THE HASHEMITE
KINGDOM OF
JORDAN

J. Acorilla

JORDAN VALLEY AUTHORITY

PD-AAR-347

JORDAN VALLEY IRRIGATION PROJECT

IDN 40204

STAGE II

FEASIBILITY STUDY

VOLUME I

MAIN REPORT

JANUARY 1978

PREPARED BY
HARZA OVERSEAS
ENGINEERING COMPANY

IN ASSOCIATION WITH
DAR AL-HANDASAH CONSULTANTS
(SHAIR & PARTNERS)

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HARZA OVERSEAS ENGINEERING COMPANY CONSULTING ENGINEERS

January 28, 1978

His Excellency, The President
Jordan Valley Authority
Amman, Jordan

Subject: Jordan Valley Irrigation Project, Stage II
Feasibility Report

Dear Mr. President:

We are pleased to present our Feasibility Report on the Stage II Development of the Jordan Valley Irrigation Project. This report completes our engineering services on the first phase of the program specified in our contract with JVA dated March 2, 1976. These studies were carried out in association with Dar Al-Handasah Consultants, Beirut, Lebanon. Subsequent phases will consist of project design, construction surveillance, and initial operation.

Background

In the late 1950's, we were priviledged to assist the JVA in the planning, design and construction of Stage I of the Jordan Valley Irrigation Project. An intake constructed at that time near Adasiye has permitted the diversion of unregulated Yarmouk River water into the East Ghor Main Canal, the main conveyance facility for the surface irrigation of about 13,500 ha of arable lands.

The agricultural production of these lands fell short of expectations, mainly because land leveling was not carried out at the time of project implemention. In the last few years and with the advent of modern technology it became apparent that, rather than leveling the lands, the conversion from surface irrigation to sprinkler irrigation would permit the achievement of much higher yields over the entire arable area.

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In accordance with the terms of our contract, we have studied the feasibility of converting the existing facilities to a sprinkler irrigation system, and of extending the irrigated area to all of the arable lands located in the east Jordan Valley. This would bring the total irrigated area to 36,000 ha, the goal of the current 7-year Jordan Valley Development Plan.

Ultimate Development of Water Resources

In order to preserve the potential development of the water resources of the Yarmouk River, we have studied the feasibility of meeting the objectives of the 7-year plan without precluding the utimate development of the available resources in the Yarmouk and Jordan River basins.

We formulated a plan for staged development of the Yarmouk River resources. The ultimate development scheme will include: a 170 m high dam, reservoir and powerplant at the Maqarin site; a 100 m high dam, reservoir and powerplant at the Khalid site; a low dam near Adasiye to divert regulated flows to the East Ghor Main Canal (EGMC); water supply for municipal and industrial uses in the Governorate of Irbid and the Jordan Valley; conveyance and distribution facilities for the irrigation by sprinklers of all the arable lands in the east Jordan Valley, including the lands now served by the EGMC; and provisions for the irrigation of about 5,000 ha of additional lands in the Jordan Valley. At all stages, the scheme will continue to provide 25 MCM/year of water supply to the Yarmouk Triangle, and will provide a municipal and industrial water supply of 47 MCM/year to meet the growing needs in Irbid and the Valley.

Stage II Development

After the submittal of our Interim Report, in October, 1976, you instructed us to proceed with feasibility-level studies of an intermediate stage that would fulfill the objectives of the current 7-year Jordan Valley Development Plan; would be compatible with the ultimate scheme of development of land, water and power resources as described above; and also would constitute an increment that could be justified economically and financially.

On the basis of our studies, we recommend that the JVA carry out implementation of the Stage II of the Jordan Valley Project by constructing the following facilities:

a. At Maqarin, a zoned earth and rockfill dam with its crest at elevation 158, that can be raised later by 42 meters to its ultimate level, complete with spillway and outlet works.

b. Near Adasiye, a low concrete dam for controlled diversion of the regulated flows into the EGMC. Also, diversion facilities on three small wadis.

c. In the 13,500 ha area currently irrigated by surface methods, install sprinkler application facilities.

d. Extend the EGMC by 14.5 km to serve about 11,900 ha of additional irrigable land, also by sprinkler application.

e. At the Maqarin Dam and the King Talal Dam, install hydroelectric powerstations (20 MW at Maqarin and 2 MW at King Talal).

Performance of the Proposed Facilities

The Maqarin Reservoir, with its normal maximum reservoir at elevation 150 will have a total volume of 320 MCM and a useful storage volume of 275 MCM. The minimum river flow as regulated by the reservoir, will be 194 MCM per year (equivalent to an average of 6.1 m^3/s). This degree of regulation will make it possible to deliver annually:

- 269 MCM/yr for irrigation by sprinklers (overall efficiency of 70 percent) of about 25,400 ha of arable lands, including about 13,500 ha currently irrigated with a surface system and about 11,900 ha of new lands not now irrigated. Together with the other on-going projects, this will bring the total area under sprinkler irrigation to 36,000 ha.

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- 20 MCM/yr for municipal and industrial water supply (12 MCM/yr destined to the Governorate of Irbid and 8 MCM/yr to the Jordan Valley).

- 25 MCM/yr for water supply to the Yarmouk Triangle. If it is not possible to construct a low diversion dam near Adasiye, it will still be possible to make a firm delivery of 17 MCM/yr to the Yarmouk Triangle. However, irrigation shortages on the EGMC Project lands will increase slightly.

- 67 Gwh/yr with a minimum dependable capacity of 13.8 MW. This will permit the JVA to generate the electrical energy required for operation of its sprinkler systems (31 Gwh/year with a peak demand of 6.6 kW) and to sell its energy surplus to the JEA as part of an exchange agreement to be negotiated.

As a result of the project, the agricultural production of the Jordan Valley will be increased significantly. We estimate that the 36,000 ha of lands irrigated in the Valley will produce annually over 800,000 tons of vegetables and 290,000 tons of fruits, in addition to new field crops and a substantial growth in the dairy industry. Some of the production will be marketed and consumed in Jordan, but a portion of the fruit and vegetable production can be exported to other Middle-Eastern countries. These foreign markets are already being supplied to some extent by surplus production from Jordan. Marketing studies that have just been completed confirm that the future surplus production from the Project can be absorbed by these markets.

Apart from the agricultural potential of the area, other existing natural resources in the areas to be affected by the proposed project are limited. Return flows from the irrigated areas may increase the salinity of the Lower Jordan River to some degree, but that reach is already highly saline, and its use is very limited. The project will, therefore, have no significant adverse effect on the environment.

Construction Costs

The estimated construction cost of the recommended project, with a breakdown of the various components, is as follows:

Maqarin Project (dam, spillway, powerplant and outlet works)-----JD	62,501,000
Adasiye diversion structure----------	128,000
East Ghor Canal (repairs & extension--	1,888,000
Small Wadis Diversion----------	135,000
King Talal Powerplant----------	465,000
Irrigations Systems:	
Conversion areas----------	20,565,000
New lands----------	22,124,000
Subtotal direct cost----------	107,806,000
Contingencies----------	16,720,000
Engineering & Administration----------	19,174,000
Total Construction Cost (1977)--------	143,700,000

The above cost estimates are based on January, 1977, price levels with provision for contingencies, engineering and owner's overhead. Costs have been expressed in Jordanian Dinars with an exchange rate of JD 1.00 equals US $3.00.

Of the total costs, it is estimated that 32 percent will be incurred in national currency, and 68 percent in foreign currency.

Possible Alternatives

The proposed Stage II development is the most economical scheme that can be constructed now and still permit full future development of the available resources. Construction of the recommended project will require certain political accommodations which could delay its implementation. We have, therefore, developed two alternatives which could be implemented under existing conditions, although at a higher cost.

1. If it is not possible to construct a diversion weir across the Yarmouk near Adasiye, diversion of required flows could be accomplished with low level uncontrolled intakes. The Maqarin dam would need to be 10 meters higher to compensate for the water passing by the intake. The additional construction cost required would amount to JD 7.75 million (1977 price level). The internal rate of return for this alternative is 12.9 percent.

2. It is possible to convey water directly to the East Ghor Canal by means of a 25-km tunnel from Maqarin Reservoir to the Wadi Arab Basin. The dam at Maqarin would remain at elevation 158, and 40-MW powerplant could be installed at the end of the tunnel. The additional construction cost required for this scheme would amount to JD 23.4 million (1977 price level).

We have given consideration to constructing Maqarin Dam to its ultimate elevation initially (200). An additional cost of JD 32.6 million (1977 price level) would have to be invested immediately. We found that it is advantageous to construct the project to elevation 158 as long as raising is not required in less than 7-8 years.

Also, it is justified to include in the initial project provisions for raising the dam in the future in order to reserve future options, even though an amount of about JD 7.9 million (1977 price level) is required initially.

Economic Evaluation

We find the Stage II Project offers an attractive economic and social development opportunity for the Government of Jordan. A summary of the economic justification analysis is presented below:

Item	Direct Only	Direct Plus Indirect
Annual Benefits (JD)	17,495,000	29,352,000
Annual Costs (JD)	12,295,000	18,378,000
Benefit-Cost Ratio @ 10 percent	1.4	1.6
Internal Rate of Return (percent)	13.4	15.0

In addition to direct and indirect benefits, there are important intangible benefits that will result from the Project. Lasting benefits will occur through improvements in the balance of trade, balancing the economy toward the producing rather than the service sectors, self sufficiency in meeting food requirements, improved living standards, more efficiency in providing public services, and increased productivity of land. For example, it is estimated that Stage II development will increase the annual gross crop value by JD 50.9 million which will both reduce the amount of agricultural imports and increase the amount of exports.

Financial Viability

Construction of the proposed project will require funds in the amount of JD 72.6 million in national currency and US $408.5 million in foreign currency. These amounts include an escalation allowance assumed to 8 percent per year for the foreign currency component and 12 percent per year for the national currency component. The amounts do not include interest during construction, since estimating the latter requires a knowledge of the amount that can be funded directly by the Government of Jordan, and of the lending terms that can be negotiated with international financing agencies.

In order to obtain a measure of the financial viability of the proposed project, we have made some assumptions regarding financing terms, and have investigated the ability of the

Project to repay the initial investment required for its implementation. We assumed a range of interest rates from 0.0 to 7.0 percent per annum and repayment of the principal over 25 years, following a 10-year grace period. To account for future cost escalation, expenditures following the initial construction period for O & M were increased at the rate of 3.0 percent per annum, and revenues from irrigation power, and M&I water charges were increased at the annual rate of 4.0 percent.

The analyses of payment capacity on representative farm units indicates that substantial amounts of residual income will be available for payment of Project costs by year 7 of Project development. Prior to reaching full development, farmers on new lands may experience financial problems unless such assistance as intermediate-term credit and a grace period on payment of Project costs is provided. The farmers in the conversion areas will have less difficulty in becoming established during the development period. At full development, farmers on both the new lands and conversion areas would have sufficient residual income, after meeting other obligations, to pay irrigation water charges in the range of 125 to 130 fils/m^3.

The Project repayment analysis, based on the financial assumptions described above, indicates that Project costs, including escalation, can be paid by anticipated revenues from the sale of irrigation water, hydroelectric power, and M&I water. For example, a 35-year loan at 3.5 percent interest with a 10-year grace period could be repaid with initial charges of 11.0 fils/m^3 for irrigation, 12.0 fils/kWh for power, and 30 fils/m^3 for M&I water. If the interest rate on the loan is 7 percent, an initial water charge of 17.5 fils/m^3 would be required to fully recover investment and O&M costs. Since these rates are considerably less than the estimated residual farm income available for payment of water charges, it is evident that the Project is financially feasible if measures are taken to avert financial problems for farmers on new lands during the initials 4 or 5 years.

Project Implementation

Our analyses of constructon procedures and schedules have established that all the proposed facilities can be constructed so that the project becomes fully operational during the 1984 dry season. In order to meet that schedule, construction must begin in July, 1979. That can be accomplished within the framework of our engineering assignment, as long as funding is secured and construction contracts are awarded on schedule.

We recommend that construction of the Project be undertaken under three separate contracts as indicated hereafter. The amounts shown include an allowance for escalation, assumed to be 8 percent per annum for foreign currency and 12 percent per annum for national currency.

	National Currency	Foreign Currency
	(In JD million)	
Maqarin Storage and Power Facilities	47.8	75.0
Irrigation Facilities North of the Zarqa River	11.5	31.3
Conveyance & Irrigation Facility South of the Zarqa River	13.4	29.8

Each of the above three construction projects will be attractive to international contractors, and the work thus divided geographically and functionally will lend itself to an efficient construction operation.

Conclusion

The Second Stage Project of the Jordan Valley Development will make a major contribution to the improvement of the standard of living of the population of the Valley, and to the economies of the region and of the entire country. Following your instructions we are proceeding with the detailed design of the Maqarin Project and associated facilities.

We recommend that you proceed with negotiations aimed at securing the funds required for its construction. We stand ready to assist you in any way we can with the achievement of this important Project.

Very truly yours,

John A. Scoville

John A. Scoville
Project Director

TABLE OF SIGNIFICANT DATA

Project Setting

The Project is located in the Jordan River Valley 40 km west of the capital Amman and 300 km north of the port of Aqaba.

	1976	1987	2000
Jordan Valley Population	70,000	156,800	230,000

Hydrology

Average Annual Precipitation

Yarmouk River Basin	390 mm
Zarqa River Basin	250 mm
East Ghor Wadis	470 mm

Average Annual Streamflow

Yarmouk River at Maqarin	240.3 MCM
Yarmouk River near Adasiye	393.3 MCM
Wadi Raqqad near Rafid, Syria	73.3 MCM
Wadi Arab	28.8 MCM
Wadi Ziglab	9.5 MCM
Wadi Jurum	11.2 MCM
Wadi Yabis	3.5 MCM
Wadi Kufrinja	6.1 MCM
Wadi Rajib	7.1 MCM
Zarqa River at Deir Alla	67.1 MCM
Wadi Shueib at Shunat Nimrim	7.9 MCM
Wadi Kafrein	14.3 MCM
Wadi Hisban	5.0 MCM

Storage Facilities

Reservoir

Drainage Area	5,950 km^2
Normal Maximum Water Level	El. 150.0
Volume at El. 150.0	320 MCM
Surface Area at El. 150.0	7.0 km^2
Normal Minimum Water Level	El. 90.0
Volume at El. 90.0	45 MCM
Surface Area at El. 90.0	2.4 km^2
Live Storage	275 MCM
Sediment Storage	45 MCM

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TABLE OF SIGNIFICANT DATA (Continued)

Dam	
Type of Dam	Zone Earth and Rockfill
Crest Elevation	El. 158.0
River Bed	El. 30.0
Height	128 m
Fill Volume	14.3 MCM
Spillway	
Type of Spillway	Gated Concrete Ogee
Spillway Crest	El. 135.0
Spillway Discharge Capacity at Normal Maximum Elevation	2,820 m^3/s
Gates	3-8 m wide x 15 m high
Excavation Volume	3.94×10^6 m^3
Concrete Volume	187,000 m^3
Spillway Design Flood	
Peak Inflow	6,420 m^3/s
Peak Outflow	5,400 m^3/s
Surcharged Reservoir Level	El. 157.5
Low-Level Outlet Works	
Type of Low-Level Outlet Works	High pressure outlet with regulating valves.
Intake Structure Invert	El. 50.0
Outlet Structure Invert	El. 31.0
Minimum Discharge Capacity	20 m^3/s
Railroad Relocation	21 km
Diversion Structures	
Yarmouk River near Adasiye	
Type	Diversion Dam
Dam Crest	El. -202.5
Intake Invert	El. -208.5
Diversion Capacity	20 m^3/s

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TABLE OF SIGNIFICANT DATA (Continued)

Physical Data

Powerplant Type	Surface	Pit
Water Conductors		
Length	1,730 m	130 m
Diameter	3.2 m	1.5 m
Surge Tank		
Height	184 m	-
Diameter	3.2 m	-

	Maqarin Powerplant	King Talal Powerplant
Penstock		
Length	150 m	30 m
Diameter	2.3 m	0.75 m
Normal Tailwater Level	El. 8	El. 80

Estimated Project Cost

Stage II	Total Cost (JD 1000)
Maqarin Dam and Appurtenances	58,467
East Ghor Main Canal Extension and Repair	1,888
Irrigation Facilities	42,689
Maqarin Powerplant	4,034
Yarmouk Diversion near Adasiye	128
Side-Wadi Diversions	135
King Talal Powerplant	465
Sub-Total	107,806
Contingencies	16,720
Total Direct Cost	124,526
Engineering and Administration	19,174
Total Construction Cost - 1977	143,700
Escalation to end of construction	65,050
Total Construction Cost	208,750
Annual Operating Costs	1,247

TABLE OF SIGNIFICANT DATA (Continued)

Wadi Yabis	
Type	Concrete Uncontrolled Overflow Weir
Height of Weir	2.0 m
Length of Improved Channel	600 m
Wadi Kufrinja	
Type	Concrete Uncontrolled Overflow Weir
Height of Weir	2.0 m
Length of Improved Channel	1700 m
Wadi Rajib	
Type	Concrete Uncontrolled Overflow Weir
Height of Weir	2.0 m
Length of Improved Channel	400 m
Irrigation System	
Length	14.5 km
Capacity at Adasiye	20 m^3/s
Area Irrigated	
New Lands	12,511 ha
Converted Lands	12,842 ha

Power Facilities

Generation Data

	Maqarin Powerplant	King Talal Powerplant
Maximum Gross Head	142 m	84 m
Minimum Gross Head	82 m	43 m
Rated Head	120 m	67 m
Maximum Flow	20 m^3/s	3.8 m^3/s
Installed Capacity	20.0 MW	2.0 MW
Number of Units	2	1
Minimum Dependable Capacity	12.8 MW	1.0 MW
Average Annual Energy Production	58 GWh	8.7 GWh

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Currency

1 Jordanian Dinar (JD)	=	1000 fils
1 JD	=	U.S. $1.00

Weights and Measures

1 - meter (m)	=	3.2808 feet
1 - kilometer (km)	=	0.6214 miles
1 - square kilometer (km^2)	=	0.3861 square miles
1 - hectare	=	2.471 acres
1 - hectare	=	10.0 dunums
1 - kilogram (kg)	=	2.2046 pounds
1 - metric ton	=	1.102 short tons
1 - million cubic meter (MCM)	=	810.6 acre-feet
1 - liter	=	0.264 gallons (U.S.)
1 - cubic meter per second (m^3/s)	=	35.31 cubic feet per second
1 - kilowatt (kW)	=	1.341 horsepower
1 - megawatt (MW)	=	1000 kilowatts
1 - kilowatt-hour (kWh)	=	3,413.0 Btu
1 - Gigawatt-hour (GWh)	=	1,000,000 kilowatt-hours
1 - kilovolt-ampere (kVA)	=	1,000 volt-amperes
1 - Megavolt-ampere (MVA)	=	1,000 kilovolt-amperes
1 - kilowatt-hour	=	3,415 British thermal units
1 - kilovolt (kV)	=	1,000 volts
1 - barrel (bbl)	=	42 gallons (U.S.)

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LIST OF ABBREVIATIONS

Jordan Valley Authority	JVA
Jordan Valley Commission	JVC
National Resources Authority	NRA
Harza Overseas Engineering Company	HARZA
Dar Al-Handasah Consultants (Shair & Partners)	DAR
Consulting Engineering Center	CEC
Cubic Meter Per Second	m^3/s
East Ghor Canal Project	EGCP
East Ghor Main Canal	EGMC
Food and Agricultural Organization (United Nations)	FAO
Gigawatt-hours	GWh
Gross Domestic Product	GDP
Gross National Product	GNP
Hectare	ha
International Development Association	IDA
Irbid District Electric Company	IDECO
Japan International Cooperation Agency	JICA
Jordan Electric Authority	JEA
Jordan Electric Power Company	JEPCO
Jordanian Dinar	JD
Kilometer	km
Kilovolt	kV
Kilovolt-ampere	kVa
Kilowatt hour	kWh
Lump Sum	LS
Megawatt	MW
Millimeter	mm
Million cubic meters	MCM
Normal Maximum Water Surface	normax
Probable Maximum Flood	PMF
Probable Maximum Precipitation	PMP
Square kilometer	km^2

DEFINITIONS

Conversion Area	Land in the East Ghor Canal Project under the command of the first 78 km of the East Ghor Main Canal.
New Land Area	Land located primarily in the southern part of the Jordan Valley with some lands located above the EGMC and in the sidewadis.
Base Load	The minimum load over a given period.
Demand	The load at the terminals of an installation or system averaged over a specified interval of time (demand interval).
Energy	Result of power acting for a period of time. Measure in kilowatt-hours or gigawatt-hours.
Installed (or Nominal) Capacity)	The full-load continuous rating of a generator and its prime mover or other electrical equipment under specified conditions as designated by the manufacturer. It is usually indicated on a name plate attached.
Peaking Capacity	The maximum output which a generating plant can produce under specific conditions for a given time interval and within the operating limits of its component parts.

Peak Load	The maximum load consumed or produced by a unit or group of units in a stated period of time.
Power	Instantaneous electrical output or demand. Measured in kilowatts or megawatts.
Regulated Stream Flow	The controlled discharge rate during a specified period resulting from reservoir operation.

FOREWORD

Authorization

This Feasibility Report on the Jordan Valley Irrigation Project, Stage II was prepared in accordance with the terms of the Contract for Engineering Services between the Jordan Valley Authority of the Hashemite Kingdom of Jordan (JVA) and Harza Overseas Engineering Company (Harza), dated March 2, 1976. The report summarizes the studies carried out as the first phase (Phase A) of the engineering services outlined in the contract. Phase A consists of technical, economic, and financial feasibility studies of Stage II of the Jordan Valley Irrigation Project including preliminary design. The subsequent phases will consist of the following

Phase B_1: Final design, contract drawings and tender documents,

Phase B_2: Bid Evaluation and award services,

Phase C: Construction surveillance and contract administration, and

Phase D: Operation and maintenance supervision.

