CONFIDENTIAL

The Ministry for Foreign Affairs has the honour to acknowledge the receipt of the Aide Memoire of the American Embassy dated 13 April 1954 concerning "The Unified Development of the Water Resources of the Jordan Valley Region".

The Ministry encloses herewith, for the study of the United States' Government, observations of a technical nature prepared by experts of the Government of Israel.

At the same time these observations must not be deemed to reflect any definitive position at this stage on the part of the Government of Israel to the essential problems raised by the Unified Development Scheme.

Jerusalem , 3 May 1954.

The Embassy of the United States,
Israel.

INTRODUCTION AND SUMMARY

A. INTRODUCTION

1. Present Status of Irrigation Development in Israel

Israel is importing half of the food required to feed its population; the country could become self-supporting, as far as ~~x~~ food is concerned, if an area of about 1 dunam was irrigated per head of population. Though irrigation has almost tripled since the establishment of the State of Israel - we are now irrigating more than 700,000 dunams as against 230,000 dunams in 1948 - we still have not reached even the half-way mark, and at least 1,000,000 dunams additional irrigation has to be developed within the next seventeight years at the rate of about 150,000 dunams per annum. This large-scale irrigation program necessitates the full-scale utilisation of all available local water resources.

2. The Negev

The Negev, the semi-arid to arid area comprising the southern half of Israel, contains more than one-third of the country's irrigable lands. The irrigation of the potentially fertile expanses of the Negev is an indispensable part of Israel's short-term irrigation program, since, without the Negev, Israel cannot become self-supporting in its food supply.

B. SUMMARY OF CRITICAL SURVEY ON CHAS. T. MAIN REPORT

1. The report is a desk study. It is based on data which, at least in the case of Israel, has not been brought up to-date.

2. After analysing the engineering aspects of the report, we have come to the conclusion that the engineering argumentation cannot be justified if we approach the matter from a purely technical point of view.

3. The principal doctrine made use of to support the suggested allocation of water (e.g. exclusive within-basin use of water, exclusive use of gravity flow, exclusive use of within-basin storage sites, etc.) have generally been discarded in favour of newer concepts.

4. The limitations imposed by these doctrines resulted in the non-utilization of important quantities of water which could reasonably be included within the scheme.

5. The high water consumption assumed by Chas. T. Main, especially in the Jordan Valley and the Yarmuk Plateau, appears to be extravagant and wasteful.

6. The project leaves only about one quarter of the river flow of the basin for use in Israel; a quantity so small as to be utterly out of proportion to any reasonable minimum to be allocated to Israel.

7. Sparing application of river water in the Jordan Valley, in conjunction with the fullest possible utilization of local flood, spring and underground water, would benefit future hydro-power generation within the framework of a Mediterranean - Dead Sea.

Power Project based on the diversion of the Mediterranean sea water into the Dead Sea. The water use pattern implied in the Chas. T. Main Report will have an opposite effect.

8. Part of the flow of the Litani river, having no irrigation outlet within the Lebanese Republic will, if diverted into the Jordan basin, initially generate important quantities of cheap hydro-power, while it could ultimately be diverted for irrigation if sea water would eventually replace sweet water in the hydro-electric plants in the area.

9. The hydro-power schemes comprised in the report do not include some most attractive projects. This applies especially to the Lake Tiberias power project now under construction in Israel. This last-mentioned project fits, incidentally, perfectly into the project lay-out of the Chas. T. Main Report.

CHAPTER I
THE "MAIN REPORT"

FROM THE ENGINEERING POINT OF VIEW

1. Introduction

The report on the "Unified Development of the Water Resources of the Jordan Valley Region", which is discussed on the following pages, was prepared under the direction of the Tennessee Valley Authority, upon the request of the U.N. Relief and Works Agency for Palestine Refugees in the Near East. The U.N. Relief and Works Agency - in the following abreviated to U.N.R.W.A. - felt the need to review all the proposals, which had previously been prepared by various agencies, on the utilization

of the water resources of the Jordan Valley Region, before committing itself to a project, having the main objective of making possible the establishment of Palestinian refugees in the newly irrigated areas. The T.V.A. - a regional organization set up by the United States Government for flood control, the utilization of hydro-electric power and general industrial and agricultural development of the Tennessee Valley - was approached by U.N.R.W.A. with the request to prepare such a survey and to indicate the most efficient way for utilizing the water resources of the Jordan Valley.

Without in any way belittling the spectacular achievements of the T.V.A. the suggestion is ventured that the conditions in the area under consideration are so far dissimilar from those in the Tennessee Valley that other organizations concerned with problems more closely resembling those in this area - e.g. those concerned with irrigation schemes in the arid areas of the Western States - might well have been preferred. In fact it appears that under the imprimatur of the T.V.A. the working out of the present report was entrusted to a private engineering firm, i.e. Chas. T. Main Inc. of Boston Mass. (in the following referred to as consultant), specializing mainly in power and industrial engineering.

The report discussed here (in the following called the Report) is the outcome of an office study made by the engineering firm of Charles T. Main, Inc., and submitted by Mr. Gordon R. Clapp, chairman of the Board of the T.V.A.,to the U.N.R.W.A.

2. Terms of Reference

Describing the terms of reference for the Report, Mr. L.J. Carver, Acting Director of U.N.R.W.A., said in his introductory Note:

> "It was found upon examination that no comprehensive survey of all the various proposals had been previously prepared; the director therefore decided, with the concurrence of the Advisory Commission, to place the responsibility for such an investigation in the hands of the T.V.A. ... The director also took steps to have studied the legal issues involved in the development of this international river.... the T.V.A. was invited to disregard political boundaries, and to prepare a report indicating the most efficient method of utilising the whole of the watershed in the best interests of the area."

