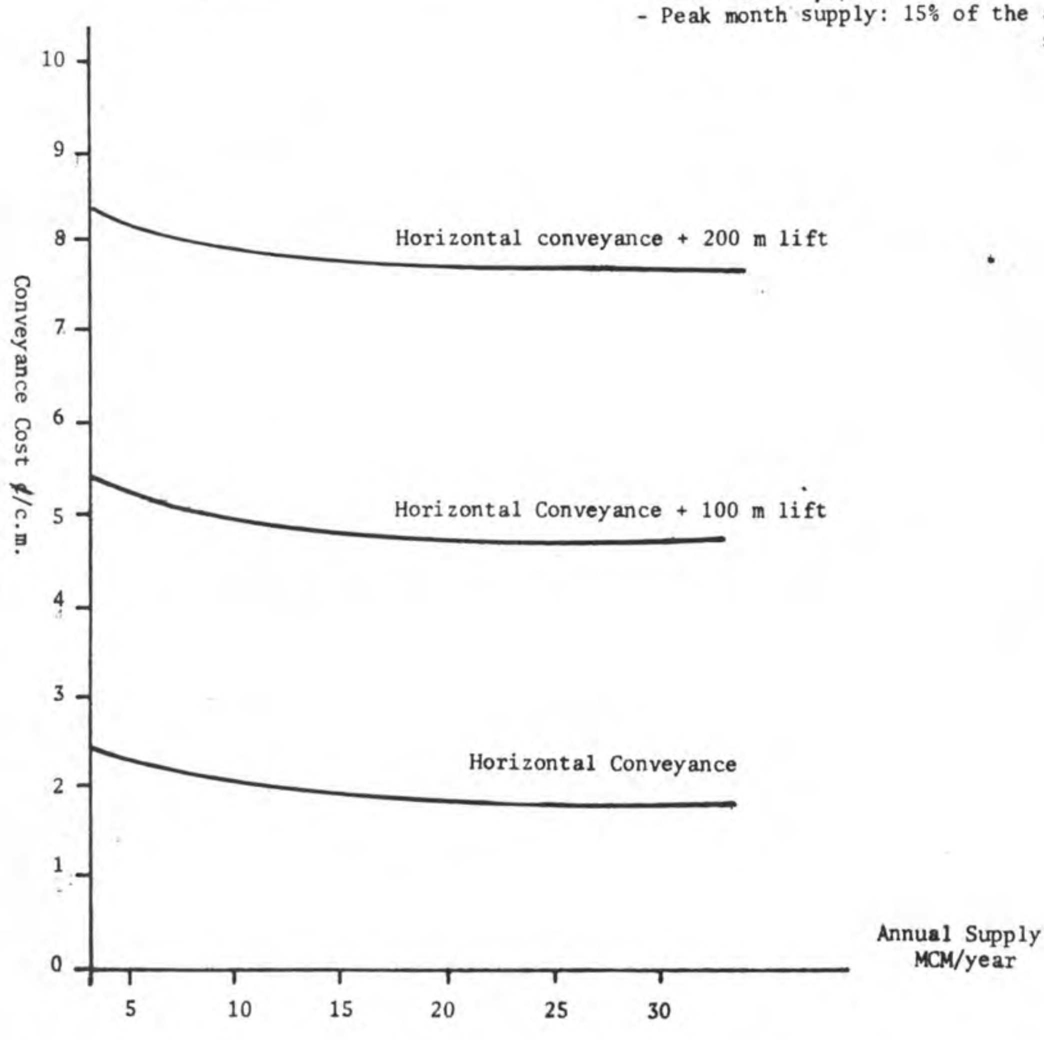
While all schemes are designed to provide water not only to the WBGS but also to Israel and possibly Jordan there are no technical (as opposed to, for example, political) reasons why the several schemes cannot be implemented, irrespective of the final international status of the WBGS. Clearly the detailed arrangements must be worked out between the different parties and must also be satisfactory to third parties (who would most probably be required to provide support and concessional financing for implementing them). However, it is thought that given the mutual benefits to be derived from each of the different schemes described, if a will could be found to move ahead so could a way. In other words, there are no insurmountable legal or technical obstacles.

APPENDIX I

Costs of Water Conveyance in Pressure Pipeline,
10 K.M. Range, 1983 Prices

Based on:

- Capital payment: 5% per year (1)
- 36" Diam. pipeline cost: $0.3M/K.M.
- Pumping Station Cost: $1200/KW
- Power Cost: ¢7/KWh
- Peak month supply: 15% of the annual supply



(1) 5% of the capital as annual payment coincides with a Capital Recovery Factor of about 4% over a 40 year period. Capital costs are based on the assumption that low cost financing will be available.

APPENDIX 2

Investment and Water Cost of Various Parts of the Project

(does not include internal network for consumer water allocation) the Egyptian Alternative.