The contract authorizes Harza to associate with Dar Al-Handasah Consultants, (Shair and Partners) of Beirut, Lebanon (DAR). This report reflects preliminary comments made by representatives of international lending agencies (Arab Fund, Kreditanstalt fur Wiederaufbau, Kuwait Fund, U.S.I.D., World Bank) at a meeting held in London in June 1977.

Objectives

The overall objective of development in the Jordan Valley is to maximize the contribution of the East Jordan

Valley to the economy of Jordan.[1/] As a part of this maximization, many new jobs will be created and the standard of living of the farmers, which presently is very low, will be significantly increased.

The objective of the Phase A studies is to formulate the optimum program for development of the land and water resources of the East Jordan Valley. This development will provide for increased agricultural production from the area along the east bank of the Jordan River and for the production of hydroelectric power on the major rivers. The goal of Stage II development is to have a total of 36,000 ha of this east-bank area under irrigation from sprinkler irrigation facilities. During Stage II, 11,927 ha under the command of the East Ghor Main Canal and 2,132 ha irrigated from other sources will be converted from surface to sprinkler irrigation, and 11,294 of presently unirrigated lands will be developed. In addition, 10,647 ha will be brought under sprinkler irrigation with water from smaller streams on which projects are currently under construction.

The results of the feasibility studies are intended to assist the JVA in the selection of a program for development and in its negotiations for financing design and construction of the seldcted scheme.

Scope of Services

The scope of services for the feasibility studies are described in detail in Section V of the Contract.

1/ Jordan Valley Development Plan 1975-1982. Jordan Valley Commission, November 1975.

Generally, the services required are as follows:

1. Review and evaluate existing data and studies.
2. Determine storage requirements of Maqarin Dam for a variety of conditions.
3. Evaluate modes of conveyance from the storage facilities on the Yarmouk River to the Jordan Valley.
4. Define agronomic and irrigation criteria for agricultural development in the Jordan Valley by sprinkler irrigation methods.
5. Evaluate potential for power development.
6. Estimate costs and benefits of the recommended project.
7. Develop implementation and construction schedules.
8. Determine economic and financial feasibility.

The reporting requirements for the studies include an Inception Report which was submitted on June 12, 1976; an Interim Report which was submitted on October 11, 1976, and this Final Report on Technical, Economic, and Financial Feasibility and Preliminary Design.

Organization of Report

This volume titled "Main Report" contains a summary of the feasibility studies done in connnection with the project. The details of the studies are presented in eight appendices and, with the preliminary design report, are contained in five additional volumes.

The report organization is shown below:

Volume	Title
I	Main Report
II	Appendix A - Hydrology Appendix B - Environmental Assessment Appendix C - Operation Studies
III	Appendix D - Construction Materials Appendix E - Geology
IV	Appendix F - Soils Appendix G - Agricultural Development
V	Appendix H - Economic Analyses Appendix I - Financial Analyses
VI	Appendix J - Preliminary Designs, Storage and Power Facilities Appendix K - Preliminary Designs, Irrigation Facilities Appendix L - Cost Estimates

Previous Studies and Reports

Many plans have been proposed for the development of the Jordan Valley. Most of these plans recognized the political conditions that existed at the time of their formulation; however, some were based primarily on technical considerations. The following is a very brief summary of some of the more pertinent reports which relate to the development of the Jordan Valley.

(1) Ionides, M.G. and Blake, G.S, The Water Resources of Trans-Jordan and their Development, Government of Trans-Jordan, London, 1939.

This report was one of the earliest of recent times to propose diversion of the Yarmouk River into Lake Tiberias for regulation.

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(2) Bunger, M.E., Feasibility of the Yarmouk-Jordan Valley Project, TCA/Jordan, (1952)

Mr. Bunger was the first in recent times to recommend construction of a dam on the Yarmouk River that would make the water supply for the Jordan Valley independent of any connection with storage in Lake Tiberias.

(3) Unified Development of the Water Resources of the Jordan Valley Region, Charles T Main, Inc. under direction of the Tennessee Valley Authority, 1953.

The so-called TVA plan outlined the development of the water resources of the region without regard to political boundaries. The plan proposed to divert almost all of the Yarmouk River water into Lake Tiberias.

(4) Arab Plan for Development of Water Resources of the Jordan Valley, Technical Committee of the Arab League, 1954.

The Arab plan recommended a high dam on the Yarmouk River at either the Maqarin site or the Wadi Khalid site and the diversion of only a small amount of Yarmouk River runoff to Lake Tiberias.

(5) Yarmouk-Jordan Valley Project, Master Plan Report, Michael Baker, Inc., and Harza Engineering Co., 1955.

The basic premises of this plan were unrestricted use of Lake Tiberias as a storage and regulating reservoir, and supplemental storage on the Yarmouk River to conserve water and to permit economical utilization of Lake Tiberias.

(6) The Yarmouk-Jordan Valley Project, Stage I, Economic Feasibility, Harza Engineering Company International, 1962.

This study considered the economics of Stage I of the Jordan Valley Project, which consists of the development of the unregulated runoff of the Yarmouk and Zarqa Rivers and all wadis between these rivers.

(7) The Yarmouk-Jordan Valley Project, Stage II, Economics of Development, Harza Engineering Company International, 1962.

During these studies, it was decided to eliminate the use of Lake Tiberias, as proposed in the Master Plan, by providing all of the required storage on the Yarmouk River.

(8) The Yarmouk Project, ENERGOPROJEKT, 1966.

Based on the results of a cost and benefit analysis of storage, the Yugoslavian consultants recommended the construction of Maqarin Dam in two stages to supply timely delivery of irrigation water to the Jordan Valley.

(9) Jordan Valley Project, Agro- and Socio-Economic Study, NEDECO, and Dar Al-Handasah Consulting Engineers, 1969.

The result of these studies was a comprehensive analysis of the measures needed to extend irrigated agriculture throughout the Jordan Valley.

(10) Jordan Valley Development Plan, 1975-1982, Jordan Valley Commission, 1975.

This report defines the objectives associated with the agricultural development of the Jordan Valley and proposed suitable procedures for the achievement of these objectives. The recommended development includes a dam at the Maqarin site on the Yarmouk River and a sprinkler irrigation system in the Jordan Valley.

(11) The Jordan Valley Marketing Study, Harza Overseas Engineering Company, May, 1977.

This report presents estimates of the demands of Jordan and other middle-eastern countries for fruits and vegetables, discusses the fruit and vegetable production and current export demand of Jordan, briefly outlines the potential of the European market, and presents projections of supply and demand for fruits and vegetables grown in Jordan.

Acknowledgements

Harza and DAR gratefully acknowledge the assistance that has been provided during the course of the studies. In particular, the following persons and organizations have provided invaluable assistance:

His Excellency Omar Abdullah Dokhgan, President, Jordan Valley Authority.

Dr. Munther J. Haddadin, Vice President, Jordan Valley Authority.

The Supporting Staff of the Jordan Valley Authority.

The Technical Staff of:

The Natural Resources Authority
The Jordan Electric Authority
The Royal Society for Conservation of Nature
The Department of Antiquities
The Ministry of Public Works, Soils Laboratory
The University of Jordan, Faculty of Agriculture
The Ministry of Agriculture
The Ministry of Health-Preventive Medicine
The U.S. Agency for International Development.

Subcontracts

Subcontract agreements were made with the following firms to provide general assistance to Harza and DAR and to conduct a subsurface exploration program.

Consulting Engineering Center, Consulting Engineers, Amman, Jordan

Equipment Sales & Service Company (Fuad Abujaber), Amman, Jordan and Continental Drilling Company, Los Angeles, California, a Joint Venture

Shadaydeh Company for Excavation and Geological Studies.

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Chapter I

PROJECT SETTING

Location and General Description

The Project area is located in the northwest portion of the Hashemite Kingdom of Jordan. It is comprised of the east bank area of the Jordan River between the Yarmouk River and the Dead Sea. The Project lands lie generally between 32°40' and 31°50' north latitude and along 35°30' east longitude. Amman, the capital of Jordan and the largest local market for produce, is located about 40 km to the east of the Jordan Valley. Aqaba, the major port of Jordan, is situated about 300 km to the south of the Valley. A location map is shown on Exhibit 1.

The Jordan Valley lands are divided into two distinct terraces: a flood plain (Zor) to the west, and a higher bench area (Ghor) to the east. Along most of the length of the Valley, there is a transition zone between these two terraces (Katar) which is a highly eroded area that has very limited possibilities for agricultural development. Bordering the Ghor to the east is an escarpment which quickly rises to the Eastern Highlands or the Jordanian Plateau. The Valley area is slightly more than 100-km long and ranges from about four km to nine km wide. Two rivers and nine major wadis flow through the Project area and enter the Jordan River. From north to south, they are the Yarmouk River, Wadi Arab, Wadi Ziglab, Wadi Jurum, Wadi Yabis, Wadi Kufrinja, Wadi Rajib, the Zarqa River, Wadi Shueib, Wadi Kafrein, and Wadi Hisban. The basin boundaries are shown on Exhibit 2.

The Yarmouk River Basin encompasses an area of about 6,800 km^2 of which about 25 percent is located in Jordan and

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75 percent in Syria. On the average, about 400 million cubic meters (MCM) of water flow down the Yarmouk River each year. It is on this large river that project storage facilities will be located. The Zarqa River watershed, which encompasses an area of about 3,400 km^2 is the next largest basin and produces a mean annual runoff of about 67 MCM.

About 13,760 ha of the Jordan Valley area between the Yarmouk River and the Zarqa River have been developed under the East Ghor Canal Project.using surface irrigation methods. The level of productivity on these lands has been relatively low primarily because insufficient land leveling was done.

The Project lands upon which new and more intensive agricultural development will be accomplished consist generally of highly calcareous silts and clays underlain by fairly thick saline sedimentary deposits. The lands range in elevation from El.-200 meters in the north to El.-400 meters in the south.

Regional Geology

In the geological past, a sea periodically inundated Jordan and surrounding areas which are a part of the relatively geologically stable African-Arabian shield. The last retreat of the sea occurred about 40 million years ago[1/].

About 30 million years ago, a long, narrow segment of the emerged land area began to sink. This sinking of a segment of the land, or rift, was in response to regional faulting or rifting and was accompanied by an uplift of land on either side of the rift, by folding of strata, and by the outpouring of basaltic lava. This type of activity occurred

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1/ Burdon, David J., Handbook of the Geology of Jordan, 1959.

along much of the rift which is about 5,000 km long extending from northern Syria southward into East Africa. The Jordan Valley is a short portion of this rift. Some of the other easily identifiable features of the rift in and near Jordan are the Orontes Ghab in Syria, the Lebanon Bekka, Lake Houle, Lake Tiberias, the Dead Sea, Wadi Araba, and the Gulf of Aqaba.

In Jordan and surrounding areas, the rift has been interpreted as a dislocation at the margin of the African-Arabian shield. The rift forms a low-lying valley which drains into the Dead Sea. The lowest point of this rift lies beneath the northern part of the Dead Sea where the sea bottom is at El. - 790. The basement rock in the Jordan Valley is poorly known and material observed in outcrop principally consists of alluvium and lacustrine deposits.

Low lying terraces dissected by gullies and intermittant streams form the lands adjacent to the Jordan River and its floodplain. The irrigation service area will be located in this terrain.

The lands east of the Jordan Valley - Gulf of Aqaba rift were not significantly affected by the rift faulting. Strata generally are gently folded and little faulted. Rocks outcropping in this part of Jordan range in age from Pre-Cambrian granites and metamorphics in the southern part of Jordan to Quaternary plateau basalts in the Project area and to the north. In part, these outcropping rocks are of continental or littoral marine origin. However, in the Project area, except for the Quaternary basalts, rocks consist of marine limestone.

The part of Jordan east of the Jordan Valley is now a plateau or highlands of modest elevation. The plateau has

a gently rolling surface and has been dissected by the erosion of small rivers and intermittant streams flowing toward the Jordan Valley.

Climate

General Climate

The climate of the Project area is influenced primarily by the moist Mediterranean air from the west and somewhat by the arid desert winds from the east. Average monthly temperatures in the Jordan Valley range from 15°C to 30°C in the north and 15°C to 33°C in the south. The average relative humidity ranges from 30 to 70 percent. The prevailing winds are from the west and southwest; however, during the winter and spring the winds sometimes shift to the east. These easterly winds blowing off the desert cause extreme temperatures in the Project area. The average annual maximum and minimum temperatures are 46°C and 0°C respectively. The Valley area is rarely subjected to severe frosts.

Precipitation

All of the precipitation in the Project area occurs as rainfall; however, it is not unusual to have snow in the highlands to the east. The Jordan Valley appears to be in a narrow rain shadow caused by the surrounding highlands.

Rainfall generally occurs between October and May with about 80 percent of the rainfall happening during the four-month period from December through March. Mean annual precipitation in the Valley ranges from 400 mm in the north to about 100 mm near the Dead Sea. Annual rainfall exceeds 600 mm on the highlands to the east of the Valley. The distribution and paucity of rainfall in the Project area clearly emphasize the need for control of the runoff resulting from this rainfall.

Effect on Agriculture

The moderate winter temperatures make it possible to grow vegetable crops for harvest in early spring. Fruit crops virtually have an uninterrupted growing cycle. The summer temperatures rarely have any adverse effect on agriculture in the northern part of the Valley; however, in the southern part, high temperatures and low humidity during the summer may cause difficulties. Generally, the climate in the Valley makes it a very favorable location for the year round production of fruits and vegetables.

Economy

The Jordan economy appears to be strong and capable of sustained growth if political stability is maintained. In the past, growth of the economy has been hindered by war, periods of stagnation, and balance of payments deficits. It is anticipated that these difficulties can be alleviated by the policies outlined in the national five-year plan for the period 1976 to 1980. The Jordan Valley Development Plan is an integral part of this national strategy. The national plan emphasizes investment in such basic activities as mining, agriculture, and tourism to provide export income and general employment. If the plan is successful, the economy will grow at an annual rate of 12 percent from 1976 to 1980, and exports will increase at an annual rate of 19 percent.

The population of Jordan is increasing by about three percent each year. This means that the gross domestic demand for foodstuffs will double in the next 25 years on the basis of population alone. Increases in personal income will further increase demand. There are no other

large potential food producing areas in the country other than the Jordan Valley. Market forecasts show that the domestic economy can absorb much of the expected produce from the Valley.

In 1975, Jordan exported fruit, nuts, and vegetables worth nearly JD 10 million. The main recipients were the neighboring countries of Saudi Arabia, Syria, Lebanon, and the Gulf States. These markets are expected to expand. With Project development, it is expected that Jordanian products will be widely distributed in the Middle East as well as in the European Economic Community (EEC).

In 1974, power consumption in Northern Jordan was 193 GWh and it is expected that the demand will be growing by about 55 GWh per year. The installed capacity in Northern Jordan is about 200 MW, increasing at a rate of about 30 MW per year. The existing capacity includes a 33.6-MW gas turbine facility, two 33-MW steam units and about 100 MW of diesel-powered generators. The transmission network in northern Jordan will provide an interconnection between the major cities of Irbid and Amman in 1979.

Population

In 1945, the population of the east portion of the Kingdom of Jordan was estimated to be about 400,000 persons. In 1950, West Jordan was annexed and in 1952, according to the first census of population, a total of 1,329,200 persons resided in Jordan. The second census, taken in 1961, showed an increase in population to 1,706,200 persons or approximately 2.9 percent per year. In 1975, the population of Jordan (East Bank only) was about 1,954,000. On the basis of an assumed growth rate of 3.2 percent per year, the population of the east bank area of Jordan through the end of the century is calculated as follows:

1980	2,300,000
1990	3,100,000
2000	4,300,000

Population in the Jordan Valley has fluctuated widely over the last 30 years as a result of political events. The most recent survey of the Valley made in 1973[2/] indicated that the population of the Valley was about 64,000. It is estimated that the present population is about 70,000.

The future population of the Jordan Valley will be strongly influenced by the economic opportunities afforded by the Jordan Valley Irrigation Project. The predicted population according to the Jordan Valley Development Plan[3/] is as follows:

POPULATION IN THE JORDAN VALLEY

1980	112,206
1987	156,828

Employment

In 1973, about 30.5 percent of the population of the Valley participated in the labor force.[4/] This rate is low by international standards, but is much higher than the national participation rate of 20 percent. In 1973, only 1.5 percent of the valley's labor force was considered unemployed. Consequently, farmers experience some difficulties in obtaining hired labor. Two developments will help alleviate this problem. First, more than one-half of the

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2/ Social and Economic Survey of the East Jordan Valley, Jordan Valley Commission, 1973.

3/ Jordan Valley Development Plan 1975-1982, Jordan Valley Commission, November 1975.

4/ See footnote 2.

population was less than 15 years old at the time of the 1973 survey. Therefore, a large number of young people will be entering the labor force in the next decade. Second, the female population is being encouraged to enter the labor force.

About 80 percent of the labor force in the Valley is classed as farmers and farm laborers. Many of the remaining people work for the government or for construction companies.

Economy of the Valley

The present economy of the Valley is dependent on agriculture. The local economy is oriented towards production activities as opposed to the national economy where 74 percent of the labor force is engaged in service activities. About 55 percent of all farms are run on a share-cropping or tenancy basis, the landlords frequently taking half of the returns in payment for use of the lands and crop input. The present local economy is characterized by marked disparities in wealth and an absence of opportunities for personal advancement.

Social Conditions in the Valley

The general level of education in the Valley is relatively low. In 1973, the literacy rate of adult males was 50 percent and for adult females it was 15 percent. However, the standard of education is improving and the literacy rate for young people is higher. For example, over 82 percent of the males and 37 percent of the females between the ages of 15 and 19 years are literate.

Residential developments consist of scattered groupings of houses with few amenities. The houses primarily are built from mud bricks and there is an average of four persons per room. The overall picture is one of overcrowded and unsanitary conditions.

Public services also are generally inadequate. Domestic water is taken from open irrigation ditches and other such sources, and power is supplied from small, local generating facilities. Many public and professional services are not available, so trips to Irbid, Salt, or Amman are necessary.

Good quality roads enter the Valley from Irbid, Salt and Amman, and connect with a major north-south road which traverses the length of the Valley.

As a part of the Jordan Valley Development Plan, provisions will be made for housing, social services, and public utilities. The fullfillment of these needs is recognized by the JVA as being of special importance to rapidly developing agricultural communities.

Existing and On-Going Development

At the beginning of 1976, about 21,960 ha were under cultivation in the Jordan Valley. Of this total, about 18,659 ha were being surface irrigated and 3,301 ha were being dry farmed. Out of the total of 18,659 ha of irrigated lands, 13,757 ha were irrigated from the East Ghor Main Canal (EGMC). The remaining area was being served from old, unlined canals (2722 ha) or from wells (2180 ha).

After completion of the projects included in the 1973/75 Development Plan, the irrigated area in the Valley is expected to increase by about 5,627 ha to 24,286 ha. About 9,397 ha of these lands will be irrigated by sprinkler methods. Anticipated development of the Wadi Arab Dam and Irrigation Project would increase the irrigated area to 24,706 of which 10,647 ha will be irrigated from a sprinkler irrigation system. About 1,850 ha of the area presently

irrigated by substandard facilities will be improved and included in the projects now under construction. The area irrigated from wells will be reduced to about 1,260 ha because the surface water formerly used for recharge of the ground water aquifer will be pre-empted for use in the Kafrein-Hisban Project.

The existing irrigation facilities and the projects included in the 1973/75 Development Plan are collectively referred to as the Stage I development of the Jordan Valley Irrigation Project. Stage I development makes use of almost all of the base flow entering the irrigation service area. The areas served from Stage I development are shown on Exhibit 3.

Completed Projects

The East Ghor Canal Project (EGCP) provides water to lands in the northeast and mid-east Ghor through a surface irrigation system. The area irrigated is about 13,757 ha. The EGCP was constructed in two phases. The first phase included 70 km of the East Ghor Main Canal (EGMC) and a gravity irrigation system for about 12,300 ha. The second phase included an eight kilometer extension to the main canal and improved gravity irrigation facilities for an additional 1,457 ha. This land is presently supplied from the unregulated base flows of the Yarmouk and Zarqa Rivers and Wadis Arab, Jurum, Yabis, Kufinja, and the regulated flow of Wadi Ziglab. At present about 11,000 ha are irrigated from the base flow of the Yarmouk River and about 2,757 ha are irrigated from the base flows of the other water sources.

When the EGCP was constructed, a negligible portion of the land leveling that had been planned for the area was

done. As a result, good yields are obtained only on a small part of the farmed lands. On the remainder, the yields are depressed by the low effectiveness of surface irrigation on unleveled lands. A study done by DAR and NEDECO[5/] indicated that shifting the method of irrigation from surface to sprinklers on the 8-Km Extension area was economically justified. The conversion from surface to sprinkler would be highly effective in raising yields and increasing farmers income. Therefore, the current program of converting from surface irrigation to sprinkler irrigation has been adopted.

After completion of Stage I and Stage II facilities, and Wadi Arab Dam, the EGCP area will be converted to sprinkler irrigation. About 1,830 ha will be supplied from the Northeast Ghor Irrigation and Rural Development Project and Wadi Arab Dam and the remainder (11,927 ha) from the regulated flows of the Yarmouk River and the base flows of Wadis Yabis, Kufrinja, and Rajib.