In addition it is pointed out by Mr. Clapp, Chairman of the Board of T.V.A., that:

> "The assignment of the water to the various areas as listed in this Report is in no sense intended as an allocation of water".

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According to these terms of reference, the UNRWA Report contains no suggestions and no data on the legal issues, connected with a ~~ma~~ unified utilization of the Jordan Basin Resources. The Report contains, however, definite proposals for the utilization of the water resources of the Basin.

Keeping in mind the t erms of reference to indicate "the most efficient method of utilizing the whole of the watershed in the best interests of the area" and interpreting the term "area" to include the whole area of the countries participating in the Jordan watershed, a criterion must be established for the evaluation of the advantages and disadvantages of the use of water in the various possible water schemes.

The foremost criterion which, in our opinion should be applied to an area like the Jordan Valley Region, where water resources are the limiting factor of agricultural development, is the volume of the crop which can be produced, at a cost which stays within the purchasing power of the population. It is felt that the vol me of the crop, rather than the expenditure for water per unit of area, should within reasonable limits, be decisive, as in relatively undeveloped countries, like the Jordan Valley Region, a slightly higher price of water would imply only a slight shift towards low-priced crops, while the lowering of the volume of production would - unless the country is supported from abroad - involve a radical reduction in the diet.

It is undoubtedly more economical and more beneficial to the region as a whole to irrigate by gravity with the high-elevation Jordan water extra-basin areas adjoining the Basin in Israel, than to use 2-3 times as much water per unit of land in the Lower Jordan Valley; so much more so when no use is made of the power potential of the Upper Jordan, as proposed in the Report.

3. The Basic Data

The U.N.R.W.A. Report is an engineering office-study prepared from written material, maps, etc., made available to the Consultant. It is understood that neither field investigations nor even a preliminary field reconnaissance were undertaken. The various organizations and consulting engineers who had, in the past, cooperated in the drawing up of water plans in this region, were apparently not consulted. The Consultant had, therefore, to ~~ma~~ rely completely on the data ~~ma~~ contained in the material

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placed at his disposal. The publications on the development of Hashemite Jordan, which were made available to the Consultant, included the latest reports, maps and project data, while the material used on the development of Israel included only data published until the end of 1945 (item 4 on the Report's reference list, "T.V.A. on Jordan" by J.B. Hays, is a summarized reprint of reports published mainly in 1945).

It is to be observed that since 1948 extensive basic investigations, planning work and numerous project suggestions have been prepared in Israel under the direction of notable U.S. engineering consultants, by an extensive engineering staff in Israel after 1948, and a number of detailed reports are available.

The maps on Israel (Palestine) used by the Consultant, are all based on 1:50,000 surveys, and their topographical details are, according to our experience, inadequate, even for general planning work and preliminary cost estimates. This has a bearing on the actual length of the proposes conduits - actual lengths are about 20 p/c. higher than lengths scaled from small-scale maps. Consequently estimates of conduits included in the Report do not, in our opinion, reflect actual costs.

The material available to the Consultant on soil classification seems to have been equally inadequate. The conclusions arrived at on the use of lands are not always reconcilable with established facts.

It also seems that data available to the Consultant on ground water, salinity, relative crop expectancy, alkalinity of soils, water requirements and availability of storage capacity in Israel, was insufficient. This is reflected in various discrepancies between facts and conclusions appearing in the Report and actual observations made in Israel during the last few years.

4. Synopsis of Main Project Features

The project submitted to the U.N.R.W.A. includes three major diversions:

1) The Upper Jordan Diversion including the canal Banias river - Galilee hills, as its principal feature. The objective of the diversion is to supply 284.0 million m^3 per annum for the irrigation of the Upper Hula region, the Ayeleth Hashahar area, the Lower Galilee, the Yavneel Valley and the Afuleh-Beit Alfa area. Generation of about 76 million Kwh per year, by developing the head available between proposed storage reservoir on the Hasbani river and the level of the main canal

is an incidental feature of this part of the project. It should be borne in mind that, although the canal starts at elevation above 180 m., the largest portion of the area irrigated is in the low valleys and does not require such a high head (Upper Hula, part of the Lower Galilee and the major portion of the Afuleh-Beit Alfa area). The use of this high level water for relatively low lying areas, without integrated utilization of power, is a major engineering disadvantage of this proposed diversion. Since this diversion includes no storage features, except the Hasbani reservoir in Lebanon, the flow in the conduit will have to be limited to the irrigation season, and utilization confined to the summer flow of the river. The assumed lack of adequate storage sites for this diversion is claimed to be the limiting feature of this diversion.

ii) The lower Jordan Diversions

The remainder of the flow of the Jordan river tributaries and the flow accruing between Lake Hula and Lake Tiberias, will continue to flow in the natural river bed into Lake Tiberias. Here, again, large quantities of water, flowing at relatively high elevations, are discharged into Lake Tiberias, leaving a large block of potential hydro-power unutilized. This is a serious flaw in the proposed Project. Two major diversions issue from the southern end of Lake Tiberias: The Western Ghor Canal and the Eastern Feeder Canal. These two diversions are fed from the flow of Jordan water into Lake Tiberias and from the diversion of the Yarmuk river, through the Yarmuk diversion canal, into Lake Tiberias. The Western Ghor Canal runs parallel to the river on the western slopes of the Valley. The Eastern Ghor Feeder Canal discharges into the Eastern Ghor Canal.