Water Cost Cent/cu.m.	Operation and Maintenance (includes purification) (Cent/cu.m.)	Cost of water at Source (cent/cu.m.)	Energy component in price of water (cent/m)	Investment[2] component in the cost of water (cent/cu.m)	Investment ($ million)	Average supply at peak months (cu.m/sec)	Annual supply (millions cu.m.)	Subject and Details
19.2					119.0	5.5	95	1) Nile Water Supply Directly to Gaza Strip
13.2	1.0	4.0	4.2	4.0	76.0 (1)			1.1 Expansion of Egyptian System
6.0	2.5	-	1.0	2.5	43.0			1.2 Installation of Conveyance system to Gaza Strip (including purification)
19.5					190.6	6.0	105	2) Nile Water Exchange Supply to Samaria (1)
13.2	1.0	4.0	4.2	4.0	84.0			2.1 Expansion of Egyptian System
8.0	2.5	-	3.0	2.5	52.0			2.2 Installation of Conveyance system to the Negev(including purification)
-7.5	-0.5	-	-7.0					2.3 Pumping from the Kinneret in the Israel Water system
5.8	1.0	-	2.2	2.6	54.6			2.4 Supply Systems from the National System to
25.1					58.0	1.5	26	3) Nile Water Exchange Supply to Judea (1)
13.2	1.0	4.0	4.2	4.0	20.8			3.1 Expansion of Egyptian System
8.0	2.5	-	3.0	2.5	13.0			3.2 Installation of Conveyance System to the Negev (including purification)
-9.7	-0.6	-	-9.1	-	-			3.3 Pumping from the Kinneret
13.6	1.2	-	7.7	4.7	24.2			3.4 Supply systems from the National System to Judea
25.4					54.8	1.4	24	4) Nile Water Exchange Supply to Hebron
13.2	1.0	4.0	4.2	4.0	19.2			4.1 Expansion of Egyptian System
8.0	2.5	-	3.0	2.5	12.0			4.2 Installation of Conveyance System to the Negev (including purification)
11.2	-0.7	-	-10.5	-	-			4.3 Pumping from the Kinneret
15.4	1.4	-	9.1	4.9	23.6			4.4 Supply systems from the National System to Hebron
14.9					49.9	1.5	27	5) Supplying Water from the Yarmouk to the Subdistrict of Jericho
1.1	0.1	-	-	1.0	3.8			5.1 Participation in diverting the Yarmouk to the Kinneret
0.1	-	-	-	0.1	0.3			5.2 Participation in increasing storage capacity of Kinneret
13.7	1.0	-	4.3	8.4	45.8			5.3 Water Division System
17.5					30.9	1.9	33	6) Supplying Water from the Yarmouk to Samaria
1.4	0.2	-	-	1.2	4.6			6.1 Participation in diverting Yarmouk to the Kinneret
0.1	-	-	-	0.1	0.3			6.2 Participation in increasing storage capacity of Kinneret
8.0	0.2	-	7.0	0.8	5.4			6.3 Pumping from the Kinneret
2.2	0.2	-	1.5	0.5	3.4			6.4 Underground storage of winter water
5.8	1.0	-	2.2	2.6	17.2			6.5 Supply System from Israeli pipeline to Samaria
28.8					51.7	2.2	38	7) Supplying Water from the Litani to Samaria
18.3	1.0	14.2(5)	-	3.1	16.7			7.1 Installation to divert water from Yarmouk to Ayoun (5)
-5.6	0.5	-	-7.0	0.9	4.7			7.2 Electricity production in diversion system
0.2	-	-	-	0.2	0.4			7.3 Participation in increasing storage capacity of Kinneret
7.9	0.1	-	7.0	0.8	6.2			7.4 Pumping from the Kinneret
2.2	0.2	-	1.5	0.5	3.9			7.5 Underground storage of winter water
5.8	1.0	-	2.2	2.6	19.8			7.6 Supply System from Israel pipeline to Samaria
36.5					40.6	1.3	23	8) Supplying water from the Litani to Judea
18.3	1.0	14.2	-	3.1	10.1			8.1 Installation to divert water from the Litani to Ayoun
-5.6	0.5	-	-7.0	0.9	2.9			8.2 Electricity Production in diversion system
0.1	-	-	-	0.1	0.2			8.3 Participation in increasing storage capacity of Kinneret
7.9	0.1	-	7.0	0.8	3.7			8.4 Pumping from the Kinneret
2.2	0.2	-	1.5	0.5	2.3			8.5 Underground storage of winter waters
13.6	1.2	-	7.7	4.7	21.4			8.6 Supply System from Israel's pipeline to Judea.
					595.5	21.3	371	TOTAL

(1) Investment estimated according to reference 6
(2) Investment component calculated according to 5% payment on investment per annum
(3) Investment component in pumping from the Kinneret signifies proportional participation in the cost of pumping station
(4) Due to publication 7
(5) Due to publication 8
(6) This figure accounts for 25% of the water which will be lost in winter storage in the Kinneret
(7) Including electricity produced in the "Almagor" plant which is to be constructed Northof the Kinneret
(8) Under the assumption that only two thirds of the water can be stored underground(the rest will be supplied direct)

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