Projects Under Construction

Zarqa River Project. The Zarqa River Project consists of the King Talal Dam which will be completed in 1978, sprinkler irrigation facilities for 1,527 ha in the Zarqa Triangle, and sprinkler irrigation facilities for 3,550 ha supplied from an 18-km extension to the EGMC. The original development plan also included water releases to irrigate lands in the East Ghor Canal Project area. This plan has been changed for the present studies as follows: the King Talal Reservoir surplus water beyond that needed to irrigate

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5/ East Ghor Canal Extension, Sprinkler Alternatives, The 8 Km Extension, Dar Al-Handasah, Beirut Lebanon and NEDECO, The Hague, September 1973.

the lands in the Zarqa Triangle and the 18-km Extension will be used to provide a partial water supply to Amman, and the lands in the EGCP area will be irrigated entirely from Stage II facilities. An operation study of the Zarqa River Project has been performed and confirmed the practicality of this modification.

Kafrein - Hisban Project. This project is located in the southern part of the Valley about eight kilometers north of the Dead Sea. The project will supply irrigation water, using sprinkler irrigation facilities, to about 1,560 ha. The project consists of a diversion dam on the Wadi Hisban, the existing Kafrein Dam, a pipeline between Wadis Hisban and Kafrein to convey Hisban flows in excess of local irrigation requirements to Kafrein Reservoir, and a sprinkler irrigation system. The project was scheduled for completion in 1977.

North East Ghor Irrigation and Rural Development Project.

This project, sometimes referred to as the NEG project will irrigate 2,760 ha from the unregulated base flows of Wadis Arab and Jurum and the flows regulated by Ziglab Dam on Wadi Ziglab. All lands will be irrigated from a sprinkler irrigation system. The irrigation area includes 1,000 ha formerly supplied from the EGMC. The project has the capacity to irrigate an additional 700 ha which have been located but not yet surveyed and which are to be developed in the future.

For the current studies, the 1,000 ha formerly supplied from the EGCP were assumed to be irrigated prior to completion of the works recommended in this report for Stage II development. The 700 ha reserved for future development were included in the full-development scheme. Construction began in 1976 and is scheduled to be completed in 1978.

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Anticipated Construction

The Japan International Cooperation Agency (JICA) has recommended construction of a dam on Wadi Arab to regulate the flood flows of that wadi. Harza has been directed by the JVA to assume that this project also will be available to contribute to meeting the Stage II goal. JICA recommends that the dam on Wadi Arab be operated in conjunction with the NEG project. Operating in this mode, the JICA project will irrigate an additional 1,250 ha using sprinkler application methods. The service area will be located in the northern part of the Ghor between the Yarmouk River and the Wadi Arab. Of the 1,250 ha, 830 ha are presently irrigated by surface irrigation from the EGCP, and 420 ha are not irrigated.

The combined NEG and JICA project is referred to as the Wadi Arab Complex.

Summary

The areas that are or will be irrigated after completion of the on-going projects are shown in Table I-1.

Table I-1

EXISTING AND ON-GOING PROJECTS

Project	Area Irrigated (ha)	Method of Irrigation	Source
Kafrein-Hisban	1,560	Sprinkler	Wadis Kafrein, Hisban
Zarqa River	5,077	Sprinkler	Zarqa River
Wadi Arab Complex NEG Project	2,760 a/	Sprinkler	Wadis Arab Jurum, Ziglab
Wadi Arab Dam	1,250 b/	Sprinkler	Wadi Arab
EGCP	11,927 c/	Surface	Yarmouk River, Wadis Yabis Kufrinja
Subtotal	22,574		
Individual Farms	2,132	Surface	Rivers, Wadis, Wells
TOTAL	24,706		

a/ Includes 1,000 ha formerly served from the EGCP.

b/ Includes 830 ha formerly served by EGCP.

c/ Area to be converted to sprinkler irrigation during Stage II development. Area consists of the EGCP (13,757 ha) less area irrigated from the NEG Project (1,000 ha) and less area irrigated from Wadi Arab Dam (830 ha).

A summary of the storage features included in the on-going projects is shown in Table I-2.

Table I-2

SUMMARY OF STORAGE PROJECTS

Project	Storage Facility	Active Storage (MCM)	Status
Wadi Arab Complex	Ziglab Dam	4.3	Completed
Wadi Arab Complex	Wadi Arab Dam	10.0	Planned
Kafrein-Hisban	Kafrein Dam	4.8	Completed
Zarqa	King Talal Dam	48.0	Under Construction
Shueib	Shueib Dam	2.3	Completed

Chapter II

THE JORDAN VALLEY IRRIGATION PROJECT

Introduction

The Jordan Valley Irrigation Project is the primary feature of the Jordan Valley Development Plan. The Project has as its goal the full development of the water resources available to the Valley. As discussed in Chapter I, substantial development of the water resource has already begun.

At ultimate development, 41,147 ha of irrigated land will be supplied from Project sources. The Project will also provide 25 MCM/yr to the Yarmouk Triangle, and 47 MCM to supply municipal and industrial water requirements in Irbid and the Jordan Valley. In addition, a net consumption in Amman of 10 MCM/yr will be drawn from the King Talal Reservoir. Hydroelectric powerplants with a capacity of 40 MW can be installed to generate an average energy of about 100 GWh per year.

Ultimate development will be realized in three construction stages. The elements of Stage I described in Chapter I are under construction or in the final design stage. Stage II development, as described in this report, will be constructed in the near future to meet the objectives of the current seven-year national development plan. Stage III, the final construction stage to full development, will be implemented when conditions are appropriate. A diagram of the features in the ultimate development scheme is shown on Exhibit 4.

Ultimate Development

When all of the facilities that are included in the ultimate development scheme are completed, essentially all

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of the water resource of the Yarmouk River basin will be put to beneficial use. Irrigated agriculture will be developed to the maximum extent possible using the most efficient methods best adapted to the soil and climate conditions. Implementation of this ultimate development has been planned to take place in successive stages so as to defer to a later date the construction of those features which cannot be put to beneficial use in the near future.

The Ultimate Development Plan will make it possible to irrigate the 36,000 ha of arable lands identified and classified in the east-bank area of the Jordan Valley plus 5,147 ha of land to be identified later.

In addition to the existing and on-going works discussed in Chapter I (Stage I facilities) the Ultimate Development Plan will include the following major elements.

1. A storage project at the Maqarin damsite (Reservoir El. 193),

2. A 28-MW hydroelectric powerplant at the Maqarin Dam,

3. A storage project at the Khalid damsite (Reservoir El. 12). The Khalid damsite is located at the confluence of Wadi Khalid, Raqqa and the Yarmouh River. It should not be confused with the site of Khalid Bin ir Al Walid Dam (Mukheibeh site) which is about seven kilometers downstream,

4. A 10-MW hydroelectric powerplant at Khalid Dam,

5. A 2-MW hydroelectric powerplant at King Talal Dam,

6. A diversion dam across the Yarmouk River at the location of the existing intake to the EGMC,

7. A main conveyance canal extending to the southern end of the East Ghor, and

8. Sprinkler irrigation facilities for a total irrigable area of 41,157 ha. (including the 10,647 ha, in Stage I)

The major elements that will be constructed after Stage II is complete are discussed in Chapter XI. The following discussion relates to the Stage II Development which is the primary subject of this report.

Stage II Development

General

Upon completion of the Stage II facilities a total of 36,000 ha will receive a firm water supply using a sprinkler irrigation system. This area will consist of 10,647 ha that currently are being developed for sprinkler supply from ongoing project; 11,927 ha of the EGCP currently being supplied by a gravity irrigation system; 2,132 ha currently being supplied by wells and the base flow of the side wadis, and 11,294 ha of lands, located mainly in the south part of the Valley, which are not now irrigated.

The Maqarin Reservoir will be designed to supply 12 MCM per year to Irbid and vicinity for municipal and industrial (M&I) uses, and releases will be made to provide 8 MCM per year to the Jordan Valley for M&I uses and livestock watering.

Stage II development will include a 20-MW powerplant at Maqarin dam and a 2.0-MW powerplant at King Talal dam. These two powerplants will have an average energy generation of 67 GWh per year to met the pumping requirements of the project and to serve the interconnected system.

A release of 25 MCM will be made to supply the Yarmouk Triangle Area.

Stage II Elements

The major elements that comprise the Stage II Project are listed here and briefly described in the following section.

1. A storage project at the Maqarin site (Crest El. 158) with provisions for raising (to crest El. 200)
2. The 20-MW powerplant at Maqarin Dam,
3. The 2.0-MW powerplant at King Talal Dam,
4. The diversion dam across the Yarmouk River at the existing intake to the EGMC,
5. The 14.5 km extension at the south end of the EGMC,
6. A sprinkler irrigation system for 25,353 ha, and
7. Rehabilitated or new diversion facilities on Wadis Yabis, Kufrinja, and Rajib.

Description of Major Elements

Maqarin Dam will be a zoned earth and rock fill dam designed to be constructed in two stages: first to a height of 128 m above streambed and ultimately raised by 42 m from El. 158 to El. 200. The initial stage is designed to minimize costs that are only needed to permit raising the dam at a later time.

A chute spillway with a flip bucket will be located on the left abutment. The capacity of the spillway will be sufficient to pass the maximum design flood discharge of 5,400 m^3/s using a surcharge of 7.5 m above normal maximum reservoir El. 150. A low-level outlet with a capacity of 20 m^3/s at minimum operating level will be constructed in the diversion tunnel. The reservoir area and storage features for the Stage II development at Maqarin are shown on Exhibit 5.

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A conventional powerplant will be located about two kilometers along the river downstream from the Maqarin damsite on the left bank of the Yarmouk River. The plant will contain two generating units and have an installed capacity of 20 MW. A 66-kV transmission line from the powerplant will connect with the national grid system in Irbid.

A concrete diversion dam will be constructed immediately below the existing intake to the EGMC. The dam will provide for diversion of the river up to 20 m^3/s, the capacity of the EGMC. Facilities will be included to permit releases for the Yarmouk Triangle Area.

A pit-type powerplant will be installed in the right abutment immediately downstream from King Talal Dam. The plant will have an installed capacity of 2.0 MW; the energy will be transmitted to a substation near Abu Hamid by a 33kV transmission line.

A sprinkler irrigation system will be provided for a total of 25,353 ha. The irrigation facilities will include a pipe distribution network, a farm system, and pumping stations located along the EGMC. To serve the Project lands in the southern part of the Valley, a 14.5 km extension to the EGMC will be required.

Small diversion dams and canals will be constructed on Wadis Yabis, Kufrinja and Rajib to collect the base flows for use on Project lands.

Environmental Impact of the Project

The primary sources of impact identified are as follows:

1. Construction and land preparation activities,

2. Inundation of the Maqarin Reservoir area.

3. Changes in streamflow patterns,

4. Changes in agricultural practices, and

5. Changes in demographic and social characteristics

The environmental studies considered the impact of these sources in the following aspect:

1. Terrestrial resources

2. Aquatic resource

3. Socio-cultural characteristics, and

4. Public health.

The environmental assessment studies included field investigations in the Project Area, a review of available information, and consultation with appropriate government agencies. A detailed presentation of the results of these studies is given in Appendix B, Environmental Assessment.

Source of Impacts

The primary potential sources of impact are identified as the inundation of the Maqarin Reservoir and the construction and land preparation activities in the proposed irrigation area. Secondary impacts may result from changes in demographic and social characteristics.

Construction of the dam and diversion on the Yarmouk River will have the effect of diverting water that is relatively low in total dissolved solids away from the Jordan River. Return flows to the Jordan River will have increased nitrogen, phosphorous, and total dissolved solids concentrations. This conditions may increase the salinity of the Jordan River to some degree; however, as the present use of the Jordan River waters is limited because of its existing state of high salinity, the increased salinity, if any, due to the Project will not have any measurable effect on water use.

The major change in agricultural practices, aside from the larger area brought under irrigated agriculture, will be the increased use of fertilizer and pesticides. The adverse impact of this increased use can be minimized through careful choice of the chemicals to be applied, methods of application, and quantities to be used, coordinated with rigorous monitoring and control of use.

Resultant Impact

Apart from the agricultural potential of the area, the existing natural resources in the areas to be affected by the Project are limited. It is not anticipated that construction of the project will result in major adverse effects on existing resources.

The development of an irrigation project offers a good possibility for the concurrent development of a fish culture program. Development of this program could be done using surplus or marginal land and water in a manner that is not competitive with irrigation and other needs. In addition to the more traditional methods of fish culture in diked ponds, screened-off sections of the irrigation canal and the culture of fish in floating cages in the reservoir merit consideration.

Of all the anticipated changes in the social and cultural characteristics in the Project Area, three are of major importance. These changes, which will require some further consideration outside the scope of the current studies, are: 1) future social and cultural development, 2) preservation or excavation of significant archaeological sites, and 3) planning for recreation and tourism.

The Jordan Valley Authority has been planning for the social and cultural development of the Project for several

years. The plans for development of population centers and for the associated social infrastructure are presented in the Jordan Valley Development Plan. Review and evaluation of these plans was not done as a part of these studies.

The Jordan Valley and the side valleys leading to it have played a major role in the development of civilization. A recent survey of the Valley identified 225 archaeological sites on the east bank of the Jordan River between the Yarmouk River and the Dead Sea. The only identified potential impact of the Project is the possible loss or damage to these archaeological sites. Identified significant sites should be protected until detailed evaluation can be made as part of the on-going program by the Ministry of Antiquities and Tourism.

Although no survey has been made of the Maqarin Reservoir area, evidence of archaeological sites has been found. An archaeological survey team should visit the area that will be inundated to identify and evaluate possible sites of archaeological importance. If an important site is found, a program can be developed so it can be salvaged before the reservoir is filled.

Maqarin Reservoir may provide opportunities for the development of water-oriented recreation. The dam itself would be an attraction for tourists traveling in the area. Plans for recreation and tourist facilities can be made after an evaluation of the physical and aesthetic impacts of reservoir fluctuations is made.

Public health programs are well established in the Project Area and there are no present health problems associated with the Project. Malaria and other vector-borne diseases have not been present or are under control. Snail hosts for

schistosomiasis have been found at isolated locations, but the disease organism is not present. Programs for the identification and control of this vector are being implemented. Control of vector-borne disease also will increase because the irrigation water will be conveyed almost entirely within enclosed pipes.

Chapter III
PRELIMINARY DESIGN

The preliminary designs of the features included in the recommended plan for Stage II development are discussed in this chapter. Stage II includes storage and power facilities at the Maqarin site, a low diversion structure to divert flow to the ECMC, a powerplant at King Talal Dam, diversion facilities on three side wadis, a 14.5 km extension to the EGMC to serve the southern part of the Valley, and a sprinkler irrigation system for 25,353 ha. A description of the general geology and the location and availability of construction materials is given, followed by design considerations for each of the major elements. Additional detail is presented in Appendix D, Construction Materials; Appendix E, Geology; Appendix J, Preliminary Design of Storage and Power Facilities; and Appendix K, Preliminary Design of Irrigation Facilities.

Geology

Areal Geology and Seismicity

The Maqarin Dam and Reservoir will be located in the Yarmouk River Valley in the highland area east of the Jordan Valley. This highland area is a moderately high (El 300 m to 500 m) plateau which has been dissected by wadis to form steep-sided valleys draining into the Jordan Valley.

Rocks of the plateau consist of very gently northerly dipping Mesozoic and Tertiary marine chalks, limestones, chalky limestones, and bituminous marly limestones of the Balqa Series. These beds are locally overlain in the plateau area by Quaternary basalt flows and by soils, and in the

valleys and on the valley sides by talus, alluvium and local basalt flows. Landslides have occurred on the sides of the valleys in some places. The regional geology is shown on Exhibit 6. Rocks, characteristic of the plateau outcropping, are exposed on the sides of the Yarmouk River Valley.

The Jordan Valley, which is considered to be a rift valley, is a graben separated from the highlands by a large regional fault. Exposed sediments in the Jordan Valley consist of Quarternary and Late Tertiary continental and lacustrine deposits.

Seismic activity appears to be associated with the Jordan Valley faulting and severe earthquakes have been felt in the Project area.

Investigation Program

The geologic investigation program has been organized to confirm the results of prior investigations and to provide answers to questions developed from a review of these studies. The current investigation program consisted of surface mapping and drilling 15 holes for a total depth of 1,030 m including 93 m in possible quarry areas. During this program and the prior investigations, 44 drill holes totaling 2880 m have been drilled at the Maqarin damsite. In addition, during the current program, four adits totaling 96 m were constructed to examine the talus covering the damsite slopes and underlying bedrock, and five shafts totaling 50 m were excavated to examine bedrock and overburden.

Reservoir mapping done for a previous study was confirmed and reconnaissance geologic mapping and verification of existing mapping has been made for the alternative schemes. Descriptions of the results of these studies and summary logs of the drilled holes, shafts and adits are included in Appendix E, Geology.

The following summary description pertains to the elements included in the Stage II development.

Geology of the Maqarin Damsite

The Maqarin damsite is located in a narrow, steep sided portion of the Yarmouk River Valley. This river, or the railway that parallels the river, forms the boundary between Syria and Jordan; thus a part of the site is in Jordan and a part is in Syria.

There are three principal bedrock units at the damsite. Underlying the lower portion of the valley sides and the valley bottom to unknown depth are thick beds of moderately hard bituminous marly limestones which have been referred to as bituminous marl in previous reports. Since these strata correctly should be classified as limestones, they are referred to as marly limestones or the Bituminous Marl Unit in this Report. Overlying the marly limestone conformably are a series of thick-bedded chalky limestones which in the Report are referred to as the Chalky Limestone Unit or chalky limestone and have a stratigraphic thickness of about 80 m. at the damsite. Basalt flows, which outcrop high on the valley sides unconformably overly the chalky limestones. In local areas, generally in the valley bottom, a few zones in the Bituminous Marl Unit have been altered to locally plastic clay.

Beds of the Chalky Limestone and Bituminous Marl Units dip about six degrees in the northwesterly or downstream direction. The beds form a broad, gently plunging anticline. The basalt flows are nearly horizontal.

Talus, shallow landslides, generally now stable, and a possible slump block overlie bedrock on parts of the valley sides, and alluvium overlies bedrock in the valley bottom. In some places the talus has slumped and in others voids of

up to three cubic meters exist. Parts of the talus and alluvium are cemented and parts are uncemented and loose. This variation in cementation, local voids and slumping results in great inconsistency in the physical characteristics of the talus.

Locally in the valley bottom, open joints and/or pothole-like features have been formed in the bedrock. These are filled with alluvial clays, silts, sands and gravels. One of these features extends to a depth of at least 56 m below the valley bottom.

Evaluation and Conclusions of Foundation Conditions

Because of the variation in the physical character of the talus, it should be removed from the foundation area of the dam embankment. The existence of open joints and/or pothole-like features of uncertain origin in the valley bottom will require thorough examination before embankment construction. To permit this examination it will be necessary to remove the alluvium from most of the embankment area. The unweathered chalky limestone and marly limestone bedrock possess adequate strength to support the embankment.

The spillway crest structure will be founded on the fresh marly limestone. These beds have adequate strength for this structure.

The spillway bucket and most of the chute would be founded on the fresh marly limestone. The strength of these beds is great enough to support these spillway structures. Permanent cut slopes in the rock and overburden will be at 1.5H:1V; however, temporary slopes of 1H:IV can be used where they will later be supported by backfill. Temporary

slopes of 0.25H:1V will be used for limited height cuts. However these steep slopes will be supported with rock bolts where it is important to avoid deterioration of the slope.

The diversion tunnel will be driven through beds of the marly limestone. This rock is considered to have characteristics favorable for tunneling and probably can be supported by a conventional support system consisting of steel sets at the tunnel portals and locally in fault zones and zones of altered and weak rock, rockbolts, and shotcrete and wire mesh. Tunnel portals will be designed so that a thickness of at least two diameters of intact rock are above the tunnel crown at the portal.

Evaluation of Maqarin Reservoir Geology

The Maqarin Reservoir will be mainly in valleys eroded into gently dipping beds of the Chalky Limestone Unit, capped in places by basalt flows. The contact between the basalt and the limestone, except in a limited area of the left abutment of the damsite, has generally been found to be higher than El.193 which is the highest of the planned reservoirs. Springs often occur at the contact between the basalt and the chalky limestone. This indicates that the permeability of the basalt-limestone contact zone is lower than the permeability of the basalt which is generally fractured and permeable and that ground water generally drains toward the pre-basalt valleys which form the reservoir. The direction of ground water movement indicates that leakage from the reservoir, except near the damsite is unlikely to be a problem.

Relatively wide valleys have been eroded into the nearly flat lying beds which form the reservoir. This has resulted in generally stable valley sides. These valley sides will remain stable during reservoir operation, and

massive landslides, which could damage the project, are unlikely.

Water will be released from the Maqarin Reservoir at about the same rate as the present flow rates in the Yarmouk River. Thus, no changes in the stability of valley sides are anticipated as a result of using the stream channel as a conveyance route.

Evaluation of the Maqarin Powerplant

The proposed Maqarin Powerplant will be constructed in the marly limestone. These beds have adequate strength to support this structure.

The power tunnel will be constructed in the marly limestone. Tunneling will be by conventional means and ordinary support systems will suffice.

The gate shaft will be placed partly in the marly limestone and partly in the chalky limestone. No unusual difficulties are anticipated in the construction of this feature.

Evaluation of the King Talal Powerplant

The powerplant at the King Talal Project will be located on the right abutment between the downstream embankment and the spillway chute. At this location it will rest upon the Jurassic sandstones, shales and carbonate rocks that form the foundation for the dam. It is anticipated that the geologic conditions that allow construction of the King Talal Dam will also allow the construction of a small powerplant at the site.

Evaluation of the Diversion Damsite at the EGMC Intake

A low dam, approximately 5 m high, will be required to divert river water into the East Ghor Main Canal. This

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diversion dam would be located immediately downstream from the present EGMC intake. Preliminary geologic studies of the site indicate that it is favorable for the construction of the proposed diversion dam.