iii) The Yarmuk Diversion

The Project proposes to construct a reservoir on the upper reaches of the Yarmuk river for partial regulation of the flow and power utilization. The head available between this reservoir and the Eastern Ghor Canal is used for power generation (38,000 Kw capacity, 134 million Kwh per annum.) The Upper Canal connects the Yarmuk reservoir with the power plant. The Eastern Ghor Canal issues from the tailrace of the power plant and continues on the eastern slopes of the Valley

... to the Jordan river. The two Ghor Canals irrigate the Ghor, on both sides of the river, between Lake Tiberias and the Dead Sea. The Project proposes to use Lake Tiberias for seasonal and carry-over storage with a storage capacity of around 830 million m^3. The smaller reservoir on the Upper Yarmuk will be used mainly for power regulation. According to the Report, the total available storage capacity is not sufficient to regulate the whole flow of both the Jordan and Yarmuk rivers, and an allowance of 150 million m^3 per annum had, therefore, to be made for losses deriving from flood flows which cannot be stored on a long-term basis.
The Project also deals, though in very general terms, with the utilization of perennial and flood flows from the wadis and the use of pumped water from wells; these water resources are proposed mainly for use for irrigation in the Ghor. Since the proposals are on very general lines, and no details are given as to how the various flows will be regulated for actual irrigation utilization, it is impossible to comment on this phase of the Project. The Project is based on a total watershed yield of 1213 million cubic metres per annum, including 831 million cubic metres per annum riverflow and 382 million cubic metres per annum wadi and well flow. The allocation to Israel is 394 million cubic metres per and that to Hashemite Jordan 774 million cubic metres while Syria has been allotted 45 million cubic metres.

5. Implied Planning Premises

A study of the Report shows that the proposed Unified Utilization of the Jordan Valley Region Water Resources has been based, in addition to the explicit terms of reference, on three underlying principles which appear to have been taken for granted. These principles are:

(a) Irrigation to be confined only to lands within the hydrographic boundaries of the Jordan river basin;

(b) Exclusive use of gravity flow and avoidance of any pumping, except for purely local purposes;

(c) Non-availability of storage capacity at gravity control of the water resources of the proposed Upper Jordan Diversion.

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The following pages contain an analysis of these three major premises of the U.N.R.W.A. Report.

(a) Within-basin Development vs. Extra-basin Development

The Report assumes the exclusive use of the water resources of the Jordan Valley on lands lying within the hydrographic boundaries of the basin as a definite principle. It appears to us that it is incumbent upon the planner to prove in every specific case the advantages of within-basin development as compared with combined within-basin and extra-basin development.

Numerous cases are known where extra-basin development has proved more economical and more feasible than within-basin development. Many of these prijects are located in the western part of the U.S.A. To mention but one of the more spectacular examples; The extra-basin use of a considerable portion of the flow of the Colorado river, although within-basin use could be found for most of the basin's water. The Report of the Bureau of Reclamation on the Colorado river of March 1946, says on page 13:

> "Although there would be enough water in the river system for all of the 134 within-basin projects or units of projects, if no further exportation of water is made, it may b e f o u n d m o r e e c o n o m i c a l, and the States may elect to forego consideration of some irrigation projects within the internal drainage basin, in order to make water available for exportation to adjacent watersheds within the basin states."

The major extra-basin projects using water exported from the Colorado river basin are the All-American Canal and its laterals, the Colorado River Aqueduct of the Metropolitan Water District of Southern California, the Colorado - Big Thompson Project; etc. etc.

The realistic term "basin state", contained in the above quotation, and including the total area of all states participating in a certain watershed, should, in our opinion, replace the purely hydrographic term of river basin used in the Report.

In our case the Report gives two specific advantages for within-basin development as compared to extra-basin development in the Jordan Valley:

(i) The higher fertility of the soil in the Jordan Valley as compared with that of the adjoining areas;

(ii) The lower cost of water in the Jordan Valley.

We shall later analyse these two claims in greater detail.

The Report does not refer to the connection between the use of water within the Jordan basin and the ultimate power generation capacity of a Mediterranean Dead Sea hydropower project. The power capacity of this project would be proportional to the quantity of water actually withdrawn from the basin. With the high water duty prevailing in this area, a considerable percentage - which may be conservatively estimated to be between ⅓ to 1/3 of the quantity of water diverted - will revert to the river as return flow, and proportionally decrease the power potential of the system. Hence, it appears that, by using part of the basin water outside the boundaries of the basin and thus reducing return flow to the Jordan river and the Dead Sea, the ultimate power potential of the power project can be considerably increased. Assuming a return flow of about 1/3 every cubic metre used outside the basin would increase the power capacity of the hydro-electric project by ⅔ of Kwh as compared to within-basin use. Taking this into consideration, a relatively high pumping lift would still be admissible for extra-basin development without influencing the ultimate power balance of the whole development.

(b) Gravity Flow vs. Pumping

Here, again, no generalization can hold true for all cases. The choice between pumping and gravity flow is a question of engineering economics and not one of principle; in every individual case, a proper quantitative comparison has to be made before arriving at conclusions.

Pumping solutions have often been preferred, in large-scale [illegible] developments, to pure gravity solutions. As an example, we refer, again, to a large-scale project fed from the Colorado watershed: the Colorado River Aqueduct of the Metropolitan Water District of Southern California, where, after a careful examination of all 2333 possible alternative projects, a high-lift pumping solution was found to be the most economical one - this solution was actually executed.

On page 41, the Report says:

> "It is well recognized that a gravity system of water distribution is preferable to a system requiring extensive pumping. The initial cost of construction is usually lower and the heavy continuing, operating and maintaining costs are avoided. It also makes unnecessary the employment of highly trained technical staff which any large pumping system would require."