Construction Materials

Exploration Program

An exploration program was conducted to define potential construction material sources for the dam embankment and for concrete aggregate. Maqarin Dam will be a zoned earth and rockfill dam and will include an impervious core, filters, rockfill and river alluvium shells, rip rap, and an upstream weighting berm.

The exploration program for construction materials included surface mapping, and excavation of 17 test pits. In addition, three boreholes were drilled for a total depth of 93 m to investigate potential sources of chalky limestone and basalt to be used in the rockfill shells, for filter material, and for concrete aggregate. Laboratory testing was done by the Natural Resources Authority and the Ministry of Public Works in Jordan. Selected representative samples were sent to the United States for additional testing. Potential sources of chalky limestone and basalt were investigated to determine their suitability for use as filter, rockfill, riprap, and concrete aggregate. The location of the exploration sites, borrow areas and potential quarries are shown on Exhibit 7.

Shell Material

The shell of the dam will consist of river alluvium, limestone and basalt rockfill obtained from required excavation and from designated quarry areas. The haul distance for

alluvium from Borrow Area U ranges from 200 m to 2000 m; accessibility is good except during high river flow. It is estimated that Borrow Area U will produce about 4,800,000 m^3 of shell material. Borrow Area D has the same haul distance and accessibility. The estimated yield from Area D is 2,700,00 m^3 of alluvial material.

A potential basalt quarry is located about one kilometer downstream from the dam on the right side of the river. Tests indicate that the basalt will produce good quality rockfill and that adequate-size riprap can be obtained. The quantity of basalt, available within an economical haul distance of the dam site, far exceeds the construction material requirements. Recent investigations indicate that a suitable source for basalt rockfill may be located on the left abutment in the vicinity of the dam axis. If additional investigations confirm this source, it would likely be the preferable source of the material.

Impervious Material

Impervious fill materials are available from the required excavation and Borrow Areas B, B1, R1, and R2. These materials exist in alluvial deposits, often covered with talus which is also impervious. The impervious materials consist of medium to highly-plastic clays and clayey gravels. Access to these areas is good. Clayey soils in borrow areas A,A1, J1, J2 and R4 are possible sources of impervious fill if sufficient quantities are not available in the primary areas. Borrow area R3 also is a potential source for fine-grain materials; however, no estimate of material yield has been made. Table III-1 gives a summary of the estimated yields of these borrow areas.

Table III-1

IMPERVIOUS MATERIAL

BORROW AREAS

	Borrow Area	Estimated Yield (m^3)
Primary Areas		
	B1	1,400,000
	B	967,000
	R1	762,000
	R2	672,000
	Total	3,801,000
Secondary Areas		
	A	1,610,000
	A1	75,000
	J1	135,000
	J2	135,000
	R4	675,000
	Total	2,630,000

Filter Material

The proposed embankment section includes thin double-stage filters on both the upstream and downstream sides of the core. There are no naturally occurring filter materials within economic haul distance. Materials which could be processed for filter material include the alluvium, basalt, and possibly the chalky limestone. The basalt appears to be the most attractive source of filter material. This material could be produced in conjunction with the production of concrete agregate.

Concrete Aggregates

The basalt appears to be the most favorable source of concrete aggregates. The laboratory tests indicate that the basalt will not be reactive and will produce satisfactory

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aggregate. The river alluvium is generally unsatisfactory and the chalky limestone and marly limestone would not produce an acceptable concrete aggregate.

Material from Required Excavation

The embankment was designed to use suitable materials from the required excavation. This excavation will result from construction of the tunnels and portals, the spillway, and from the dam foundation excavation.

The Stage II dam foundation excavation will produce the following quantities of material.

Table III-2
DAM FOUNDATION EXCAVATION

Material	Volume (m^3)
Talus	1,677,000
Alluvium	697,000
Marly Limestone	625,000
Chalky Limestone	155,000

The talus can be used in Zone 2 forming the downstream supporting zone of the core of the dam. The dam section is shown on Exhibit 8. The river alluvium is suitable for placement in embankment Zones 4 and 5. The marly limestone is highly weathered and decomposed and is not suitable for embankment fill; however, it can be used in the upstream weighting berm. The chalky limestone can be used in Zone 4.

The spillway excavation will require the removal of the following materials:

Table III-3

SPILLWAY EXCAVATION

Material	Volume (m^3)
Talus and Clay	1,020,100
Basalt	757,000
Marly Limestone	812,000
Chalky Limestone	1,351,000

The clay material is suitable for placement in the impervious portions of the cofferdam or in Zone 1 of the embankment and the talus is suitable for placement in Zone 2. Most of the poorer-quality basalt and a portion of the limestone will be placed in Zone 4. The better quality basalt will be placed in Zone 6. The marly limestone will be placed in Zone 7.

Storage Facilities

Maqarin Dam will consist of a zoned earth and rockfill embankment 128 m high above the streambed. The total volume of the embankment is estimated to be about 14 million m^3. A diversion tunnel, spillway, low-level outlet, and powerplant will be located on or in the left abutment. The location and sections of the storage facilities are shown on Exhibit 8.

At the normal maximum operating level, El. 150 the reservoir will have a total volume of 320 MCM. The area of the reservoir at normal operating level is 7.0 km^2. At minimum operating pool, El. 90, the reservoir will have a volume of 45 MCM and an area of 2.5 km^2. A curve of area and volume versus elevation is shown on Exhibit 8.

Embankment Design

Foundation Excavation. Foundation excavation beneath the dam, weighting berm and upstream cofferdam will consist of stripping of all organic and highly compressible materials and talus. In addition all river alluvium will be excavated from beneath the dam and weighting berm and excavation beneath the shells will be to hard weathered rock. Excavation beneath the core will be to fresh rock.

Foundation Grouting and Drainage. A grout curtain and a grouting gallery will be constructed under the center of the impervious core (Exhibit 8, Sheet 2). Grouting galleries will be provided in both abutments at El. 30, 90, and 158. A single-row grout curtain will be required in the bituminous marl, and a multi-row curtain in the chalky limestone.

Consolidation grouting will be done where required to a depth of six meters. This will serve to seal the upper portion of the core foundation and confine the grout from the curtain grouting.

Under the core, the foundation will be cleaned with air and air-water jets, moistened, and covered with slush grout just prior to placement of the impervious core.

It is expected that beds of the Bituminous Marl Unit are relatively tight and will require only a single-row grout curtain. Costs were based on an average grout take of 60 kg/m^2. Joints in the beds in the Chalky Limestones Unit are open and pervious for their full depth. A multi-row curtain in the Chalky Limestone Unit will tie into the grout curtain in the Bituminous Marl Unit and extend deeply into the abutment. A grout take of 150 kg/m^2 was used for the cost estimate.

Drainage galleries are included in both abutments to intersect seepage passing through and around the grout curtains. Drainage curtains will be constructed by excavating

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drainage adits at El. 30 and 90. Drain holes will be drilled to connect the adits as well as downwards from the lower adits. The drainage galleries combined with the inherent drainage capability of the rockfill shells will prevent the build-up of undesirable water pressure under the downstream portion of the embankment, and improve the stability of the abutments and spillway.

Embankment Design. The investigations and studies have shown that sufficient quantities of satisfactory construction materials are available near the site to construct a high rockfill embankment. An inclined-core, rockfill-shell structure is proposed which can be raised to El. 200.

The zoning configuration is based on the properties of the materials available from required excavation and borrow and a consideration of cost and ease of construction. The embankment configuration was developed in accordance with the strength and quantity of the available materials. The section was analyzed for stability and modified until the safety factors for critical conditions met accepted standards.

Zone 1 will consist of medium to highly plastic clays. Because of their shear strength and relative consolidation characteristics, an upstream inclined core is proposed.

Zone 2 will consist of clayey talus material which is relatively impervious. The material will generally have good shear strength.

Zone 3 will consist of double-stage filters which will provide a transition from the impervious material to the granular shells. The filters also are the primary protection against piping if cracks develop due to differential settling or seismic shaking.

Zone 4, on the upstream side of the embankment, will be constructed of poorer-quality basalt, chalky limestone, and alluvium.

Zone 5 will include the cleaner portions of the river alluvium. This material will be pervious to free-draining.

Zone 6 forms the outermost portion of the downstream shell and the upstream shell in the drawdown zone. This zone will be compacted basalt rockfill. The larger pieces of rock will be pushed to an oversize zone on the upstream slope to provide wave protection.

Zone 7, the upstream weighting berm, will be constructed using materials not suitable for placement in the interior zones of the embankment.

Approximately 14 million cubic meters of material must be obtained either from required excavation or from borrow areas. Table III-4 shows the embankment requirements and the source from which these materials will be obtained.

Instrumentation. Instruments will be placed in the embankment and foundation to monitor their performance during and after construction. The instrumentation will measure seepage, surface movement, pore pressures, and internal movements in the embankment and foundation.

Stability

The embankment was analyzed for stability under two extreme conditions i.e. the lowest crest elevation of 150 m and the highest crest elevation of 200 m. The stability analyses were performed using the Morgenstern-Price limit equilibrium computer method to determine the minimum factor of safety using an effective stress analysis. These analyses indicate that the embankment is stable for the expected loading conditions. Since the embankment is stable at both crest elevations 150 m and 200 m, the embankment at El. 158 (Stage II development) also will be stable.

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Table III-4

EMBANKMENT REQUIREMENTS

(Crest El. 158)

Zone	Material	Source	Quantity Available ($m^3 \times 10^6$)	Quantity Required ($m^3 \times 10^6$)
1	Impervious Clay	Borrow Area B	1.40	2.56
		" B1	0.97	
		R1	0.76	
		" R2	0.67	
		" A,A1,J1,J2,R4	2.63	
2	Impervious Talus	Required Excavation	2.70	1.35
3F	Fine Filter	Quarry QB1	Unlimited	0.30
3C	Coarse Filter	Quarry QB1	Unlimited	0.26
4	Random Rockfill	Borrow Area U	1.92	2.83
		Borrow Area D	1.08	
		Quarry QL2	3.20	
		Required Excavation	2.03	
5	Alluvium	Borrow Area U	2.88	3.14
		Borrow Area D	1.62	
		Required Excavation	0.70	
6	Basalt Rockfill	Quarry QB1	Unlimited	2.94
		Required Excavation	0.23	
7	Random Fill	Required Excavation	1.44	0.94

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The minimum factors of safety obtained for the static analyses are summarized below:

Loading Condition	Crest El. 200		Crest El. 150	
	Upstream	Downstream	Upstream	Downstream
Steady Seepage	1.8	1.7	2.2	1.7
Rapid Drawdown	1.3	-	1.6	-
End of Construction	1.2	1.7	1.8	1.6

Pseudo-static analyses were done using different seismic coefficients. The following tabulation indicates the magnitude of seismic coefficient which results in a factor of safety of 1.1.

Loading Condition	Crest El. 200		Crest El. 150	
	Upstream	Downstream	Upstream	Downstream
Steady Seepage	0.14 g	0.20 g	0.20 g	0.22 g

Detailed stability studies will be done in the design phase when additional laboratory test data become available.

Spillway

Spillway facilities at Maqarin will be capable of passing the probable maximum flood (PMF) without endangering Project structures. The spillway will consist of an approach channel, a gated ogee control section, a straight, constant-width chute, and a flip bucket to direct water to the natural river channel. It will be located in the left abutment and have a discharge capacity of 5,400 m^3/s with 7.5 meters of surcharge on the reservoir. The control section will contain three gated bays with 8.0 m wide by 15 m high tainter gates. A rating curve for three gates-full open is given in Exhibit J-15, Appendix J, Preliminary Design of Storage and Power Facilities. The discharge capacity at normal maximum water surface elevation is 2,820 m^3/s. The spillway weir structure, chute and flip bucket will be founded on the marly limestone. The spillway will support the embankment at the spillway approach channel and control structure.

The spillway will be about 360 m long and have a width of about 26 m. The minimum slope of the chute will be about 8.0 percent to maintain supercritical flow. A bridge will be built across the spillway weir to provide access to the dam crest. The mechanical and electrical equipment for gate operation will be serviced from this bridge.

The spillway crest will be at El. 135 and approach channel to the spillway will be at El. 120 to assure that the design discharge coefficient will be developed. The flip bucket lip at the downstream end of the chute will be at El. 40. The flip bucket will be located so that the plunge pool will occur in the river and not undermine the bucket. The discharge point will be about 8 m above the maximum tailwater elevation so that water will spring free from the bucket without cavitation damage. Large spillway releases will discharge into the Yarmouk River channel about 200 m downstream of the dam which will prevent damage to the embankment from erosion that will occur in the plunge pool area. The area below the bucket will be paved to prevent undermining tendencies at low spillway discharges.

Major excavation will be required for the approach channel, the gate structure, the chute, and the spillway bucket. Part of the excavation will be used in the shell of the dam and in the impervious-talus zone. Excavated slopes bordering the approach, the chute, and the bucket-discharge area are to be 1.5H:1V.

A plan and profile of the spillway are shown on Exhibit 8, Sheet 3.

River Diversion During Construction

The construction diversion facilities consist of upstream and downstream cofferdams and a tunnel located in the left abutment. The concrete lined tunnel will be 900 m long with an internal diameter of 6.5 m. The discharge capacity

will be about 500 m^3/s at a velocity of about 15 m/sec. This capacity corresponds to a flood with a recurrence interval of about 20 years. The tunnel capacity could be increased significantly with a higher cofferdam without much change in cost.

An approach channel 140 m long will lead to the intake portal. The approach channel will be horizontal and approximately at elevation 30 m. The portal excavation will be into a rock face with 10-15 m of rock cover. Excavation slopes will be 0.25H:1V in rock and 1.5H:1V in overburden. A 30 m long discharge channel will extend from the downstream portal to the river channel. The diversion tunnel will be driven through bituminous marl. Conventional methods will be used for excavation and tunnel support.

The cofferdams will have upstream and downstream slopes of 2H to 1V and include an impervious core and a rock shell. The upstream cofferdam will be about 32 m high and contain about 268,000 m^3 of fill. The downstream cofferdam will be 12 m high and include about 38,000 m^3 of fill. The upstream cofferdam will be incorporated into the main embankment. The downstream cofferdam may be removed when the diversion tunnel is closed.

The diversion tunnel will be closed when the dam embankment is up to the crest elevation of the spillway. The closure operation will consist of lowering the closure gate, and installing a tunnel plug. It is expected that closure will occur in the latter part of 1982.

Low-Level Outlet

The low-level outlet facilities will make use of the existing diversion tunnel and will consist of an intake, a concrete-lined inlet tunnel, a steel outlet conduit, a 1.8 m butterfly valve, a 1.5 m Hollow Jet valve, and a 1.5 m cone valve.

The intake structure for the outlet works will be located at El. 50. From the intake water will travel through a 2.3 m concrete-lined tunnel and inclined shaft about 50 m to the diversion tunnel. Under the impervious core, the flow will be confined to a 1.8 m steel pipe. A butterfly valve will be used to control flow into the steel pipe. Access to this valve will be through the lower drainage adit. A valve house will be located at the downstream end of the pipe and will contain a cone valve and a Howell Bunger valve. The capacity of the outlet works at minimum operating level is 20 m^3/s; sufficient to meet the peak irrigation requirements. Using only the outlet works, the reservoir can be lowered 20 m below the normal operating level in about two months.

Power Facilities

The power facilities that will be included in Stage II development are a powerplant at Maqarin Dam and a powerplant at King Talal Dam. The power features include the intake structure, water conductors, powerhouse structure and electro-mechanical equipment, and transmission facilities including substations.

Powerplant at Maqarin Dam

The powerplant at Maqarin is located about two kilometers downstream from the dam on the left bank. The plant will have an installed capacity of 20 MW in two generating units. The plant will be designed to operate under the full range of Stage II conditions. The plan and section of the powerplant are shown on Exhibit 9.

Water Conductor. The power intakes will be located slightly up-reservoir from the spillway approach channel. The intake structure will consist of a reinforced-concrete box structure with trashracks on the upstream face. The

intake will be at El. 80. An approach channel about 50 m long will be excavated to the intake structure.

The water conductor will consist of a 3.2 m diameter tunnel 1730 m long, a 2.3 m diameter tunnel 150 m long and a bifurcation at the power units. The 3.2 m tunnel will be concrete-lined; a steel liner 22 mm thick will be required near the powerplant where the tunnel has limited rock cover. The tunnel diameter will be 2.3 m where it requires a steel liner. Maximum velocity in the 3.2 m tunnel is 2.5 m/s. The water conductor will be located in the marly limestone. Conventional methods will be used for tunnel excavation and support.

The gate shaft will be located about 250 m downstream from the intake structure. The shaft and superstructure will be about 120 m high with the top of the shaft at El. 200. The gate shaft will house two in-line 3.2 m by 3.2 m clear-opening wheel gates.

The surge tank will be located about 320 m upstream from the powerhouse. The tank will be about 180 m high and have an internal diameter of 3.2 m.

Powerhouse. The Maqarin powerplant will be a conventional structure, 20 m long and 19 m wide. The house will include a machine hall with two generating bays, an erection bay and a control area. The minimum foundation level will be at El. -1.0 and the distributor will be at El. 3.0.

The installed capacity will be 20 MW in two units. Each generator will have a nominal rating of 11.1 MVa, 0.9 pf at 60° C temperature rise and will be capable of continuous operation at 115 percent of rated kVa without injurious temperature rise. The generators are designed to permit generation with a maximum turbine discharge of 20 m^3/s at maximum head. The turbines will be vertical-shaft Francis-type machines with a design head of 120 m. The turbines are

designed to release 20 m^3/s, which is the irrigation system capacity, at minimum head. The operating speed of the turbine will be 750 revolutions per minute.

Transmission. One three-phase power transformer will serve both units. It will be oil insulated, self cooled and rated at 26 MVa, 13.8/66 kilovolts (kV). A single-circuit 66 kV transmission line will lead from the switchyard to Irbid, about 30 km away. A one-line diagram of the major electrical features is shown on Exhibit 10.

Access

Access to the Project Area will be by existing roads from Irbid or by railroad from Der'a, Syria if suitable arrangements can be made.

In the construction area, the existing road will be relocated to provide access to the dam crest, the base of the dam, and the powerplant. Approximately four kilometers of access road will be required.

Relocation

The relocations required as a result of the Project include only the re-routing of the Himma Railroad. The relocation was designed for a maximum grade of two percent and a minimum horizontal radius of curvature of 120 m. The railroad was relocated to El. 165 and the relocated length was 21.5 km. The relocation is discussed in more detail in Appendix J, Preliminary Design of Storage and Power Facilities.

Powerplant at King Talal Dam

The powerplant at King Talal Dam will have an installed capacity of 2 MW in one generating unit. A plan and sections of the powerplant are shown on Exhibit 11.

Water Conductor. The existing low-level outlet and diversion tunnel will be used for the power facilities. The intake for the existing outlet works is at elevation 116 m.

The outlet tunnel has a diameter of 3.5 m and passes through a valve chamber prior to joining the diversion tunnel which has a diameter of 6.5 m. The existing valves in the valve chamber will be replaced by spherical valve. The flow diameter of the water conductor will be reduced from 6.5 m in the diversion tunnel to a steel pipe which will bifurcate into a 1.50 m bypass pipe and 0.75 m penstock. The penstock will be placed in a 2.0 m unlined tunnel from the diversion tunnel to the powerplant. A 2.0 m tailrace tunnel will discharge back into the outlet portion of the diversion tunnel.

A spherical valve will be located immediately above the powerhouse. A butterfly valve and a 0.75 m ring-jet valve will be installed in the by-pass.

Powerhouse. The King Talal powerhouse will be a pit-type structure 13 m long and 7 m wide. The house will include a machine area and an erection area. Control facilities will be located in the machine area. The minimum foundation level will be at El. 70 and the powerhouse roof will be near ground surface at El. 90.

The turbine will be designed to produce 2.0 MW at a rated head of 67 m and a rated discharge of 3.4 m^3/s. The generator will be rated 2,222 kVa, 0.9 power factor at 60 degrees centigrade temperature rise. The generator will be capable of continuous operation at 115 percent of rated kVa without injurious temprature rise. The turbines will be vertical-shaft Francis-type machine operating at a speed of 1000 revolutions per minute.

Transmission. The three-phase power transformer will be oil insulated, self-cooled and rated at 2,600 kVa, 2.4/33 kV. A single-circuit 33 kV transmission line will connect with the Amman-Salt transmission line at a substation about 9 km from the powerstation. A one-line diagram of the major electrical features is shown on Exhibit 12.

Diversion to the East Ghor Main Canal

The diversion facilities for Stage II development will consist of a diversion weir constructed across the Yarmouk River immediately downstream from the existing intake for the EGMC and a sediment sluiceway. The dam will divert up to 20 m^3/s. The design of diversion structure, as shown on Exhibit 13, has been taken from the Yarmouk Project Report[1/].

The diversion structure will be an uncontrolled concrete weir about 60 m long. The top of the weir will be approximately at El. - 202.5; the weir will be about 5.5 m high. A 0.8 m diameter steel pipe will be embedded in the overflow section to provide releases for the Yarmouk Triangle area. A spherical valve will be installed at the downstream end of the pipe.

The desilting facility consists of an open channel parallel to the river at the entrance to the intake. The channel is 2.5 m wide and the depth ranges from 0.7 m at the upstream end to 1.27 m at the downstream end. The slope of the channel is three percent. A parallel training wall separates the desilting works from the riverbed. The function of the wall is to direct the flow towards the upstream part of the desilting works. The sediment can be flushed from the channel by raising the tainter gate at the downstream end.

Side Wadi Diversion Structures

A portion of the flow of Wadis Yabis, Kufrinja, and Rajib are available to meet the irrigation requirements of the Project. From an inspection trip, it was learned that

1/ Yarmouk Project, Khalid Bin Al Walid - Wadi Arab Scheme, Energoprojekt, June 1967.

no weir is presently located on Wadi Rajib, that the weir on Wadi Kufrinja is damaged, and that the weir across Wadi Yabis is in fairly good condition. Estimates of capacity of the diversion were made and discussions were held with members of the NRA on operation and capacity.

Suitable mapping is not available for preliminary design or rehabilitation of these weirs. Therefore, locations and required repairs were determined in the field and costs of improvements were estimated on the basis of a typical diversion weir and connecting canal to the EGMC. Layouts of these typical features are shown on Exhibit 14.

The typical diversion shown is very similar to existing structures. The structure will be a buttress-type check with an uncontrolled spillway in the center of the structure. Low-level releases can be controlled by stop logs. Flow into the diversion canal will be regulated with a 0.65 m by 0.8 m sluice gate located at the entrance to the canal. The diversion canal will be a rectangular concrete-lined structure 0.8 m wide and 0.65 m deep.

Wadi Yabis Diversion

The diversion is located about one kilometer east of the Jordan Valley highway. The diversion and connecting canal are now operating and do not require much repair work. The accumulated sediment will be removed and the rockfill embankment which has eroded away will be replaced on the abutments of the weir. The concrete bulkhead, used as a check facility, will be replaced by reinforced concrete stoplogs.

Wadi Kufrinja Diversion

A new diversion will be installed across Wadi Kufrinja immediately upstream from the existing diversion . A new 1700 m long lined canal will connect with the EGMC.

Wadi Rajib Diversion

A new diversion will be located about 100 m to the west of the Jordan Valley highway. The weir will be 40 m long; the connecting canal to the EGMC will be 400 m long.

Irrigation System

The irrigation system will serve 11,927 ha in the EGCP area currently being supplied by a gravity irrigation system, 2132 ha currently supplied by wells and the base flow of side wadis, and 11,294 ha of unirrigated land. The irrigation system will include a 14.5 km extension to the main canal, 18-25 pumping stations, about 1000 km of asbestos cement pipe for the pipe network, a farm distribution system, and drainage facilities. Additional discussion and details of the irrigation system design are reported in Appendix K, Preliminary Design of Irrigation Facilities. A layout of the irrigation system is shown on Exhibit 15. Layouts at a scale of 1:10,000 are shown in Annex K-1 to Appendix K.

General Design Concepts

There are five primary design concepts that were adopted for these studies. They are as follows:

1. Sprinkler irrigation was adopted as the method of irrigation. This selection was based on the difficulty and cost of land grading, the relatively high efficiency of sprinklers over surface methods, the rather shallow soils of the Valley, and the relative costs of the combination of labor and sprinkler equipment. The use of alternative irrigation systems is discussed in Appendix K.

2. A semi-portable farm system consisting of a fixed buried asbestos-cement farm main and a portable flyline will be used.

3. Water will be delivered on a rotation basis rather than on demand in order to reduce the construction cost.

4. Gravity will be used to supply the pressure required for sprinklers whenever feasible.

5. A group of farms, usually about 20 in number, will be served from one headgate unit main pipe.

Design Criteria

The design of a complex irrigation system requires that many general and specific criteria be adopted. The more important criteria are summarized below:

New Areas. The layout criteria for the new lands conform with Temporary Law No. (18) for the year 1977, Jordan Valley Development Law. This law is briefly discussed in Chapter V under Land Reform. The main criteria for the new areas are as follows:

1. The area of each farm plot will range from three to five hectares. The shape will be rectangular and the dimensions will be approximately 216 m by 180 m.

2. Farms will be grouped into "Tertiary Headgate Units" where groups of farms have one common headgate unit main (HUM) pipeline supplied from one turnout on the distributory main. Each farm plot will have an individual turnout on the HUM pipeline leading to a farm main.

3. The required pressure at the headgate main turnout on the distribution pipe will be at least 3.5 kg/cm^2.

4. All pipelines will have 10 m wide right-of-way and surface drainage ditches on their lower sides.

Conversion Areas. The sprinkler layout will follow the existing farm boundaries. The farm plots will remain as they were divided during the initial stages of the East Ghor Canal Project. The pipes will be aligned along the existing roads next to the lined canals rather than in the canals.

Farm System. The sizing of the farm-system components will be based on meeting the peak irrigation requirement of alfalfa irrigation 23 hours per day, six days per week. Alfalfa was used because it represents a water use greater than the use estimated for the average cropping pattern.

Pressure-Pipe Network. The capacity of the system through the headgate unit mains will be based on supplying the peak requirement of an average cropping pattern. The design requirement is determined by making the following adjustment:

Area less than 100 ha - add 60 percent
Area from 100 ha to 250 ha - add from 60 to 25 percent
Area greater than 250 ha - add 25 percent

Main Canal Extension. The more important design criteria applicable to the extension of the main canal are as follows:

A slope of 28 cm/km was adopted for the entire length of the extension.

A concrete-lined trapezoidal section with side-slopes of 1.5H:1V was used.

An interceptor ditch would be located on the uphill side when necessary.

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Pumping Plants. A summary of the design criteria used for the pumping plants is as follows:

Centrifugal pumps driven by electric motors would be used. A 33 percent standby capacity would be provided.

One-stage pumping facilities were used regardless of the pressure requirements. No stand-by generators were provided.

Irrigation System Layout

An irrigation network layout for the converted and new-land areas has been made on available 1:10,000 scale maps (Annex K-1). No layout was prepared for the potentially irrigable lands (1947 ha) because these lands are not yet mapped.

From the layouts, it has been determined that 12,662 ha will be supplied by gravity, 7,894 ha by low-head pumping plants, and 2,850 ha by high-head pumping plants. Low-head pumping refers to stations acting as booster pressure stations for areas adjacent to and below the EGMC to which water would flow by gravity. The pumps provide the pressure required to operate the sprinklers. High-head pumping is required for areas which lie above the EGMC and require pumps to lift the water as well as to supply pressure for the sprinkler systems. For the very high head pumping areas single-stage pumping is provided in conjunction with pressure regulators.

Irrigation System Design

Pumps. All pumps will be centrifugal pumps working under positive pressure. The pumps will be driven by electric motors. Power will be available from the grid planned for the Valley. The large pumping stations will include operator's living area, an office, a small workshop, and an overhead crane.

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Pressure-Pipe Network. The diameter of the pipes was based on delivering the peak irrigation requirement at the desired pressure. The pipes were sized using an economic analysis which indicated the minimum total cost, including the cost of furnishing and installing the pipe and the cost of the energy required to overcome the friction loss. For the gravity system, the major constraint was to limit the velocity in the pipes to 2.0 meters per second.

Farm Distribution System. The farm system will include a turnout assembly, farm mains and hydrants, and portable aluminum flylines. The turnout assembly consists of a pressure regulator, a gate valve, a flow regulator, and a flow meter. The farm mains will be 100 mm asbestos cement pipe with risers every 54 m. The flylines, for the recommended size plot, will be about 180 m long and have 15 sprinkler heads.

Surface Drainage. The surface drainage system will consist of interceptor drains collecting water from the farms and main drains which collect water from the interceptor drains and transport it to the Jordan River or to a sink for evaporation. All drains will be unlined canals. The interceptor drains will have a capacity equal to 1.0 liter per second per hectare from the farm areas above them. The main drains will be sized at 40 percent to 70 percent of the interceptor drain design flow.

Sub-surface Drainage. Subsurface drainage facilities for 500 ha are included in the initial construction phase. An observation well network will be installed to monitor the water table throughout the service area. If drainage problems are observed in certain areas drainage facilities will be installed based on data collected from this network and

piezometers. In addition to the 500 ha, it is anticipated that an additional area of 200 to 300 ha will require drainage annually. The cost for these drains has been included in the annual maintenance cost of the Project.

Chapter IV

COST ESTIMATES

Cost estimates have been prepared for the Stage II Project Facilities described in Chapter III. The costs used in these estimates represent the prevailing rates during January 1977. The estimates are based on the assumption that the project will be constructed by international contractors without restriction on sources of supplies and equipment. Estimated costs have been separated into national and foreign currency components. All costs are expressed in Jordan Dinars (JD) with an exchange rate of JD 1.00 equals U.S. $3.00. Cost estimates for all facilities included in the Stage II development have been prepared at feasibility level.

Project Construction Costs

The Project construction cost includes acquisitions, relocation and access, civil works, electro-mechanical equipment, contingencies, escalation during construction, and engineering and administration.

The national component of the cost includes construction labor, fuel, and lubricants. The foreign component includes costs of supervisory personnel, construction equipment and spare parts, cement, reinforcing steel, piping and electrical materials, and permanent mechanical and electrical equipment.

A summary of the construction costs for Stage II development is shown in Table IV-1. The construction costs for the recommended Stage II development are presented in detail on Exhibit 16. Total costs are shown with and without the cost for the portable farm system. The portable farm system is not considered as a project cost; however, it is a cost that initially will be met by the JVA.

Table IV-1

SUMMARY CONSTRUCTION COSTS
Stage II Development

(JD 1,000)

Item	National Currency	Foreign Currency	Total
Storage Facilities-Maqarin Dam El. 158			
Acquisition, Relocations, Access	2,361	4,236	6,597
Operator's Village	100	400	500
Diversion and Control of Water	1,182	2,301	3,483
Main Dam	11,489	19,622	31,111
Spillway	5,799	10,565	16,364
Low-Level Outlet	159	254	413
Sub-total	21,090	37,378	58,468
Power Facilities - Maqarin Dam			
Powerplant and Water Conductor	911	1,162	2,073
Mechanical and Elect. Equipt.	265	1,162	1,427
Transmission	187	346	533
Sub-total	1,363	2,670	4,033
Power Facilities - King Talal Dam			
Powerplant and Water Conductor	27	45	72
Mechanical and Elect. Equipt.	64	207	271
Transmission	43	79	122
Sub-total	134	331	465

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1,59

1,590 JD/ha.

Table IV-1 (Cont'd)

SUMMARY CONSTRUCTION COSTS
Stage II Development

(JD 1,000)

Item	National Currency	Foreign Currency	Total
Diversion Facilities			
Yarmouk Near Adasiye	42	86	128
Wadi Rajib	15	33	48
Wadi Kufrinja	26	58	84
Wadi Yabis	1	2	3
Sub-total	84	179	263
Sub-total - Storage, Power, and Diversion	22,671	40,558	63,229
Irrigation Facilities			
Main Canal Extension	364	1,034	1,398
Main Canal Repair	164	326	490
Sub-total	528	1,360	1,888
New Lands (Land Groups A&B - 10,524 ha)			
Pressure Pipe Network	1,187	6,593	7,780
Farm Systems (Fixed Components)	360	2,040	2,400
Pumping Stations	757	1,776	2,533
Drainage	766	928	1,694
Miscellaneous	457	835	1,292
Sub-total	3,527	12,172	15,699
Farm Systems (Portable Component)	105	945	1,050
Sub-total	3,633	13,117	16,750

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Table IV-1 (Cont'd)

SUMMARY CONSTRUCTION COSTS
Stage II Development

(JD 1,000)

Item	National Currency	Foreign Currency	Total
Converted Area (Land Group C - 12,842 ha)			
Pressure Pipe Network	2,270	11,320	13,590
Farm Systems (Fixed Components	420	2,380	2,800
Pumping Stations	465	1,085	1,550
Drainage	312	314	626
Miscellaneous	724	1,275	1,999
Sub-total	4,191	16,374	20,565
Farm System (Portable Component)	175	1,575	1,750
Sub-total	4,366	17,949	22,315
Potential Lands (Land Group D - 1947 ha)			
Without Portable Farm System	1,928	4,497	6,425
With Portable Farm System	1,947	4,673	6,620
Sub-total Irrigation			
Without Portable Farm System	10,174	34,403	44,577
With Portable Farm System	10,473	37,099	47,572
Subtotal Direct Costs			
Without Portable Farm System	32,845	74,961	107,806
With Portable Farm System	33,144	77,657	110,801

Table IV-1 (Cont'd)

SUMMARY CONSTRUCTION COSTS
Stage II Development

(JD 1,000)

Item	National Currency	Foreign Currency	Total
Without Portable Farm System			
Sub-total Direct Costs	32,845	74,961	107,806
Contingencies	5,095	11,625	16,720
Total Direct Costs	37,940	86,586	124,526
Engineering and Administration	7,670	11,504	19,174
Total Construction Cost-1977	45,610	98,090	143,700
Assumed Escalation to end of Construction	26,980	38,070	65,050
TOTAL CONSTRUCTION COST	72,590	136,160	208,750
With Portable Farm System			
Sub-total Direct Costs	33,144	77,657	110,801
Contingencies	5,090	11,929	17,019
Total Direct Costs	38,234	89,586	127,820
Engineering and Administration	7,670	11,504	19,174
Total Construction Cost-1977	45,904	101,090	146,994
Assumed Escalation to end of Construction	26,656	37,090	63,746
TOTAL CONSTRUCTION COST	72,560	138,180	210,740

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Land Acquisition

The allocation for land acquisition for the Maqarin storage project will include all land in the reservoir plus lands for project structures, the relocation of the Himma railroad, borrow areas, and temporary structures. These areas comprise a total of about 13 km^2 of which 8.7 km^2 are in the Stage II reservoir area. The value of these lands has been estimated on the basis of field inspections and discussions with appropriate local agencies.

Civil Works

Estimates of construction quantities were made on the basis of layouts for the proposed structures. The unit prices were calculated for each operation using standard equipment and conventional construction practices. An allowance was made for contractor's overhead and profit which was based on current international practices. Overhead and profit were prorated and added to the direct costs of all items. The major items included in contractor's overhead are supervisory, administrative, and general service personnel; vehicles, office equipment and supplies; office, shops, and housing facilities; and communications, insurance, performance bonds, taxes, and home office overhead. Unit prices were calculated for all the principal work items. Other costs for minor work items and equipment that would be included under general construction contracts have been based on estimates received from manufacturers and previous bid experience. Customs duties on imported items are excluded.

Permanent Equipment

The major items of permanent equipment include turbines, generators, governors and their control systems, the powerhouse gantry crane; the switchyard equipment including transformers, circuit breakers, and controls; and the transmission facilities.

It is anticipated that all of these items of equipment will be provided under separate supply contracts. These supply contracts will be let at about the same time as the general construction contract.

Contingencies

A contingency allowance is included in the cost estimate for unforseen site conditions, possible omissions, approximations, and the chance of future design changes. For the feasibility-level estimates, an allowance of 20 percent was used for the storage facilities and the railroad relocation, 10 percent for the electrical and mechanical equipment and the irrigation facilities, and 15 percent for all other items. The contingency allowance for the storage facilities has been increased from 15 percent in the draft feasibility report to 20 percent in this report. The increase was made primarily to provide an additional sum for more extensive foundation treatment if further investigations show this to be necessary.

Engineering and Administration

Indirect costs for engineering services prior to and during construction and for administration costs of the owner chargeable to the Project are based on previous experience for similar projects. It has been estimated that 15 percent of the total direct costs will be adequate for engineering and administration. It is assumed that the local component of these costs will be about 40 percent of the total and the foreign component will be 60 percent.

Escalation During Construction

The cost escalation allowance for civil works and mechanical and electrical equipment is established under the assumption of an escalation rate of 8.0 percent per year for foreign currency costs and 12 percent per year for national currency costs. Escalation covers the period from January 1977 (the time of the estimate) until construction is complete.

Annual Operating Costs

The annual operating costs include the costs of operation and maintenance (O&M) for the various features, the cost of replacing short-life equipment, administration by the owner, and insurance.

Experience data collected by the U.S. Federal Power Commission[1/] was used as a basis for estimating operating costs for the storage and power facilities. The operating cost for the irrigation facilities was based on an assessment of the cost of required personnel, equipment, spare parts, energy, materials and supplies, and general property maintenance. The energy cost is based on the assumption that the power and energy requirements for the irrigation system will be supplied from Project facilities. The energy cost consists of a charge for exchanging energy with the JEA, including provision for transmitting power and energy over the interconnected system, because Project facilities cannot supply all of the required energy when needed. In addition, an allowance for installing a subsurface drainage system at the rate of 250 ha per year was included.

About 15 percent of the operating cost for the irrigation facilities is for energy and spare parts drive the pumps located along the main canal. Personnel account for about 53 percent. The operation staff will consist of more than 200 people including office workers, and skilled and unskilled laborers. Equipment for transportation of personnel and for maintenance of the system accounts for an additional 19 percent. The remaining 13 percent will be used for office supplies and materials, spare parts, and general property maintenance. The annual costs are shown in Table IV-2.

1/ Hydroelectric Power Evaluation, Federal Power Commission, 1968.

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Table IV-2

ANNUAL OPERATING COSTS

Facilities	Cost of Operation Maintenance, Replacement Administration and Insurance
	JD x 10^3
Storage Facilities	205
Power Facilities	
Maqarin Dam	45
King Talal Dam	13
Irrigation Facilities	
Personnel	450
Equipment	166
Energy and spare parts	128
Miscellaneous	110
Total	854
Subsurface Drainage Installation	130
Total Annual Operation Costs	1,247

Chapter V

LAND AND WATER RESOURCES

Land Resources

The objective of the land resources study was to determine the extent, location, and quality of arable land found in the Project Area. A reclassification of lands not yet included in any sprinkler irrigation scheme was done according to the sprinkler irrigation specifications for land classification followed by the U.S. Bureau of Reclamation, with certain modifications to suit local conditions. Details of the work program and results of the investigations are presented in Appendix F, Soils.

Topography

The Project Area is enclosed by natural boundaries; the Yarmouk River in the north, the Dead Sea in the south, the Jordan River in the west and an escarpment in the east. The Project Area consists of a terrace adjacent to the escarpment, a transitional zone consisting of highly eroded lands, and a flood plain. The terrace, transition zone, and flood plain are referred to as the Ghor, Katar, and Zor, respectively.

The Ghor is 30 m to 60 m above the Jordan River and slopes toward the river at a rate of about two percent. In the north, the Ghor is from two to four kilometers wide, increasing to six kilometers farther south.

The North Ghor, north of the Zarqa River, consists of a series of alluvial fans with a gradient seldom greater than four percent. The majority of the area in the South Ghor is characterized by long, gentle slopes, well suited to irrigated agriculture. Minor amounts of levelling and vegetative removal will be necessary.

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In the transitional area between the Ghor and the Zor, the land is highly eroded and generally unsuited for agriculture.

The Zor is a minor valley one to two kilometers wide which is subjected to annual flooding. The Zor area is characterized by old stream channels which have been filled by flood action. Thick growths of cane and salt cedar are prevalent.

Soils

The description of soils in the Project Area is based on a review of previous studies which include the Baker-Harza report on the Yarmouk-Jordan Valley Project Master Plan, a special Salinity/Alkalinity study by the Institute of Pedology and Technology of Yugoslavia, and a soil classification study by Dar Al-Handasah and Nedeco.

General Description of Soils. The soils in the Project Area are generally immature, relatively low in organic material, and highly calcareous and gypsiferous. The majority of these soils are permeable.

The soils originated from material of three main deposits; lacustrine sediments, fluviatile-colluvial sediments, and alluvial sediments. The lacustrine sediments are composed primarily of Lisan Marls deposited during the Middle Pleistocene period. Lisan Marls are composed mainly of thinly laminated beds of alternating layers of white gypsiferous chalks and grey calcarious marl. The fluviatile-colluvial sediments consist of eroded material from the Eastern Uplands which are composed of limestone, sandstone, and local deposits of basalt. The alluvial sediments, which are recent fluviatile sediments, are found in the Zor and in the flood plains of the side tributaries. The origin of these sediments is mostly untraceable.

The soils of the Ghor have been formed primarily from alluvial materials. In the North Ghor, the soils range from moderately fine to fine-textured loams, silty clay loams, clay loams, and clays. The moderately fine-textured material covers more than 75 percent of the North Ghor; the fine textured materials are derived mainly from Yarmouk River sediments. The soils of the North Ghor are medium deep to deep ranging between 45 cm and 90 cm, have good water holding capacity and are quite fertile. Salinity and alkalinity problems occur on only about five percent of the arable area. These problems are generally associated with drainage deficiencies.

The most favorable soils of the South Ghor are located on the broad, smooth, gently sloping fans of Wadis Shueib, Kafrein, and Hisban. The soils range from moderately fine-textured silty loams to moderately course-textured sandy loams. Soils on these fans are deep, porous, and relatively free of soluble salts and alkalai. In the northern part of the South Ghor, clay loams predominate and the soluble salt content is relatively high.

The Zor soils are young and show very little profile development. The soil texture ranges from moderately fine to moderately coarse.

Soil Fertility. The analytical data show that the chemical properties of the soils throughout the Valley are quite consistent. The differences are too insignificant to vary the recommendations for the quantities and types of fertilizer used. From the analysis of these data, it is recommended that heavy nitrogen dressings be applied. The phosphorous content is sufficient for crop requirements, and only enough need be added to maintain present levels.

Potassium fertilization is expected to be unnecessary prior to the year 2000.

Soil Salinity and Alkalinity. About 8700 ha in the Stage II Project Area have salinity/alkalinity problems and about 95 percent of these areas are located in the South Ghor. The majority of this land is located at the lower edge of alluvial fans and is not irrigated. Salinity problems are almost exclusively caused by fossil salts present in underlying lacustrine sediments. By upward moisture movement and diffusion, salts have penetrated into the fluviatile-colluvial cover. The soluble salts are mostly chlorides; large amounts of gypsum also are present. Table V-1 indicates the areas involved and the degree of the problems.