In irrigation systems of the scope considered here, the inclusion of occasional pumping installations would constitute only an insignificant portion of the total capital cost of the Project: the staff required to operate and maintain a modern automatic pumping plant, even of large size, is extremely small. As to operating and maintaining cost of pumping systems, the power cost is by far the foremost contributing factor.

Without going, at this stage, into greater detail, it seems feasible and economical to utilize the hydro-power potential of the water resources of the Jordan Valley to a higher extent than indicated in the Report. Power thus generated could be used for pumping elsewhere, without affecting significantly either the investment required or the operation cost of the Project. It might, in certain cases, be also defendable to use for pumping, in excess of this hydro-power, power drawn from external sources, if a better use of the water resources/ of the basin can thus be achieved.

(c) Non-availability of Storage

The Report states on page 26:

> "The part of the available water which could be used at Jisr Benot Yaacov would depend upon the amount of storage which could be developed to regulate the variable runoff";

the Report goes on to say:

> "No good sites are available within the gravity reach";

and, again, on page 41:

> "In the Upper Valley, the amount of water which could be diverted from the rivers to serve the high country by gravity is limited by the lack of suitable sites for storage".

and later on:

> "If storage facilities were provided in the hills, some of the winter flows could also be diverted and stored for later use. Greater amounts of the summer flows could be obtained by pumping from remaining sources of supply found at a lower elevation".

From the above quotations it appears that the major limiting factor of the volume of the Upper Diversion was an assumed lack of storage sites within gravity reach of this Diversion. It is surprising that consideration was not given in the Report to the well-known Sahl Battauf reservoir site, which has an ultimate potential capacity of more than 1,000 million m^3, and the numerous smaller reservoir sites in the foothill area of the Mediterranean watershed, having individual capacities ranging between 20 and 170 million m^3. Many of those reservoir sites have been investigated in detail and found feasible from the engineering ~~xx~~ point of view. Construction has lately been started on a

number of minor reservoirs. Sahl Battauf and a number of other reservoirs are within gravity reach of the Upper Diversion proposed in the Project.

It would, therefore, appear that the conclusion arrived at regarding storage facilities for the Upper Diversion may have been based on insufficient data. The only other possible motivation for the non-consideration of storage facilities in the hills and foothill area can be the orthodox and over-rigid adherence to the within-basin principle . But, surely, adherence to the within basin principle should not constitute the sole engineering motivation in determining such basic conclusions as the relative potential size of the Upper and Lower Diversions.

(d) Summary

Summarizing our comments on the three major premises on which the Project was based, it appears that these premises are generalizations which do not hold true under conditions prevailing within the Project area. In the following, we shall, therefore, not take these premises for granted a priori, but re-evaluate, in every individual case, the merits of extra-basin as against within-basin utilizations, Lake Tiberias storage as against hill storage; and exclusive gravity flow as against a combination of gravity flow, hydro-power development and pumping.

CHAPTER II

PRINCIPAL ENGINEERING, AGRICULTURAL AND ECONOMIC ADVANTAGES OF THE MAIN REPORT

A. Non-inclusion of Litani River in Jordan Basin Resources

The Jordan Valley Region and the adjoining Mediterranean watershed are deficiency areas as far as water is concerned. On the other hand, on the northern fringe of the Jordan watershed, there exists an unutilized river which, in the opinion of all engineers who have studied the potentialities of the region, has no economical outlet for most of its water within its own basin or adjoining areas in the north and east. The Litani river in the Lebanon has a flow larger than that of the Jordan watershed at the inflow into the Sea of Galilee and discharges unutilized into the sea, a few miles from a deficiency area, where it would work wonders.

The inclusion of a Litani diversion, though it would increase somewhat the construction cost of the project, would make the whole project more attractive from the economic point of view, since the growth of capacity would by far outweigh the additional cost. The additional quantity of water diverted into the Jordan watershed could be usefully distributed to the best use of the whole watershed. The high head available between the Litani and the Upper Jordan Diversion, on one hand, and between this Diversion and the Sea of Galilee, on the other hand, could be utilized for power generation. Since the power feature is only an incidental feature of a project having primarily irrigation functions, the additional specific expenditure for power generation would be relatively small.

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The power that can be generated within the Jordan Basin from the water proposed for diversion from the Litani river would be at least equal to the power which could be developed from the same water within the Lebanon.

It appears that the inclusion of the diversion of part of the Litani flow into the Jordan watershed would be most desirable both from the point of view of irrigation within the Jordan watershed (and adjoining areas) as well as from the point of view of generation of hydropower for the whole region.

B. Deficiency of Data

A number of inaccuracies have crept into the report, some of them having an important bearing on the crucial question of water allocation, some having an influence on minor issues. The following is a short summary of the more important points :

(1) River Hydrology

There is a number of discrepancies in the figures quoted by the Consultant regarding river flows and water balances in the Basin. The figures used in the following have been corrected according to latest available data.

(2) Wadi and Spring Flows

The major discrepancy concerns the Beisan springs: these springs, rising in the western Jordan valley, south of the Sea of Galilee, are included in the water resources allocated for the irrigation of the Ghor, although these springs are, at present, completely utilized for the irrigation of lands in the Beisan Valley, which are within gravity control of these springs, though they are above the level of the Western Ghor Canal proposed by the Consultant and have + in orthodox compliance with the principle of gravity

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control by the canal - not been included among irrigable areas in Israel. Thus, an area at present successfully irrigated in Israel, has been excluded from the list of irrigable lands, while the water now used for this irrigation has been allocated to the Lower Jordan Valley. Incidentally, a considerable part of this water has a high salinity (in the Beisan Valley this saline water is mainly used for fishponds which have a higher salinity tolerance), and would therefore be a rather unwelcome addition to the relatively salty water issuing from the Sea of Galilee.

(3) Ground Water Resources

The Consultant's estimates of utilizable ground water resources seem to be arbitrary. Since ground water resources are included in the national water allocations, the order of magnitude of these resources included in the allocation of each nation is quite important. The Israel allocation in the Report includes 20 million cubic metres per annum from the small Yavneel Valley, and an insignificant and unidentifiable portion of the ground water from the western border of the Jordan Valley. The allocation to the Kingdom of Jordan, on the other hand, includes only 20 million cubic metres per annum for the more than 200 kilometres (straight line) of the west and east banks of the Jordan river below the sea of Galilee. Incidentally, the safe yield of the Yavneel Valley ground water resources has been established - by actual long-term pumping - to be in the order of magnitude of 3 - 5 million cubic metres per annum. Surely the ground water resources of both banks of the Jordan between Lake Tiberias and the Dead Sea must be of another order of magnitude. These estimates show certainly "misplaced generosity" in the allocation for Israel of ground water and an unmotivated extreme pessimism regarding the potential ground water development in the Kingdom of Jordan. The inclusion of these arbitrary figures on ground water tends to distort the actual scope of national allocations. It should, in addition, be kept in mind that a complete utilisation of all

ground water resources occurring in the Jordan catchment is most desirable from the point of view of the ultimate power potential of the Mediterranean - Dead Sea hydro-development, since every cubic metre of ground water actually consumed makes room for the admission of the same volume of sea water having a power potential of 0,8 Kwh per m^3.

6. Unutilized Flow

The Report, having regard for limitations of the Basin principle - apparently assumed Lake Tiberias to be the only major storage reservoir available for the regulation of the Jordan and Yarmuk rivers, except for the limited capacity of the Hasbani and Baghani reservoirs. As a result of this self-imposed limitation, marginal 150 million cubic metres per annum of the mean river flows could not be regulated in this one reservoir, and would be allowed to flow wasted into the Dead Sea. Thus the quantity of water available for utilization would in fact be reduced by 150 million cubic metres per annum (about 9% of all regional resources). Similarly the potential annual power output of the Dead Sea power projects would be reduced by 120 million Kwh per annum (!) (worth, at prevailing local fuel prices almost one million U.S.$ per annum).

Once the ban on extra-basin development is lifted, practically unlimited additional storage capacity becomes available, and the 150 million cubic metres per annum wasted in the project under consideration could be fully included in the region's utilizable water resources to the benefit of both irrigation and power generation.

On the following pages it will be shown that the Johnston's water allocation to the Ghor is excessive, and that large quantities of water would have to be wasted under this allocation.

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It is estimated that in the suggested allocation about 200 million cubic metres per annum cannot be usefully consumed for irrigation in the Ghor. This affects again both the irrigation and the power potential of the Basin. It thus appears that about 300 million cubic metres per annum or about 2% of the total available water resources of the whole Basin would have to be wasted. This could be avoided if the basin principle were abandoned and water allocation governed by agricultural needs. At the same time, the power potential of the Basin could be increased by about 250 million Kwh per annum worth, at prevailing local fuel prices about 2 1/2 million U.S.$ per annum.

Actually, the quantity of water that would go to waste in the Consultant's Project might still be larger, if allowance is made for the fact that "experience has indicated that on the average approximately 15% of the project lands are idle each year for one reason or another" (U.S. Bureau of Reclamation Manual, Volume IV, Chapter 7. 2 B. 6). Since there exists no alternative irrigation outlet for this (statistically established) percentage of unused water (amounting to about 70 - 80 million cubic metres per annum) in the Ghor or adjoining areas, the water would actually have to be wasted, if firmly allocated to the Ghor. In order to remain on the safe side, this reduction of actual use, as compared with theoretical allocation, has not been taken into consideration.

D. Overirrigation of the Jordan Valley (Ghor)

(1) Irrigable Areas in the Jordan Valley

The Basin States participating in the Jordan Basin are water deficiency areas: available water resources are not sufficient to irrigate available lands. Water will, therefore, be the limiting factor in agricultural development. The basic fact necessitates:

i. Careful planning of the water conservation and conveyance features, with a view to conserving as much as possible of the available meagre resources and preventing any avoidable waste.

ii. Careful planning of the agricultural aspects of water utilization, in order to assure the largest possible crops from available water resources.

iii. Careful determination of most suitable lands for irrigation with a view of optimum combined utilization of land and water resources.

The area is too poor in water to be able to afford projects which would not fulfil these basic conditions. It is our feeling that the Report does not give enough weight to these basic facts. In the following are pertinent facts and figures.

According to the Report, whithin the boundaries of the Jordan Basin 490,000 dunams are irrigable in the Ghor and 30,000 on the Yarmuk plateau. These figures were computed from maps 1:50,000 or smaller scale. There exist, however, more accurate maps

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Total:	408,700 d.

published by the Palestine Survey drawn on a scale of 1:20,000; a study of irrigable areas based on these maps and other data indicates that these estimates are rather exaggerated. The figures computed from these more accurate maps give the following gross irrigable areas in the Ghor, arranged according to the same subdivisions as used in the Report. (The figures quoted in the following, apply to that portion of the Ghor which lies within the boundaries of the Kingdom of Jordan):

Ghor - N.E.	74,100 d.
N.W.	8,100
E.C.	117,400
W.C.	88,700
S.E.	74,400
S.W.	46,000
Total:	408,700 d.

These figures are gross irrigable areas within gravity control of the proposed canals and after deduction of broken ground, flooded areas, wadis, steep slopes, escarpments, etc.

To arrive at the net irrigable areas, a deduction of 10% has to be made to allow for canal rights of way, internal roads, buildings, etc.