Table V-1

AREAS AFFECTED BY SALINITY/ALKALINITY[a/]
(hectares)

	Non or Slightly Alkaline	Moderately or Strongly Alkaline	Total
Slightly Saline	850	550	1400
Moderately Saline	200	1400	1600
Strongly Saline	700	4900	5600
Sodic (Solonchak)		100	100
Total			8700

a/ Data from maps prepared by the Institute of Pedology and and Technology, Zagreb, Yugoslavia. Salinity/Alkalinity classification criteria given in Soils and Irrigation Appendix.

The areas which require leaching have not been defined. In 1955, the Baker-Harza Report stated that approximately 8,450 ha required leaching. Of this total, a substantial

area has been reclaimed, mostly by farmers. Recommendations for leaching are given in a subsequent section.

Permeability. Field investigations were conducted by Baker-Harza in 1954 to obtain the permeability and inter-water movement rates of various soils under undisturbed field conditions. Yarmouk River water, class C2-S1, was used. These infiltration studies were done in accordance with the method given in Salinity Laboratory Handbook No. 60, U. S. Department of Agriculture.

Thirty eight sites were selected to represent typical areas. Below are the ranges of final uniform infiltration rates for the various soils.

Soil Type	Infiltration Rate mm/hr
Clay	0.5-5
Clay loam, Silty clay loam	5-25
Silt loam, Loam	25-40
Loam, Sandy Loam	60-100+

Infiltration rates in non-saline soils were generally very satisfactory with the exception of a few observations in the northern part of the Project Area.

Some of the saline soils had slow infiltration rates because of a compact carbonate gypsiferous layer existing about 25 cm to 40 cm below the surface. Indications are that mechanical probing of these soils would increase the permeability and aid in reclamation. Adequate drainage will be required to maintain productivity once the soils have been reclaimed.

Present Land Use

The best available information on land use is reported in the Agricultural Census in the Ghors, 1975. The crop

groups grown on the cultivable area are shown in Table V-2. Since some areas are double cropped, the total cropped area exceeds the cultivable area by a small margin. The cropping intensity in 1975 was about 106 percent.

Table V-2

CROPS GROWN IN THE VALLEY, 1975

Crops	Area in ha[a/]
Fruit	2,572
Vegetables	11,437
Field Crops	9,364
Total Cropped Area	23,373
Cultivable Area	21,960

a/ Includes immature fruit trees and temporary fallow.

Available data from the 1973 and 1975 Agricultural Sample Surveys in the Ghors and other sources of historical data indicate the following production trends over the last seven years:

Production Trends

Crop Type	Area	Yield	Production
Fruit	Up slightly	Constant	Up Slightly
Vegetables	Increasing	Improving	Increasing
Field Crops	Decreasing	Increasing	Constant

Total agricultural production has almost doubled in the last seven years. Bananas and lemons occupy over half of the area planted to fruit trees. Tomatoes are the most widely grown vegetable, accounting for 40 percent of the land planted to vegetables. Wheat accounts for about 75

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percent of the field crop area. About 70 percent of the vegetables come from autumn-sown crops. These vegetable crops have the advantage of lower water requirements, higher prices, and ease of cultivation. Yields of autumn-sown vegetables appear to be about 10 percent less than crops sown in the spring.

From the available data, an estimate was made of the existing land use on the Stage II lands. Land use is presented for two land areas each of which are subdivided into irrigated and non-irrigated lands. The total Project area is 25,353 ha. The Conversion Area is the land that is presently commanded by the EGMC and includes 11,927 ha currently irrigated by surface methods and 915 ha currently unirrigated. The New Land Area consists of 10,379 ha currently unirrigated and 2,132 ha currently irrigated from side wadis and wells but which are not part of any irrigation project. An estimate of the land use on these areas is given in Table V-3.

Table V-3

ESTIMATED LAND USE IN THE PROJECT AREA
1975-1976
(ha)

	Conversion Area		New Land Area	
Crop	Irrigated	Non-Irrigated	Irrigated	Non-Irrigated
Field	5,248	300	1,050	-
Vegetables	5,486	-	850	-
Fruits	1,908	-	-	-
Total Crop Area	12,462	300	1,900	-
Cultivated Area	11,927	300	1,900	-
Waste/Grazing	-	615	232	10,379
Total	11,927	915	2,132	10,379

The cropping intensity for the cultivated land is estimated to be as follows:

Crop	Intensity
Wheat	0.36
Barley	0.08
Tomato	0.17
Eggplant	0.09
Pepper	0.01
Squash	0.07
Cucumber	0.02
Beans	0.03
Cauliflower/Cabbage	0.02
Other Vegetables	0.01
Watermelon	0.04
Oranges	0.05
Lemons	0.04
Grapefruit	0.04
Bananas	0.02
Other Fruit	0.01
Total	1.06

Land Reclassification

Previous land classification studies have been based on the assumption that irrigation would be accomplished using surface methods. Reclassification was done using specifications required for sprinkler irrigation for all lands not presently included in a sprinkler irrigation scheme. Generally, the specifications of the U.S. Bureau of Reclamation were followed. Certain modifications were made to suit local conditions.

The reclassification was based on land classification photo maps prepared by Baker-Harza in 1955 and a soil map prepared by Dar Al-Handasah and Nedeco in 1969. Field checking was done where necessary.

Upgrading of lands from one arable land class to another and from non-arable land to arable land was done by reviewing the deficiencies and characteristics reported in previous studies in view of the specifications for sprinkler irrigation. The main characteristics used as criteria for the reclassification were texture, depth, soil salinity, drainage, slope, and cover.

The Project Area has been divided into the following land groups according to their location and their stage of development. The location of these land groups is shown on Exhibit 4. The gross areas have been reduced by six percent to provide for farm buildings, roads, and other infrastructure in order to determine the net irrigable area.

Land Group A. This land group is located between the end of the 18-km extension of the EGMC and the Dead Sea. The gross area of Land Group A is 10,107 ha, of which 9,483 ha will be irrigated by Project facilities. This land group includes 1,610 ha that are currently being irrigated with a surface system.

Land Group B. This group is located between the Zarqa Triangle Area and the Wadi Yabis, above the East Ghor Main Canal. The gross area is 1,146 ha of which 1,081 ha will be irrigated. This area was not included in previous schemes because of its elevation above the Main Canal.

Land Group C. This group includes the area commanded by the EGMC that is to be converted from surface to sprinkler irrigation. It includes both Ghor and Zor land from the Yarmouk River to the end of the 8-km extension to the EGMC and is referred to as the Conversion Area. The gross area in Land Group C is 13,672 ha; the net irrigated area will be 12,842 ha.

Land Group D. This group is composed of seven small areas located in the valley areas of the Yarmouk River, the Zarqa River, and Wadis Ziglab and Kufrinja; and above the EGMC in the vicinity of the Zarqa River and the 18-km extension area. The gross area in Land Group D is about 2,630 ha of which 1,947 ha will be irrigated. These lands have not been systematically classified.

Study Results. The results of the reclassification studies are shown in Table V-4. Refer to Exhibit 4 for location of the various land groups and to Exhibit 17 for the graphic presentation of the results of the reclassification. The specifications for the land classification are shown in Table V-5.

Classes 1, 2, 3 and 4 are arable and irrigable with progressively greater limitations. Class 4 defines saline areas which require leaching.

In addition to the lands included in the on-going sprinkler irrigation projects, there are about 27,000 ha of arable land in the Valley. This total includes 2,000 ha of potentially irrigable lands which have not been previously classified. To meet the Stage II goal of irrigating 36,000 ha, most of the potential area must be used. Therefore, a land classification survey is required for these lands. Recent aerial photos and new topographic maps will be needed.

Approximately 40 percent of the gross area, excluding the area of on-going projects, has been identified as Class 1 land. After reclamation, this percentage will increase to 50 percent. These lands are suitable for intensive agricultural development at moderate cost, and they are capable of growing a variety of crops.

Table V-4

LAND RECLASSIFICATION IN THE PROJECT AREA
(Gross Area in Hectares)

Land Class or Type	Land Group[a/] A	B	C	D	Total
1	2,689	222	8,662	-	11,573
2	2,209	541	2,676	-	5,426
3	916	383	881	-	2,180
4 (1) b/	2,020	-	225	-	2,245
4 (2) b/	2,165	-	228	-	2,393
4 (3) b/	108	-	-	-	108
Unclassified (Potentially Irrigable)	-	-	-	2,630[c/]	2,630
TOTAL	10,107	1,146	13,672	2,630	27,555 d/

a/ Refer to Exhibit 4 for location of land groups.

b/ Class in parenthesis indicates class after reclamation.

c/ The unclassified lands (potentially irrigable) are as follows:

Yarmouk Gorge	950 ha	Zarqa Gorge	223 ha
Ziglab Gorge	52 ha	South of Zarqa River	305 ha
Kufrinja Gorge	104 ha	East of 18-km Ext.	546 ha
East of LG B	450 ha		

d/ Of this total a net of 25,353 ha will be irrigated.

Table V-5

SPRINKLER IRRIGATION SUITABILITY LAND CLASSIFICATION
SPECIFICATION ADOPTED WITH MODIFICATION FROM BUREAU OF RECLAMATION

Land Classification	Symbol	Class 1 - Arable	Class 2 - Arable	Class 3 - Arable
Texture	l, m, h	Fine sandy loam to friable clay loam	Loamy sand to very permeable clay	Loamy sand to permeable clay.
Depth	D, M	Greater than 36 inches	Greater than 24 inches	Greater than 12 inches
Water holding capacity (0 - 40 inches)		Greater than 6 inches	Greater than 4.5 inches	Greater than 3 inches
Salinity	a	Less than 4 mmhos	Less than 8 mmhos	Less than 12 mmhos
TOPOGRAPHY				
Slope	g	0.7% slope	Up to 12% smooth slope Up to 7% rough slope	Up to 20% smooth slope Up to 12% rough slope
Cover	c	Can be cleared at minimum cost	Can be cleared at moderate cost	Can be cleared at high cost
Erosion	e	Slightly eroded	Moderately eroded	Eroded
DRAINAGE	d	Can be provided with moderate cost	Can be provided with moderate cost	Can be provided with high cost.

After reclamation, Class 2 lands will account for about 30 percent and Class 3 lands, including all potentially irrigable lands, accounts for the remaining 20 percent of the gross area.

Leaching

Prior studies and experiments were directed toward evaluation of leaching requirements for various soils using surface irrigation. The results of the Baker-Harza experiments in 1955 indicated that about 90 cm applications would remove salts to a safe level for shallow rooted crops. The Institute of Pedology and Technology, Zagreb, classified soils into two categories for leaching. The first was soils to be leached by normal farming methods. These soils can be reclaimed after one winter and require one or two pre-irrigations of about 25 cm and 20 percent over-irrigation. The second category was the soils to be leached by basin flooding. These soils require 30 percent over-irrigation and flooding to a depth ranging from 100 cm to 150 cm.

No leaching experiments using sprinkler irrigation have been done in the Valley. However, some advantages to this procedure are apparent as follows:

1. No land levelling or land forming is required,
2. Management of the soil-water regime is greatly improved,
3. Less water will probably be required, and
4. Salt-tolerant crops, such as barley, can be grown during the latter stages of leaching.

A method of leaching recommended for the Valley is described in Appendix F, Soils.

At this time, it is not possible to define the quantity of water required for the leaching operation using sprinkler

application; however, assuming conventional irrigation practices, it can be expected to be less than for surface application.

During reclamation, crops can be grown for financial return. Barley or wheat can be grown during leaching on slightly saline soils or during the first winter after leaching on moderatly saline soils. Legumes and vegetables can be grown during the second winter.

Nutrients are leached with the salts, and heavy fertilizing, especially with nitrogen, is recommended for the first two or three seasons.

Drainage

Surface Drainage. The natural surface drainage network is generally adequate to handle excess surface water. Irrigation water and rainfall runoff move by overland flow until picked up by one of the branches of the natural surface drainage system. Drainage water is conveyed in an east to west direction through the Katar and Zor to the Jordan River. Farm and collector drains will be required to transport excess surface water to the natural drainage network.

Subsurface Drainage. Except for areas having a shallow water table, natural subsurface drainage is adequate to prevent high groundwater levels.

In problem areas, a subsurface drainage system will be required to maintain water levels at a depth dictated by plant growth considerations. The safe depth of the water table, considering the quality of the groundwater and the type of soils, is estimated to be 1.5 m below soil surface.

The requirements for subsurface drainage are expected to be limited with the introduction of sprinkler irrigation. Therefore, rather than installing a costly subsurface drainage system, it is proposed that a monitoring network be installed

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covering the known areas of high water levels and strongly saline soils. From the data collected from this network during the first years of operation, a suitable subsurface drainage network can be designed.

The need for drainage on 500 ha has been defined on the basis of high water tables in the immediate vicinity. The cost of the subsurface system required for this area has been included in the project initial construction cost. In addition, an allowance for the cost of installing subsurface drainage at a rate of 250 ha per year has been included in the irrigation system annual operating cost.

Land Tenure and Credit

The most common form of tennancy in Jordan is the owner-operated farm which accounts for nearly two-thirds of the total agricultural land[1/]. The latest study on land tenure[2/] indicates that the land tenure situation in the East Jordan Valley differs from that in other areas of Jordan in that share-cropping is the most common form of land tenure. Land tenure in the Valley for the years 1961 and 1973 are shown in Table V-6.

1/ Report on Agricultural Census 1965, Department of Statistics, June 1967.

2/ Agro-Economic Aspects of Land tenure in the East Jordan Valley 1975, Royal Scientific Society, Economic Research Department.

Table V-6

LAND TENURE

Type of Tenure	Percent of Area	
	1961	1973
Owner Operator	32.5	35.9
Sharecropper	39.0	47.2
Cash-rent	1.8	2.7
Mixed Tenure	26.7	14.2

In general, it is thought that owner operators are the most efficient, but studies in the Wadi Dhuleil area and the Jordan Valley indicate that the sharecroppers were more efficient. Some of the reasons for the relatively greater success of the sharecroppers are that the sharecroppers are younger, better trained in farming, have a higher rate of literacy, and are more likely to have had contact with an extension agent. In the Jordan Valley, the prevalence of the sharecroppers possibly can be attributed to characteristics of the landlords. About 37 percent of the landlords are non-residents of the Valley, 15 percent reside in the Valley but are non-farmers, and another 15 percent lease part of their farm holdings because their holdings exceed the area they could cultivate using family labor. Leasing excess land is more profitable than hiring labor to farm it. The remaining landlords wanted to stop farming for various reasons.

Lease agreements are usually oral, and very few are for durations longer than one year. One-year leases were favored by 92 percent of the landlords and 65 percent of the tenants. Sharecropping accounted for 95 percent of the lease agree-

ments. A 50-50 disposition of the returns was most common. Inputs also are split on this basis except for hired labor which generally is paid for by the sharecropper and irrigation water which was paid for by the landlord in one-third of the cases. Cash rentals account for only five percent of the lease agreements although a majority of the sharecroppers indicate a preference for this arrangement.

Commission agents are the most widely used source of credit. Relatives, friends, and landlords supplied the remaining credit requirements in equal proportions. The credit generally is not officially recorded, is for short-term, and is not guaranteed by mortgage of real estate. Government agencies usually do not extend credit to tenants.

Land Reform

The basic purpose of the existing land reform provisions is to limit the maximum and minimum size of holdings and to redistribute land from larger farmers to small farmers. The laws also contain provisions outlining the manner in which the land reform program is to be carried out.

Jordan Valley Development Law No. 18 (1977 Temporary) requires that land holdings in government developed irrigation areas should be allocated in four-hectare holdings on the best quality land, and five-hectare holdings on the poorest land class. The maximum holding that can be retained by present owners of large areas is 20 hectares. Under this system, it is estimated that only about six percent of the land would remain in farms larger than seven hectares. However, the reform does not eliminate tenancy and the Jordan Valley Development Plan will permit the situation where many of the three-hectare farms would support a tennant and his family, and a landlord. The law does not permit

resale of the land at a price higher than the value determined by the JVA which disregards any rise in land price resulting from construction of the Project.

Information of the impact of the East Ghor Canal Land Reform Laws was reported by the Royal Scientific Society[3/]. The primary impact of the reform was to narrow the size-range of holdings from 1.0 ha to 100 ha in 1960 to 2.0 ha to 40 ha in 1971. The average size of ownership decreased from 4.3 ha to 2.4 ha over the same period. Joint ownership and fragmentation were reduced and, as mentioned before, share-cropping increased.

Water Resources

The hydrologic studies prepared for this report include an analysis of the available water supply, an estimate of flood flows, and an estimate of anticipated sediment accumulations in Maqarin and Khalid Reservoirs. Water supply studies were performed for the Yarmouk and Zarqa Rivers and the nine principal side wadis tributary to the Jordan River. Flood studies were concerned with estimates of a probable maximum flood at the Maqarin and Khalid dam sites and of the frequency of occurrence of lesser floods. A more extensive discussion of the following presentation, including supporting tables and exhibits, can be found in Appendix A, Hydrology.

Water Supply

Recorded and synthesized streamflow data are available for the Yarmouk River, the Zarqa River, and nine principal side wadis for various periods between 1926 and 1976. Most of the streamflow data which predate 1950 were synthesized. The locations of the stream gaging stations are shown on Exhibit 18.

3/ Hezleton, Dr. J.E., The Impact of the East Ghor Canal Project on Land Consolidation, Distribution and Tenure, Royal Scientific Society, Economic Research Department, December 1974.

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After a review of the available data it was decided that data for water years 1954 to 1975 are adequate for the present studies. This period essentially corresponds to the period of record of the gage near the Maqarin site. Streamflow data are missing from many of the records during portions of this period. These missing streamflow data were estimated by correlation with data at nearby stations.

Average annual flow over the period of record of the Yarmouk River was 255.6 MCM at the Maqarin damsite and 408.6 MCM at Adasiye. After correction of these flows for the anticipated Syrian withdrawals, the average annual flow is calculated to be 240.3 MCM and 393.3 MCM at Maqarin and Adasiye respectively. The average unregulated flow of the Zarqa River and the nine side wadis totals 160.5 MCM annually. The water available from all potential sources is about 553.8 MCM annually, equivalent to 50 mm of runoff per year or about 15 percent of the average annual precipitation. Drainage area, mean annual precipitation, and mean annual runoff for the streams in the Project area are shown in Table V-7. A histogram of monthly streamflow at the Maqarin site is shown on Exhibit 19.

Monthly Streamflow. An adjustment was made to the recorded streamflow of the Yarmouk River to reflect historical and projected future changes in diversion above the Maqarin damsite. An agreement between Jordan and Syria, signed in Damascus in June 1953 read in part: "Syria reserves the right to dispose of the waters of all streams in the basin of the Yarmouk and its tributaries, with the exception of waters which spring upstream of the dam below the 250 meter contour." The adjustment was based on the assumptions that historical change has been gradual, increased Syrian water

Table V-7

HYDROLOGIC DATA FOR JORDAN VALLEY STREAMS

Location	Drainage Area (km^2)	Mean Annual Precipitation[a/] (mm)	Mean Annual Runoff (MCM)
Yarmouk River at			
Adasiye	6790	390	393.3[b/]
Maqarin	5950	330	240.3[b/]
Zarqa River at Deir Alla	3400	250	67.3
Side Wadis			
Wadi Arab	267	485	28.8
Wadi Ziglab	106	520	9.5
Wadi Jurum	20	450	11.2
Wadi Yabis	125	540	3.5
Wadi Kufrinja	111	530	6.1
Wadi Rajib	84	530	7.1
Wadi Shueib	178	445	7.9
Wadi Kafrein	163	370	14.3
Wadi Hisban	60	340	5.0

a/ Over the drainage area.

b/ Adjusted to reflect historical and anticipated future diversions.

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use would follow a monthly pattern similar to the present estimate of withdrawals, and the maximum monthly base-flow usage would be about 3.6 m^3/s.

Surface Water Quality. Limited data on surface water quality are available for the Yarmouk and Zarqa Rivers only. The water is suitable for agricultural use and will need only moderate treatment for municipal and industrial use.

The overall quality of the water in the Yarmouk River will improve after construction of the Project. Without the Project, the quality of the water is poorest during the low-flow, dry-season months. After the Project is constructed, good-quality releases will be made during these dry-season months to meet the irrigation requirements and the quality of water during these months will improve over pre-project conditions. The quality of water during the high-flow, wet-season months is good and will continue to be good after the Project is implemented.

Reservoir Evaporation. The estimation of reservoir evaporation was based on two years of data from Class A pan installations at the Irbid Nursery and Shuneh, supplemented with long-time Piche evaporation measurements. The pan evaporation was multiplied by a pan coefficient of 0.75 to estimate reservoir evaporation. Gross reservoir evaporation is estimated to be 1699 mm per year; after deducting mean monthly precipitation, the net annual average evaporation is 1275 mm.

Ground Water. The sediments in the Valley are well suited for the storage and exploitation of ground water; however, there is excessive saline contamination in most areas away from the alluvial fans.[4/] The fans receiving fresh-water recharge from base flow or underflow are the

4/ East Bank Jordan Water Resources, Hunting Technical Services Ltd. Sir Malcom MacDonald and Partners, Volume 6, 1965.

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only ones suitable for exploitation. The saline contamination is caused by the former submergence of the sediments below the Dead Sea and the presence of some evaporitic deposition of salt. Flushing of the saline soils has only taken place adjacent to the recharging alluvial fans.

In the Baker-Harza report, the safe yield of the aquifers in the Valley was estimated to be 40 MCM per year. It also is estimated that about 2,180 ha currently are being irrigated from wells in the southern part of the Valley. After completion of the Kafrein-Hisban Project it is expected that the recharge supply for about half of the lands currently irrigated from wells will be severely curtailed and perhaps eliminated. The remaining area may continue to be supplied by using the base flow and underflow of Wadi Shueib for recharge.