The net irrigable area, remaining in the Ghor, after this deduction, will be as follows:

N.E.	66,700 d.
N.W.	7,300
E.C.	105,700
W.C.	79,800
S.E.	67,000
S.W.	41,400
Total:	367,900 d.

Irrigation water has, therefore, to be provided for a total net area of around 370,000 dunams, within that portion of the Ghor which lies in the Kingdom of Jordan.

The Plna mentions 7,000 dunams in the Hula region and 15,000 south of Lake Tiberias irrigated in Israel before development began. Today, there are some 38,000 dunams of land irrigated in the latter area alone (partly by pumping from the river Yarmik) and sufficient quantities of water should be set aside to provide for all actual present use in Israel.

(2) Water Duty in the Jordan Valley

The water allocation proposed in the Report appears excessive and wasteful.

Mr. Hays based his estimates of water duty on detailed studies of actual conditions in the various irrigated areas. He quotes for the Jordan Valley.

North: 1135 - 1181 m^3/d. averaging 1160m^3/d.

For the Central and Southern parts (est.)1500 m^3/d.

Both figures include reserves of 15%

According to these duty figures, total water requirements would be:

N.E.	74,100 - 10% = 66,700 d.	x 1160 =	77.3 million m^3
N.W.	8,100 - 10% = 7,300 d.	x 1160 =	8.4 " "
E.C.	117,400 - 10% = 105,700 d.	x 1500 =	158.5 " "
W.C.	88,700 - 10% = 79,600 d.	x 1500 =	119.7 " "
S.E.	74,480 - 10% = 67,000 d.	x 1500 =	100.5 " "
S.W.	46,000 - 10% = 41,400 d.	x 1500 =	62.1 " "
	408,700 - 10% = 367,900 d.		= 526.5 million m^3

Hays' figures for water duty were based on the type of farming which was actually practised at the time of writing his report. In the Jordan - Yarmuk Triangle Area, 15 - 20% of the irrigated area were occupied by banana plantations, and another 25% by alfalfa, both heavy consumers of water. It is quite obvious that this kind of cropping system cannot be regarded as typical for the whole valley, when fully developed, simply because there would be no market for the produce. It may be assumed that irrigated grains, vegetables and potatoes, as well as miscellaneous fruit orchards will occupy large portions of the area.

Under these conditions, and using the same water requirements as Hays for the individual crops, we arrive at a water duty not exceeding 1000m^3 per irrigated dunam in the Northern Ghor.

In the Central and Southern Ghor, similar considerations will lead to a water duty of about 1250 m^3.

Both these figures include an allowance of 15% for conveyance losses.

Substituting these water duties for those suggested by Hays, we arrive at a total water requirement of 441,400 million cubic metres per annum for the Kingdom of Jordan's portion of the Jordan Valley.

It seems also that a water duty of 1500 m^3 for the Yarmuk plateau at about 300 m^3. above sea level, with 300 - 400 mm of rain is exaggerated, and a quantity similar to that proposed by Hays for the Lower Galilee (Kfar Tabor) seems indicated: 680 mm; this would reduce allocation to this area to 20 - 25 million m^3

Summing up irrigable areas and water requirements in the Jordan Valley within the Kingdoms of Jordan and Syria, we obtain:

Areas:	Ghor	367,900 d. net
	Yarmuk Plateau	30,000 d. net
	Total:	396,900 d. net

Quantity of water required according to Hays:

Ghor	526.5 million m^3
Yarmuk Plateau	25 " "
Total:	551.5 million m^3

Water requirements conforming to revised cropping system:

Ghor	441.4 million m^3
Yarmuk Plateau	20 " "
Total:	461.4 million m^3

(3) Salinity of Soils in the Jordan Valley

There exists a study of the soild of the W.S. and W.C. Ghor, carried out by the Experimental Station at Rehovot. The size of the area investigated covers 135,000 dunams of cultivable land between Wadi Abu Sidreh and the Dead Sea. This area is identical with the W.S. and W.C. Sections of the Project.

Of these only 16,000 dunams contain less than 0.1%; of soluble salts; this makes them suitable for all crops. Another 11,000 dunams contain from 0.10 - 0.40%; such a salinity is tolerated by a limited number of crops; 6000 dunams contain up to 0.8%, the number of crops tolerating such soils is very limited; 29,000 dunams have a salinity between 0.8 - 2%, these soils are fit only for dates or pomegranates; 73,000 dunams or 54% of the area will become cultivable only after leeching. Fortunately, in most places the

salts present are white alkali (chlorides and sulphates). It should, however, be borne in mind that permanent irrigation of compact blocks of land will, under these conditions, necessitate extensive and expensive drainage works, such as had to be undertaken in the area between ther rivers Jordan and Yarmuk, where agricultural land is situated about 20 - 30 m. above the river Jordan, While evaluating the advantages of irrigation in the Ghor against other regions, the expenditure on heavy artificial drainage should be taken into account, as well as the greater quantities of water required to mature the crops.

(4) Allocations

It has been shown that about 300 million m^3, out of the total of 820 million m^3 allocated to Jordan and Syria in the Report, cannot be usefully applied in the Ghor. It may even be said that this excessive supply is bound to prove harmful, as it will result in water logging and bring high concentrations of salts to the surface layer of the soil. Drainage, though a remdy for these evils, has long been known to be insufficient by itself. In every well-developed irrigated region, farmers and irrigation exports have come to the conclusion that waste of irrigation water must be cut aswell as drainage installed, in order to ensure the permanent prosperity of a project.

There is, however, an even more compelling reason: The region as a whole, not only the Jordan-Yarmuk watershed, is in desperate need of irrigation water and the hundered millions of m^3 that, in the Ghor, would at best be wasted, might prove vital in Israel, where 5-800 m^3 per dunam are quite sufficient (differences according to local climate and cropping system) for

Negev.

(5) Overirrigation and its after-effects

It has been shown that the quantity of water which the Ghor area within the Kingdom of Jordan can usefully absorb for irrigation cannot exceed 500 million cubmic metres per annum, including allocations for irrigation in the Upper Yarmuk Basin and for irrigation of scattered areas lying above the main irrigation canal of the Jordan Valley. If this allocation of water to the Jordan Valley is adopted, drainage problems will be kept within reasonable limits and the danger of over-irrigation minimized. If, on the other hand, the considerably larger irrigation allocations of the U.N.R.W.A. Report are adopted, drainage problems will reach unmanageable proportions and water-logging and its after-effects will make irrigated agriculture less and less attractive and will ultimately result in the abandonment of large tracts of land.

In connection with the potential dangers of overirrigation to be expected from the water allocation for the Jordan Valley as proposed in the Report, it is interesting to refer to the actual experience of American irrigated agriculture in Reclamation Projects during the first twenty years of Reclamation, as desribed in the "Fact Finding Report" of the President's Committee of Special Advisers on Reclamation of April 1924. Since the data in the said report are most pertinent to our discussions, quotations, in full, will be given in the following on some aspects of overirrigation, as experienced by American irrigation farmers:

./Water-logged

..."Water-logged lands are unprofitable for agricultural purposes. Every precaution must be taken to prevent such water-logging from occuring. This is so well understood that <u>there is little excuse in our days for methods of irrigation agriculture which permit controllable water-logging</u>...

The federal irrigation projects at an early date felt the effect of the rise of ground waters, and large areas from this cause were unfitted for agricultural purposes. In 1915, the accumulation of water-logged lands totalled 78,950 acres. Twenty thousand acres were water-logged under the Rio Grande Project; 15,000 under the Uncompahgre; 11,000 under the Boise. Fourteen of the projects showed a relatively large area of water-logged lands in that year. Though drainage had been instituted and continued, about 103,000 acres of land were injured in 1923 by water-logging. This represented a seepage damage, considering only the irrigated acreage of 1922, of about 9 per cent. This, in terms of the cost of construction and agricultural reclamation, is a large sum and justifies all efforts to prevent or delay the evil.

It is usually easier to prevent danage from water-logging than to correct it after it has occured. As far as known, there is only one permanent remedy for water-logging, namely drainage, which is always expensive unless the causes fo water-logging are removed and the ground water allowed to retreat.

... Under irrigated conditions, along with injury from water-logging, comes another injury to the land, due to the alkali which usually accompanies seepage...

... seepage is a concomitant of irrigation, so

The excess irrigation water passing downward through the soil dissolves the soluble soil substances and carries them into the lower-lying soil strata, to increase the concentration of the ground water. When this alkali water is drawn to the surface by capilarity and evaporated at the surface, soluble salts are left on or near the surface as a white crust, generally known as alkali.

Damage from alkali is commonly observed in connection with seepage on all irrigation projects. Studies of the alkali evil on the reclamation projects have been made...

... Since the beginning of irrigation the rise in the ground waters on the various projects has been marked. On some of the projects the water plan has risen over considerable areas to such an extent as to render the lands unfit for cultivation, and in a few cases limited areas have actually been submerged. The cause of this excessive rise in ground water is evidently due, first, to the adequate supply of water furnished; and, second, to the excessive use of water on the art of the settlers, many of whom were in the beginning without experience in irrigation. In addition to excess irrigation waters, there are also some unavoidable losses from canals and laterals which reach the subsoil and contribute to some extent in raising the water plane.

Where the irrigation is confined to small areas or narrow valleys with open subsoil conditions, the rise in ground waters is not ordinarily sufficient to interfere with agricultural operations, the excess waters which are put on the land during the irrigation season being in general drained out and carried away

before the next season's irrigation is begun. Where, however, large areas are being irrigated and where the ground water must travel for a considerable distance before finding any natural outlet, a general rise in the water plane ordinarily occurs. The keeping down of the water plane to the requiredxdxpt depth below the surface can be accomplished by the construction of drainage works and by reducing the quantity of water used in irrigation to a minimum.

The excess water of irrigation which contributes most largely to seepage is what may be termed underground waste. It is caused by applying more water to the surface at a single irrigation than the soils can retain within the zone of plant growth. A part of it consequently sinks into the lower and more porous soil strata. Gradually the subsoils become filled to an extent that water is brought to the surface on the low areas or on the lower portion of slopes down which the ground water may be slowly percolating. The economical remedy against seepage of this kind is to reduce the amount of water applied to the soil at any one time to that which it can retain and beneficially use for the growing of plants...

It is felt that nothing need be added to the above quotation, to underline the serious effects of overirrigation especially in a region with the climatic and soil conditions of the Jordon Valley.

The allocation of water to the Jordon Valley, as proposed by the Consultant, would not only deprive Israel of a considerable portion of its extremely short irrigation supply, it would also defeat its own purpose, by seriously endangering irrigation in Hashemite Jordan.

./Uneconomical

E. Uneconomical Use of Water

It is not needed to be stressed that the Jordan Valley Region is aregion of acute water deficiency. Water use should, therfore, be planned in a way ensuring the largest possibulity for crops from the limited available supply, without increasing however water cost beyond reasonable economical limits.

Before discussing ~~it~~ in more detail the proposed utilization of water in the U.N.R.W.A. Report, let us quote a few additional passages from the above "Fact Finding Report" incorporating experience of U.S. agriculture.