Groundwater was not considered to be a reliable source of water for Stage II development. The land which is now being irrigated from wells has been included in the Project irrigation area, to be supplied from surface water. If ground water is available after the Stage II Project is in operation it can be incorporated in full development plan to supplement the surface supply.

Spillway Flood

Maqarin and Khalid spillways are designed for a probable maximum flood (PMF).

Probable Maximum Precipitation. The probable maximum precipitation (PMP) was estimated by transposing and maximizing the storm of January 29, 1958. This storm covered the entire east-bank area of the Jordan Valley. The maximized 24-hour PMP of the basin above Maqarin damsite is 200 mm; the estimate of 48-hour PMP is 230 mm.

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Probable Maximum Flood. The probable maximum flood (PMF) was obtained by applying rainfall excesses to unit hydrographs. The rainfall increments were arranged in a critical flood-producing sequence.

A 4-hour unit hydrograph was developed for the Yarmouk River above the Maqarin site. The PMF at the Maqarin site has a peak flow of 6400 m^3/s, and an 8-day volume of 660 MCM.

The PMF for the area between the Maqarin site and the Khalid site was based on a 2-hour unit hydrograph. The peak flow is 1800 m^3/s and the 6-day volume is 135 MCM.

The PMF used for these studies is larger than previous estimates by Baker-Harza (1955) and Energo-projekt (1967). The comparatively high runoff estimate appears reasonable because of the dendritic nature of the channel network which is conducive to high flood peaks, and due to the proximity of the basin to the Mediterranean Sea, an important storm moisture source.

Flood Frequency

A flood-frequency analysis was made using annual maximum flood peaks observed at Maqarin for the period including water years 1954 to 1974 excluding five years of missing data. The results are shown in Table V-8. The frequency values are derived from a Log Pearson Type III statistical distribution. Floods for the intervening area between the Maqarin site and the Khalid site were estimated using Creager's C values developed from data for the Maqarin site.

Table V-8

FLOOD FREQUENCY

Recurrence Interval	Peak Discharge	
	At Maqarin m^3/s	Between Maqarin and Khalid m^3/s
5	280	110
10	400	160
20	550	210
50	800	310

Sedimentation

Sediment Load. The average sediment load at Maqarin dam site is estimated to be 1.22 million tons per year. The total load equals the measured suspended sediment load plus 30 percent to account for bed load.

The measured load was determined by applying a sediment rating curve to a flow-duration curve. The sediment rating curve was developed using instantaneous sediment measurements taken during the period 1965-1970. Due to considerable scatter in the plotted data, a dimensionless sediment rating

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curve was prepared from data for the Zarqa River and used as a guide for defining the Yarmouk River curve. The flow-duration curve was based on 14 years of daily discharges at Maqarin.

An estimate of sediment load between Maqarin and Khalid was based on the unit yield from the area above Maqarin. An adjustment was made for the greater delivery ratio due to the smaller drainage area. The resultant sediment load is estimated to be 0.19 million tons per year.

Reservoir Sedimentation. The trap efficiency at Maqarin Reservoir is estimated to be 98 percent throughout the economic life of the reservoir. The trap efficiency for Khalid Reservoir is estimated to be 95 percent. The unit weight of sediment is assumed to be 1.35 tons/m^3. Estimates of reservoir sedimentation are as follows:

Table V-9

SEDIMENT DEPOSITION

Duration years	Maqarin Reservoir MCM	Khalid Reservoir MCM
50	45	7.6
100	90	15.2

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Chapter VI

AGRICULTURAL DEVELOPMENT AND PRODUCTION

This chapter relates the production capability of the Stage II project with potential demand for the commodities that will be produced in the project area. Sales revenues, production costs and net returns for the various crops that will be grown in the project area are presented. A brief discussion of the necessary associated developments such as the provision of machinery pools, marketing facilities and research and extension services also are given.

Potential Demand

A marketing study[1/] was undertaken that provides estimates of future demand for the major crops to be grown in the Jordan Valley under project conditions. The marketing study considered potential demands in both domestic and foreign markets. The projections are extended in five year increments from the base year 1975 through 1995. These demand projections were used in projecting cropping patterns that can be expected in the Jordan Valley under project conditions.

Domestic Demand

The domestic (East Bank) demand projections for the period 1980-1995 are based on the anticipated growth of population and income and changes in per capita utilization in each major crop category. During the period 1970-1975, the East Bank population increased by an average annual rate of increase of 3.2 percent. This rate of increase was assumed to continue through the year 1995. Based on this projection, the population of the East Bank is expected to be approximately 3.6 million in 1995 compared to 1.9 million

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1/ Supply and Demand For Jordanian Fruits and Vegetables, Harza Overseas Engineering Co. June 1977.

in 1975. Consuption of the major agricultural commodities in the vegetable and fruit categories is expected to increase at a faster rate than the population increase, primarily because incomes and purchasing power also will increase and change consumption patterns. A summary of the domestic consumption levels for the years 1975 and 1995 for vegetables, fruits and cereal grains is presented in table VI-1. For certain crops domestic consumption, has been subject to significant annual variations due to fluctuations on supply and volume of export trade. Therefore, the tonnage for 1975 is based on a trend line and differs somewhat from the actual consumption levels for that year.

Table VI-1

TOTAL DOMESTIC CONSUMPTION FOR SELECTED FOOD CATEGORIES

	1975 (1,000 tons)	1995 (1,000 tons)	Trend Line Annual Rate of Increase (1965-95) (percent)
Vegetables	228.2	719.0	4.8
Fruits	193.0	377.6	3.4
Grain (wheat)	236.4	410.3	2.8

Domestic demand for other food categories such as milk, beef, and veal are also expected to increase significantly. The Jordan Valley is expected to provide a major portion of the country's future food demand especially in the fruit and vegetable categories.

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Export Demand

Jordan and particularily the Jordan Valley, has historically been a major supplier of fresh fruits and vegetables to neighboring Middle Eastern countries including Saudi Arabia, Kuwait, Qatar, United Arab Emirates and to a lesser degree Yemen and Omen. Recent developments related to oil reserves and prices have dramatically changed the development potential of these countries. The Jordan Valley Marketing Study[1/] (JVMS) made estimates of demands for the major crops with potential for export by Jordan to these countries. The marketing study first estimated the import demand relationships for fruits and vegetables for most of the neighboring Middle East countries. Second, export demand for Jordan's fruits and vegetables in each country was estimated. Using these relationships, Jordan's share of total fruit and/or vegetable imports to each country was calculated. The results show that Jordanian exports of vegetables can be expected to increase 72 percent from 1975 to 1995. A summary of the export demand for the years 1975 and 1995 for the major vegetable crops is given in table VI-2.

Jordan exports of citrus are also expected to increase significantly. Citrus exports historically have included a large proportion of supplies that originate from the West Bank and Gaza. However, it is anticipated that the growth in export demand also will cause the amount produced for export on the East Bank to increase.

On the basis of present information it appears that the demand for Jordanian fruits and vegetables in the European markets is limited. The primary constraints are the high quality requirements and the degree of competition. However, trial shipments should continue. Improved transportation,

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1/ Source: Op-cit. Table IV-15.

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channels of communications with imports, and very high quality will be necessary to successfully penetrate this market.

Table VI-2

EXPORTS BY MAJOR CROP[1/]

Crop	1975 (1,000 tons)	1995 (1,000 tons)
Tomatoes	52	71
Egg plant	22	41
Cauliflower	6	24
Squash	4	10
Peppers	2	3
Watermelons	3	4
Total	89	153

Demand-Supply Balance

The present contribution of the Jordan Valley to national demand is presented in Table VI-3. This illustrates the importance of the existing irrigated area to the national economy. For example, in 1975 the Valley produced nearly one-half of the nations supply of vegetables. The surplus of vegetables produced permitted the export of such commodities as tomatoes, eggplant, squash, cauliflower and watermelon. However, it also is apparent from Table VI-3 that substantial national deficits occur for such products as fruit, wheat, milk, beef, and veal. The financial implications of this imbalance are demonstrated in Table VI-4 which shows that the total value of edible exports in 1975 was only one fifth the value of edible imports.

In developing the anticipated cropping pattern for the Stage II Irrigation Project, consideration was given to (1)

meeting domestic demands, (2) anticipated production from other areas of Jordan, (3) replacing the most costly imports, and (4) expanding the most profitable exports.

Table VI-3

COMPARISON OF DEMAND AND PRODUCTION FOR JORDAN 1975
(in 1000 tons)

Commodity	Total Demand in Jordan	Production outside of Valley	Production of Valley	(Deficit) or Surplus
Fruit	118	17	15	(86)
Vegetables	281	179	166	64
Wheat	236	56	8	(172)
Milk	49	21	-	(28)
Beef and Veal	5	2	-	(3)

Table VI-4

VALUE OF EXPORTS AND IMPORTS OF EDIBLE COMMODITIES - 1975[a/]
(JD 1000)

Exports		Imports	
Commodity	Value	Commodity	Value
Fruits and Nuts	6,377	Sugar	11,534
Vegetables	3,236	Fruits, Vegetables, & Nuts	9,570
Other	999	Wheat and Flour	6,824
TOTAL	10,612	Dairy Products	4,822
		Live Animals	3,185
		Other	14,740
		TOTAL	50,675

a/ Appendix G Agricultural Development

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Anticipated Cropping Pattern

The cropping pattern anticipated for the project area is shown in Table VI-5. The suggested cropping intensity is 128 percent compared to 106 percent for the present development. Sprinkler irrigation is projected for the suggested cropping whereas the present development is under surface irrigation. The intensity figures are calculated on the basis of harvested crops. The proposed pattern is based on the assumption that about 20 percent of the actual land area will be planted to fruit orchards and the remainder will be cropped with a mixture of field and vegetable crops. It is anticipated that the area planted to bananas will be larger south of the Zarqa River than in the north because of the more favorable climatic conditions. Therefore, different cropping intensities for fruit are shown for the north Valley and the south Valley.

A small area has been retained for wheat because it is probable that many farmers will continue growing this crop for their own consumption. The increase in fruit production has been somewhat curtailed because of the difficulty of supplying sufficient water to the orchards in the summer months even with the proposed storage facilities. Significant increases in the cropped area of vegetables are expected following the introduction of new rotation and cultivation practices. An example of the proposed rotation is given in Appendix G, Agricultural Development.

The cropping intensities shown in Table VI-5 can be varied to match demand conditions. Sufficient flexibility exists to incorporate new crops or to make changes in management of the project crops.

Table VI-5

CROPPING PATTERN INTENSITY FACTORS

Field Crops	Without Project	With Project
Wheat	0.36	0.05
Barley	0.08	0.15
Maize		0.03
Sorghum	-	0.03
Berseem	-	0.13
Subtotal	0.44	0.39
Vegetables		
Tomato	0.17	0.17
Eggplant	0.09	0.08
Peppers	0.01	0.04
Squash/Cucumber	0.09	0.05
Beans	0.03	0.04
Cauliflower/Cabbage	0.02	0.05
Onions		0.04
Potatoes		0.06
Watermelon	0.04	0.12
Other Vegetables	0.01	0.02
Subtotal	0.46	0.67

Fruit Crop		North Valley	South Valley
Bananas	0.02	0.01	0.03
Citrus	0.13	0.11	0.11
Other Fruits	0.01	0.10	0.08
Subtotal	0.16	0.22	0.22
Total	1.06	1.28	

The water requirement calculated for the projected pattern will permit some changes in crop selection.

Alternative forms of irrigation may be preferable to the sprinkler system for some crops or some production methods. For instance, some citrus growers may wish to retain surface irrigation while vegetable growers using plastic frames may choose trickle irrigation.

Production and Net Returns

Yields

The Jordan Valley contains a large area of fertile soil and has favorable climatic conditions for the realization of high yields. It will be possible to attain yields comparable with those obtained from highly successful projects in other countries. Crop yields for present conditions and for the year 1990 both with and without the project are shown in Table VI-6. Projected yields under with-project conditions have been estimated using data from Jordan, the United States,[5/] Cyprus, and Israel cross referenced to the best yields obtained in Jordan and to those recorded in neighboring areas.

A report on crop yields is presented in Attachment 1 to Appendix G, Agricultural Development. A summary of the yield data collected during the study is presented in Table VI-7.

5/ Water and Land Accomplishments in 1974, Appendix I, U.S. Bureau of Reclamation.

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Table VI-6

PROJECTED YIELDS

(Tons per Hectare)

Crop	Present Yields	Projected Yields for Year 1990 Without Project	Projected Yields for Year 1990 With Project
Wheat	1.4	3.0	5.0
Barley	1.5	3.0	5.0
Maize (grain)		6.5	7.5
Sorghum (forage)		35.0	40.0
Alfalfa/Berseem		50.0	60.0
Tomato	20.0	35.0	45.0
Eggplant	20.0	32.0	40.0
Squash	15.0	32.0	35.0
Cucumber	14.0	20.0	30.0
Peppers	10.0	12.5	15.0
Green Beans	10.0	12.5	15.0
Cauliflower/Cabbage	20.0	27.0	30.0
Onions		20.0	25.0
Potatoes		25.0	30.0
Other Vegetables	20.0	25.0	30.0
Watermelon	18.0	22.0	25.0
Bananas	22.0	30.0	35.0
Oranges	20.0	30.0	40.0
Lemons	15.0	30.0	35.0
Grapefruit	17.0	40.0	50.0
Other fruit	20.0	25.0	30.0

Table VI-7

COMPARATIVE ESTIMATES OF POTENTIAL CROP YIELDS
(Tons per Hectare)

Crop	Jordanian[a/] Panel	Israeli[b/] Panel	Cypriot[c/] Data	El Centro[d/] U.S.A.	Assumed Project Potential
Wheat	3.0	4.0	1.8	5.3	5.0
Barley	3.5	2.0	2.3	4.9	5.0
Maize[e/]	27.5	N.A.	N.A.	42.3	35.0
Sorghum[e/]	46.6	21.7	N.A.	42.0	40.0
Berseem[e/]	55.0	N.A.	N.A.	N.A.	60.0
Tomato	50.0	75.0	45.0	39.0	45.0
Eggplant	40.0	60.0	67.5	13.2	40.0
Peppers	30.0	35.0	45.0	13.2	15.0
Squash	30.0	25.0	26.3	22.5	35.0
Cucumber	30.0	25.0	30.0	14.3	30.0
Beans	22.5	N.A.	18.7	26.5	15.0
Cauliflower	30.0	25.0	28.5	N.A.	30.0
Cabbage	40.0	35.0	26.3	29.2	30.0
Onions	40.0	45.0	26.3	30.5	25.0
Potatoes	30.0	45.0	33.8	N.A.	30.0
Watermelon	30.0	40.0	37.5	21.2	25.0
Other Vegetables	N.A.	N.A.	N.A.	N.A.	30.0
Grapefruit	50.0	65.0	56.3	53.5	50.0
Lemon	35.0	25.0	37.5	49.6	35.0
Orange	40.0	45.0	33.8	25.8	40.0
Banana	45.0	45.0	22.5	N.A.	35.0
Grapes	17.5	20.0	15.0	N.A.	30.0

a/ Colloqium held 29/8/77, Amman.
b/ Colloqium held 7/9/77, Tel Aviv.
c/ Data from Norm Input-Output Data of the Main Crops of Cyprus, by S. Papachristodoulou, Nocosia, 1976.
d/ For field crops and vegetables, averages of data collected from El Centro, 15/9/77; for fruits, averages of data collected from Yuma, 17/9/77.
e/ Green feed.

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Yields were based on the assumption that modern technology would be adapted to project lands. The production potential and cost of development are both high. Measures must be taken to assure that modern technology is fully adopted to establish a project which will substantially increase crop yields.

Production

Combining the proposed cropping pattern, the anticipated cropping intensity, and the estimated yields, the estimated production from the total irrigable area of 36,000 ha when the Jordan Valley East Bank reaches full production in about 1990 is shown in Table VI-8. The production of milk, beef and veal was estimated on the basis that all of the barley, corn, and forages would be used for dairy production as discussed in Appendix G, Agriculture Development.

Table VI-8

AGRICULTURAL PRODUCTION FROM THE JORDAN VALLEY - 1990

Commodity	Production (1000 tons)
Fruit	280
Vegetables	777
Wheat	9
Milk	66
Beef and Veal	2

Based on the assumed cropping pattern, Jordan will have a large deficit in the production of cereals and a substantial

surplus for most categories of vegetables in 1990. The surplus goods will be available for export. It is possible that a small milk surplus could develop if the dairy industry is successful. Beyond 1990, deficits in many commodities could reappear and the surplus production will be absorbed by national requirements.

Prices

Farmgate prices were used as a basis for the economic analysis in this report. The farmgate prices for fruits and vegetables were derived from the wholesale market prices in Amman by subtracting the costs of transportation, marketing, and handling fees that occur between the farmgate and the wholesale market.

Records were obtained from the Department of Agriculture, Economic Research Section, on the quantities and prices of fruits and vegetables sold each month during 1975 and 1976. The weighted average price for each commodity was then computed for the 24-month period. The next step was subtracting the transportation, marketing, and handling fees which were derived from information given in the Jordan Valley Development Plan.[6/] The resulting farmgate price therefore represents the average prices received by farmers between January 1975 and December 1976. This is regarded as a relatively conservative method of estimating prices received in constant dinars for use in the economic analysis of the project.

Farmgate prices for field crops were derived from enquiries in the Jordan Valley and such reports as the Project Proposal: Development of 100 Cow Units in The Jordan Valley supplied by JVA.

6/ Jordan Valley Development Plan, 1975-1982, Jordan Valley Commission, November 1975.

Shadow prices were not used in the evaluation. It is believed that tariffs, subsidies, or other disturbances do not significantly affect prices. In addition, the dinar is a strong currency which can be traded freely on the market, and shadow pricing is not warranted.

Production Costs and Net Returns

The production costs for individual crops were derived from comparative studies and field inquiries. The estimates presented in Table VI-9 represent average crop production costs on four-hectare general farms and three-hectare fruit farms. Summaries of the per hectare sales revenues, production costs, and net returns under with project conditions in the conversion and new land areas are presented in Tables VI-10 and VI-11 respectively.

The value of family labor has been included as a benefit on the basis that no production to the economy will be foregone as a result of the farmers labor on the Project. This assumption implies that there is no alternative productive outlet for the farmer's energy if the Project were not constructed or, in more general terms, there is a substantial degree of unemployment in the Kingdom. As stated in Chapter I, only 20 percent of the population is employed. In addition, it was reported in the Jordan Five Year Plan 1976-1980 that about 35,000 to 40,000 individuals are expected to join the labor force annually during the period covered by the Plan. In the future, the labor force will expand because of the increasing numbers of young people who will be seeking employment and because of the emphasis being placed on encouraging the female population to work. Therefore, it is likely that there will be a substantial degree of unemployment in the country during the time the Project is being developed.

Table VI-9

PRODUCTION COSTS AT FULL DEVELOPMENT WITH PROJECT
(JD/ha)

Crops	Seeds & Plants	Fertilizer	Plant Protection	Hired Labor	Machinery	Other	Total
Wheat	6.0	29.9	10.0		53.7		99.6
Barley	6.0	29.9	10.0		51.2		97.1
Maize	5.0	57.5	13.0		75.0	10.0	160.5
Sorghum	5.0	57.5	5.0		57.5		125.0
Berseem	25.0	18.4	25.0		76.3		144.7
Tomatoes	120.0	105.0	100.0	128.0	95.0	40.0	588.0
Eggplant	120.0	124.4	125.0	97.0	108.0	20.0	595.2
Pepper	200.0	82.0	140.0	50.0	82.5	30.0	584.5
Squash	15.0	70.5	60.0	35.0	81.3	30.0	291.8
Cucumber	15.0	70.5	60.0	35.0	81.3	30.0	291.8
Beans	16.0	59.0	48.0	75.0	80.0	10.0	288.0
Cabbage	24.5	77.4	20.0	70.0	85.0	10.0	286.9
Cauliflower	24.5	77.4	20.0	70.0	85.0	10.0	286.9
Onions	20.0	70.5	30.0	80.0	85.0	30.0	315.5
Potatoes	90.0	105.0	30.0	71.0	90.0	30.0	416.0
Melons	7.5	47.5	30.0	38.0	67.5		190.5
Other Vegetables	60.0	74.0	55.0	57.0	78.5	20.0	344.5
Citrus	173.8	104.2	125.0	92.5	37.5	25.0	558.0
Bananas	610.5	131.5	120.0	160.0	32.5	40.0	1,094.5
Other Fruit	107.5	115.0	100.0	112.5	66.5	15.0	516.5

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Table VI-10

ESTIMATED NET RETURNS ON THE CONVERSION AREA AT FULL DEVELOPMENT - WITH PROJECT

Crop/Item	Sales Revenue[a/] Per ha. (JDs)	Sales Revenue[a/] Total (1000JD)	Production Costs Per ha. (JDs)	Production Costs Total (1000JD)	Net Returns Per ha. (JDs)	Net Returns Total (1000JD)
Wheat	360.0	231.1	99.6	63.9	260.4	167.2
Barley	310.0	597.1	97.1	187.0	212.9	410.1
Maize	472.5	182.0	160.5	61.8	312.0	120.2
Sorghum	400.0	154.1	125.0	48.2	275.0	105.9
Berseem	600.0	1,001.7	144.7	241.6	455.3	760.1
Tomato	2,587.5	5,648.9	588.0	1,283.7	1,999.5	4,365.2
Eggplant	1,660.0	1,705.4	595.2	611.5	1,064.8	1,093.9
Pepper	948.0	487.0	584.5	300.2	363.5	186.8
Squash/Cucumber	2,350.0	1,508.9	291.8	187.4	2,058.2	1,321.5
Beans	1,617.0	830.6	288.0	147.9	1,329.0	682.7
Cauliflower/Cabbage	1,050.0	674.2	286.9	184.2	763.1	490.0
Onions	1,687.5	866.8	315.5	162.1	1,372.0	704.7
Potatoes	2,097.0	1,615.7	416.0	320.5	1,681.0	1,295.2
Watermelon	780.0	1,202.0	190.5	293.6	589.5	908.4
Other Vegetables	1,500.0	385.3	344.5	88.5	1,155.5	296.8
Citrus	2,720.0	3,842.3	558.0	788.2	2,162.0	3,054.1
Banana	4,473.0	574.4	1,094.5	140.6	3,378.5	433.8
Other Fruit	3,000.0	3,852.6	516.5	663.3	2,483.5	3,189.3
Portable Sprinkler Equipment	-	-	26.9[b/]	345.4	-	-
Average/Total	1,974.7	25,360.1	476.5	6,119.6	1,498.2	19,240.5

a/ See tables VI 14 and VI 15 for partial list of farmgate prices. A complete list of farmgate prices is given in Appendix G Table G 18 and assosciated text.

b/ See Appendix G for details of this cost.