"RELATIONS OF WATER TO CROPS

It is an erroneous idea that the greater yields of crops obtained by the addition of large quantities of water increase the profits of the farmer. The returns from the use of a certain quantity or water area safer basis on which to found our irrigation practice than the yield per acre, especially when land without water is very cheap and water for that land is very expensive. The true measure for the proper use of irrigation water is the water cost of the crop produced. How many tons of water were required to produce a ton of alfalfa or abushel of wheat? Such questions are too often left unanswered by the farmer, but are of fundamental importance in the building of an irrigation practice which will help make our Federal irrigation projects as well as other irrigation projects prosperous and permanent...

...While in the year 1922 upward of one half of the projects cannot be said to have used water excessively on the farmers' fields, yet the other one-half used quantities of water which, undoubtedly, were largely in excess of the needs of crops. It is illuminating to note that in several instances the projects with large areas of water-logged lands are projects on which the duty of water is low. Information concerning the proper use of water in irrigation should be disseminated among the water uses and, if necessary compulsory steps should be taken to prevent the excessive use of water user project himself against his own wasteful practices. Water rights should NEVER BE ESTABLISHED EXCEPT UPON the basis of a definite quantity of water..

It is a well-established fact that whetever much water is available , the duty of water is low; wherever little water is available, the duty of water is high, and this without affecting materially the yield par acre. It is also a matter of common knowledge that under pioneer conditions the duty of water is low, whereas on older settled projects the DUTY OF water is high.

./There

There is good reason to believe, therefore, that as restrictions are placed upon the use of water, the duty of water will be increased; that is to say, less water will be used on each acre of land, and as the projects become older the general experience of farmers will lead them to use less water....

This is important because the success of reclamation depends primarily upon our success in avoiding a waste of water and preventing seepage..."

We feel that the point of view expressed in the above quotation should be adopted as guiding principles when weighing the merits of water allocation. The Report, however, does not evaluate the relative merits of alternative water allocations; and deals with this question in a rather cavaliery fashion. On page 42 is said:

"The cost of supplying water to irrigate a dunam of land in the hills by pumping and in the Ghor by gravity is very nearly the same... The greater productivity of the land in the Ghor, and the disadvantages of pumping previously discussed, led to the adoption of a gravity system of water distribution."

The gravity system of water distribution refers to additional irrigation in the Ghor, as against additional irrigation within the Basin in the hills by pumping. Since extra-basin development was a priori taboo, it was not considered at all. We hope that we have made it quite clear that extra-basin development warrants at least a thorough investigation.

Assuming that the cost of water per irrigated dunam in the hills is roughly equal to that in the Southern Ghor (as assumed in the above quotation from the U.N.R.W.A. Report), the obvious choice, from the engineering and economic point of view seems to be irrigated irrigation in the hills, since, with the scanty supply available, areas 2 to 3 times larger can be irrigated in the hills at the same irrigation cost per acre. The Consultant has, however, arrived at the opposite conclusio

./giving

giving, except for unproven generalities, no reason to motivate his conclusions.

By applying our reasoning by extra-basin gravity developments, the case of a larger Upper Diversion becomes even stronger. Water costs per cubic metre in extra-basin irrigation adjoining the watershed will be only slightly higher than water costs per cubic metre in the Southern Ghor, while the same quantity of water would, in extra-basin developments, serve for the irrigation of areas twice to three times as large. This seems a clear cut issue, and unless non-technical and non-economic motives need be allowed for, the conclusion points definitely towards a higher water allocation to the Upper Diversion. So much more so, since it has been shown in the previous section that the water allocated by the Consultant to the irrigation of the Jordan Valley could never be usefully absorbed there.

Taking as an extreme example the comparison of the irrigation of the Northern Negev with that of the Southern Ghor:- in the Negev the water cost per dunam (including pumping) is somewhat higher than that in the Southern Ghor. But here, again, the same quantity of water will irrigate in the Negev an area two or three times larger than in the Ghor!

From the engineering and economic point of view, extra basin development seems the only defensible solution.

The U.N.R.W.A. Report gives the higher soil fertility of the Ghor as a reason for the proposed high percentage of irrigation there. According to the detailed figures available on irrigation in the Jordan Valley within the boundaries of Israel, it appears that, although water consumption per dunam is 2 to 2.5 times larger in this part of the Jordan Valley than in other parts of Israel, there is no significant difference in the yield s per dunam.

./No

No detailed land classification data are available to us on the soils of the central and southern Ghor. But, according to the few data available, it would appear that the soils become less fertile as we go south, and that problems of salinity of soil become more pronounced in the arid southern section of the Ghor. The claim of higher fertility, especially as applied to the Southern Ghor, cannot therefore, be substained.

It has been proved before that the claim of the non-existence of a storage sites, adequate for the implementation of a larger Upper Jordan Diversion, was based on insufficient information. Storage capacity, available within gravity reach of the Upper Jordan Diversion, is larger than the total storage capacity proposed by the U.N.R.W.A. Project for the regulation of the Jordan and Yarmuk rivers. Lack of storage capacity for the Upper Jordan Diversion cannot, therefore, be claimed to be a limiting factor to the size of the Upper Diversion.

In the light of the above, it would appear that, allowing only for technical and economic considerations, irrigation in extra-basin developments adjoining the Jordan Valley would be by far preferable to irrigation in the Southern Ghor, and would yield larger crops. In other words, if the whole Jordan Valley area and the adjoining Mediterranean watershed of Israel were considered as one administrative unit, the most beneficialsolution would be a greater use of the waters of the Upper Jordan in the Mediterranean watershed with its land potential and a smaller use of Jordan water in the Jordan Valley, where the availability of land is, in addition, the limiting factor.

Jerusalem, May 1954