Table VI-11

ESTIMATED NET RETURNS ON THE NEW LANDS AT FULL DEVELOPMENT - WITH PROJECT

Crop/Item	Sales Revenue Per ha. (JDs)	Sales Revenue Total (1000JD)	Production Costs Per ha. (JDs)	Production Costs Total (1000JD)	Net Returns Per ha. (JDs)	Net Returns Total (1000JD)
Wheat	360.0	225.1	99.6	62.2	260.4	162.9
Barley	310.0	581.6	97.1	182.1	212.9	399.5
Maize	472.5	177.3	160.5	60.2	312.0	117.1
Sorghum	400.0	150.1	125.0	46.9	275.0	103.2
Berseem	600.0	975.7	144.7	235.3	455.3	740.4
Tomato	2,587.5	5,502.0	588.0	1,250.3	1,999.5	4,251.7
Eggplant	1,660.0	1,661.1	595.2	595.6	1,064.8	1,065.5
Pepper	948.0	474.3	584.5	292.4	363.5	181.9
Squash/Cucumber	2,350.0	1,469.7	291.8	182.5	2,058.2	1,287.2
Beans	1,617.0	809.0	288.0	144.0	1,329.0	665.0
Cauliflower/Cabbage	1,050.0	656.7	286.9	179.4	763.1	477.3
Onions	1,687.5	844.3	315.5	157.9	1,372.0	686.4
Potatoes	2,097.0	1,573.7	416.0	312.2	1,681.0	1,261.5
Watermelon	780.0	1,170.7	190.5	285.9	589.5	884.8
Other Vegetables	1,500.0	375.3	344.5	86.2	1,155.5	289.1
Citrus	2,720.0	3,742.4	558.0	767.7	2,162.0	2,974.7
Banana	4,473.0	1,678.9	1,094.5	410.8	3,378.5	1,268.1
Other Fruit	3,000.0	3,002.6	516.5	516.9	2,483.5	2,485.7
Portable Sprinkler Equipment	-	-	18.9	235.2	-	-
Average/Total	2,003.8	25,070.5	479.8	6,003.7	1,524.0	19,066.8

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Combining the information provided in Table VI-10 and VI-11 with estimates of net farm income under future without-project conditions, the increased net farm income attributable to the project can be computed. This increased net farm income which represents the irrigation benefit was calculated for each of four land conditions. These land conditions are:

1. Land presently irrigated and located in the East Ghor Canal Project (EGCP),
2. Land not presently irrigated but located in the EGCP,
3. Land not presently irrigated located mainly in the southern part of the Valley, and
4. Land presently irrigated from wells and side-wadis located mainly in the southern part of the Valley.

The results are given in Table VI-12. Additional details on the development of net farm income are given in Appendix G, Agricultural Development.

The benefits shown in Table VI-12 were used in the economic analysis.

It is expected that full development can be reached in four years on the conversion areas, and seven years on the new lands. The growth of these returns will depend upon the strength of the extension services that can be provided and the response of the farming community.

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Table VI-12

SUMMARY OF ANNUAL IRRIGATION

PER HECTARE BY AREA

Present Status of Land	Location	Net Income Without Project (JD/ha)	Net Income With Project (JD/ha)	Irrigation Benefit (JD/ha)
Irrigated	EGCP	908[a/]	1,498	590
Irrigated	Southern Valley	200	1,524	1,324
Dryland	EGCP	50	1,498	1,448
Dryland	Southern Valley	50	1,524	1,474

a/ Increases from 550 in 1978 to a maximum of 908 in 1992.

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Associated Development

The Jordan Valley Development Plan 1975-1982 establishes a comprehensive series of investment proposals. Stage II of the Jordan Valley Irrigation Project is one component of this program. The purpose of this section is to identify and add emphasis to those elements of the plan that are of particular importance to the success of the Stage II development. The following sections consider the machinery, marketing facilities, and the research and extension work that will be required.

Machinery

Machinery pools should be formed to supply the necessary equipment. This would permit machinery to be used in an efficient manner by spreading the investment and other costs over several farm units. Cost savings also would occur from the bulk purchase and storage of equipment, supplies, and spare parts. In addition, skilled mechanics and trained operators could be used more effectively. Another advantage is that a range of sizes of machinery would be available to match the work to be done. The organization and management responsibilities of the equipment pools could be assigned to the Farmers' Association. This task is listed in the scope of responsibilities of the Association.

Presently, tractors are used only for land preparation, planting, and hauling crops to market. Zig-zag channels used for surface irrigation prohibit more extensive use of tractors. With the installation of a sprinkler irrigation system, it will be possible to make greater use of equipment in the fields during the growing season, such as for applying chemicals and harvesting.

The location of the equipment pools should be chosen to keep travel time to and from the fields at a minimum. Equipment facilities could be located at each of the 36 population centers planned by the JVA. It is suggested that five or six central stations be established, each providing support for a number of smaller machine-pool stations. The central facilities would have extra equipment, more specialized repair and maintenance facilities, and the more unusual machinery.

The estimated type, number, and cost of equipment is given in Table VI-13.

Marketing

The produce for domestic consumption will be transported over existing roads to the markets. Most of the exported produce also will be transported by road to neighboring countries although some of the higher-value crops may be exported by air. It is essential that adequate marketing and transportation facilities be available to ensure that high-quality produce is delivered to the consumer.

Present Situation. About 85 percent of the sale produce passes through Amman, Irbid, and Zarqa which are the principal wholesale markets in Jordan. Most of the fruits and vegetables are sold through commission agents who receive a five-percent commission. A two-percent tax is paid by the seller and the buyer to the marketing authority. Prices are fixed daily by a committee consisting of representatives from the Department of Agriculture, Department of Statistics, and marketing personnel. Most of the exports are to neighboring countries with limited amounts of high-value produce being exported by air.

Table VI-13

ESTIMATED QUANTITIES AND COST OF EQUIPMENT REQUIRED
FOR 25,000 HECTARES IN THE VALLEY

Item	Number Required	Approximate Cost (JD)
Tractors (wheeled)	1,250	3,750,000
Chisel Ploughs	125	33,750
Disc Ploughs	500	207,000
Disc Harrows	250	100,000
Cultivators	378	138,726
Grain Drills	100	120,000
Row Planters	50	38,350
Fertilizer Spreaders	150	41,250
Mower Bars	200	64,000
Rakes	150	85,050
Balers	150	357,150
Silage Chopper-blowers	200	127,000
Trailers	500	403,500
Forage Planters	80	66,800
Trailer Sprayers	150	111,750
Combines	35	408,345
Tracked Tractors	30	101,010
Land Rover/Utilities	60	174,000
Equipment Trailers	30	30,000
Potato Diggers	30	25,500
Soil Fumigators	40	36,000
Knapsack Sprayers	2,500	62,500
Total		6,414,881

There is a move to eliminate commission agents by those who feel their services can be better handled by government enterprises. However, the commissionaires provide the important marketing services of dispensing information, providing farmers with marketing contracts and transportation facilities, and they are the greatest source of working capital for the farmer. A criticism of this system is that once the farmer becomes indebted to the agent, many of the farmer's options are closed to him as he has to agree to sell his crops through the agent.

The major marketing problem is the lack of adequate grading of the produce. Other difficulties result from the limited size and the configuration of the Amman market. There also is a need for new and improved farm roads.

Agricultural Organizations. The organizations dealing with agricultural matters and marketing include:

1. Jordan Valley Authority
2. Agricultural Research and Extension Department
3. Agricultural Credit Corporation
4. Jordanian Cooperative Organization
5. Farmers' Association

Care must be taken to avoid duplication of effort, and to assure that procedures for handling the expanded production be developed which do not cause congestion and loss of money.

Assembly Markets. Grading and packing should be done in the Valley to minimize transport by small and inefficient vehicles. Local access will allow many farmers to deliver the produce without contracting out the hauling. The purpose of the assembly markets is to assemble the produce into commercial-size lots and to prepare the produce for

market by trimming, washing or brushing, grading, and packing. Economies of scale will result from a centralized operation thus reducing the unit cost of preparation.

Packing and grading stations exist at North Shuneh and at Wadi Yabis; however, neither are fully operational. Two other small assembly markets exist at Karameh and Saoualha. The Five Year Plan recommends the establishment of four fruit and vegetable grading and packing centers in the Valley.

Research and Extension

Research dealing with such programs as the introduction of new crops, plant breeding, and testing new inputs such as pesticides are necessary if innovative agricultural techniques are to be introduced. Equally important is an extension program to transmit the results of the research program to the farmer for practical application on commercial-sized farms. Both research and extension are important because the Project development will involve changes in land ownership, farm size, cropping intensity, and probably the introduction of unskilled farmers who will require training.

Research requires substantial time before its findings can be implemented at the farm level. Research efforts and supporting logistic efforts must be carefully planned. It is suggested that the Government operate several demonstration farms as commercial enterprises. To illustrate recommended practices, field demonstrations should be given on a number of topics such as date of planting, plant spacing, crop rotations, water applications, and fertilizer rates.

If a new input or technique is important or successful enough to warrant introduction, several incentives may be offered. Free or subsidized inputs are common methods which

have met with some success. Others include guaranteed markets and price levels.

At present, there are a considerable number of skilled Jordanian agricultural scientists working at some well equipped facilities such as the Deir Alla Agricultural Research Station, the Wadi Yabis substation, and several other locations. To continue the dessemination of information will require many more trained personnel backed by strong support and adequate funds. It is suggested that more use be made of intermediary staff trained at vocational or training schools. These field men would need a broad agronomic background and would usually specialize in a single crop. These field men would be the extension of the scientists at the research stations.

Chapter VII

PROJECT OPERATION STUDIES

Introduction

The storage requirement for Stage II Development and the corresponding elevation for Maqarin Dam are based on reservoir operation studies. The operation studies were based on the following sources of water: the inflow to Maqarin Reservoir, the intervening flow between the reservoir and the intake to the EGMC, and the unregulated side-wadi flows. The studies were based on the following water demands: Stage II irrigation requirements, considering acceptable irrigation shortage allowances; municipal and industrial water supply to Irbid and the Jordan Valley; downstream requirements for the Yarmouk Triangle, and reservoir evaporation.

The operation studies were made using monthly flows for a period of 22 years from October 1953 to September 1975. This time interval represents the period of record at Maqarin Damsite.

A computer model was developed specifically for this Project which can evaluate the combined operation of the Stage I, Stage II, and full development facilities. The storage required on the Yarmouk River to irrigate a designated area, the amount of spill from Maqarin Reservoir, the amount of uncontrolled flow lost to the Project, the amount and timing of irrigation shortages, and monthly power and energy production are determined in the operation simulation.

For Stage II development, the minimum operating level was defined as the reservoir elevation corresponding to the volume needed to store 50 years of accumulated sediment. For all other reservoirs, the minimum-operating levels and

active-storage volume were taken from available reports and pertinent data listings for the projects.

The model was operated so that the initial elevation of the reservoirs and the elevation after operation over the period of record was the same. This ensured that no requirements would be met by using water that could not be replaced during the record period.

System Operation Program

The operation program was designed to meet the irrigation requirements of the area associated with the Stage I project, and then divert some portion of the surplus water into the EGMC for use on Project lands. It was assumed that the Kafrein-Hisban Project and the Wadi Arab Complex would make use of all the water in the associated side wadis. The Kafrein-Hisban Project is intended to make full use of the available water from Wadi Hisban and the existing Kafrein Reservoir[1/]. The Wadi Arab Complex is a combination of the North East Ghor Project which makes use of the base flows of Wadis Arab and Jurum and the regulated flow of Wadi Ziglab, and the Wadi Arab Dam Project which controls and distributes the flood flows of Wadi Arab. No surplus water is expected from this complex. The Zarqa Project was included in the operation study to determine if the area originally to be irrigated from the project could still be irrigated using the operating criteria developed for these studies. The operation study determined the effect of the release from King Talal Reservoir of 10 MCM per year to Amman and of the

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1/ Jordan Valley Development Plan, 1975-1982, Jordan Valley Commission, November 1975.

revised estimates of Zarqa River flow which are lower than earlier estimates. In the final Project plan, the Zarqa River was used as a supply for lands which could be served by gravity rather than the 18-Km Extension Area, which required pumping. The total area served from the Zarqa River Project; however, remained the same.

Operation for Stage II Development

The objective of the operation studies for Stage II development was to determine the storage requirements at Maqarin Reservoir to irrigate a total of 25,353 ha. This area, in addition to 10,647 ha irrigated from other sources, will meet the Stage II goal of bringing 36,000 ha of land under sprinkler irrigation. The following tabulation shows the areas irrigated and the source of irrigation water.

Project	Area in ha	Source of Water
Kafrein-Hisban	1,560	Wadi Kafrein, Hisban
King Talal Dam	5,077	Zarqa River
NEG Project	2,760	Wadis Arab, Ziglab, Jurum
Wadi Arab Dam	1,250	Wadi Arab
Stage II	25,353	Yarmouk River, Wadis Yabis, Rajib, Kufrinja

Stage II Water Requirements

Irrigation Requirements

The irrigation requirements were estimated using the Blaney-Criddle method and crop factors modified to compensate for humidity and wind. For all crops planted in the dry season, July through October, a pre-irrigation application of 60 mm was assumed. Mean effective precipitation

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was assumed to equal 90 percent of the mean monthly precipitation, when the monthly precipitation was less than 50 mm, and 80 percent when the monthly precipitation was more than 50 mm. The mean effective precipitation was multiplied by a probability factor to obtain the amount expected to be equalled or exceeded 8 years out of 10. The net irrigation requirements were computed by adding the crop consumptive use and a pre-irrigation application, and subtracting effective rainfall and a fraction of soil moisture depletion. The net irrigation requirement by month for the assumed cropping pattern is shown on Table VII-1 for the north area and Table VII-2 for the south area. Details on the development of unit water requirements are given in Appendix G, Agricultural Development.

The total water requirement is based on the net irrigation requirements with an allowance for application efficiency (75 percent) and conveyance efficiency (94 percent). This is equivalent to an overall irrigation efficiency of 70 percent. A summary of the average diversion requirements for the Valley lands using the cropping pattern discussed in Chapter VI are shown in Table VII-3. The difference between the north and south requirements reflects the differences in climate and in the proportion of bananas in the land allocated to fruit. The north-south demarcation was taken as the Zarqa River. A mathematical average of the north and south requirements was used in the operation studies. This average approximates the average demand weighted by the areas north and south of the Zarqa River.

Table VII-1

NET MONTHLY CROP IRRIGATION REQUIREMENT
NORTH ZONE - JORDAN VALLEY
(mm)

Crop		Month												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Wheat/barley		6.60	12.40	15.00	13.80	3.40	-	-	-	-	-	3.00	10.40	64.60
Berseem		5.33	5.98	9.36	7.54	-	-	-	-	1.95	10.92	6.89	4.55	52.52
Maize		-	-	-	.45	2.55	3.72	5.46	5.43	4.26	1.74	-	-	22.61
Sorghum		-	-	-	.45	2.46	3.24	4.68	5.04	4.47	1.92	-	-	22.26
Tomato	I	.91	-	-	-	-	-	1.05	6.65	7.56	8.96	5.67	1.96	32.76
	II	3.36	2.66	2.17	-	-	-	-	-	1.05	5.67	3.57	3.36	21.84
	III	-	-	-	.45	2.67	3.69	5.46	5.43	3.93	1.53	-	-	23.16
Eggplant	I	2.00	2.12	2.84	3.80	2.56	-	-	.60	3.52	3.60	3.24	2.28	26.56
	II	-	.60	2.60	3.36	6.24	7.56	7.28	6.64	5.36	2.80	1.12	-	43.56
Peppers	I	.90	.86	1.22	.96	-	-	.30	1.90	2.16	2.56	1.82	.96	13.64
	II	.30	1.12	1.08	2.42	3.34	3.46	3.46	3.12	2.48	1.08	-	-	21.86
Squash/Cucumber	I	.26	-	-	-	-	-	-	.30	1.76	1.80	1.48	.46	6.06
	II	.45	1.68	1.62	2.98	3.84	2.16	-	-	-	-	-	-	12.72
Cabbage/Cauliflower	I	-	-	-	-	-	-	.45	2.85	3.24	3.54	2.13	.51	12.72
Beans	I	.26	-	-	-	-	-	-	.30	1.76	1.92	1.42	.76	6.42
	II	.30	1.12	1.18	2.22	2.72	1.44	-	-	-	-	-	-	8.98
Melons		-	1.80	7.80	10.80	12.96	18.36	9.24	-	-	-	-	-	60.96
Potato	I	.66	-	-	-	-	-	-	.45	2.64	3.09	2.43	1.23	10.50
	II	.45	1.68	1.95	3.72	4.77	2.37	-	-	-	-	-	-	14.94
Onion/garlic		.12	-	-	-	-	-	.60	3.96	4.60	4.88	2.64	.40	17.20
Other Vegetables		.26	.14	-	-	-	-	-	.30	1.84	1.92	1.52	.66	6.64
Banana		.35	.53	.80	1.30	1.86	2.26	2.48	2.38	2.06	1.53	.88	.43	16.84
Citrus		1.21	3.19	4.07	8.47	11.22	13.53	14.30	13.64	11.77	9.13	4.95	.88	96.36
Other Fruits		-	-	1.70	6.30	11.10	14.40	15.20	13.30	9.80	6.20	2.90	-	80.90
Total		24.02	37.00	54.47	71.43	77.81	69.96	72.29	76.21	74.79	74.79	45.66	28.84	707.19

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Table VII-2

NET MONTHLY CROP IRRIGATION REQUIREMENT
SOUTH ZONE - JORDAN VALLEY
(mm)

Crop		Month												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Wheat/barley		10.60	16.20	19.20	15.00	3.60	-	-	-	-	-	3.00	11.00	78.60
Berseem		8.06	8.32	12.09	8.06	-	-	-	-	1.95	11.31	8.97	7.93	66.69
Maize		-	-	-	0.45	2.67	3.78	5.55	5.52	4.29	1.83	-	-	24.09
Sorghum		-	-	-	0.45	2.55	3.30	4.77	5.13	4.53	2.04	-	-	22.77
Tomato	I	1.61	-	-	-	-	-	1.05	6.72	7.56	9.45	6.86	3.85	37.10
	II	4.76	3.85	2.87	-	-	-	-	-	1.05	5.88	4.69	5.25	28.35
	III	-	-	-	0.45	2.73	3.78	5.52	5.52	3.96	1.65	-	-	23.61
Eggplant	I	2.76	2.84	3.64	4.16	2.68	-	-	0.60	3.56	3.84	3.92	3.36	31.36
	II	-	0.60	2.96	3.68	6.52	7.72	7.36	6.72	5.36	4.36	1.44	-	46.72
Peppers	I	1.30	1.22	1.62	1.04	-	-	0.30	1.92	2.16	2.70	2.16	1.50	15.92
	II	0.30	1.28	1.46	2.60	3.58	3.52	3.52	3.16	2.48	1.10	-	-	23.00
Squash/Cucumber	I	0.46	-	-	-	-	-	-	.30	1.78	1.92	1.54	1.00	7.00
	II	0.45	1.92	2.19	3.21	4.05	2.22	-	-	-	-	-	-	14.00
Cabbage/Cauliflower	I	-	-	-	-	-	-	0.45	2.88	4.32	3.75	2.64	0.87	14.91
	II	0.30	1.28	1.46	2.40	3.18	1.64	-	-	-	-	-	-	10.26
Beans	I	0.46	-	-	-	-	-	-	0.30	1.78	2.06	1.76	1.10	7.46
	II	0.30	1.28	1.58	2.40	2.86	1.48	-	-	-	-	-	-	9.90
Melons		-	1.80	8.88	11.76	18.36	19.92	9.36	-	-	-	-	-	70.08
Potato	I	0.93	-	-	-	-	-	-	.45	2.67	3.27	2.94	2.04	12.30
	II	0.45	1.92	2.52	3.99	5.01	2.73	-	-	-	-	-	-	16.62
Onion/garlic	I	0.48	-	-	-	-	-	0.60	4.00	4.64	5.16	3.32	1.48	19.68
Other Vegetables	I	0.64	0.30	-	-	-	-	-	0.30	1.84	2.06	1.86	1.20	8.20
Banana		1.62	2.13	3.00	4.17	5.82	6.90	7.56	7.26	6.21	3.83	3.15	2.10	54.75
Citrus		3.41	4.07	6.16	9.35	11.88	13.75	14.41	13.86	11.88	9.79	6.71	3.74	109.01
Total		38.89	49.01	71.63	78.67	84.93	82.34	72.69	77.52	79.94	82.36	55.68	46.42	820.08

Table VII-3

SUMMARY OF DIVERSION REQUIREMENTS

Month	North Area (m^3/ha)	South Area (m^3/ha)	Valley Average (m^3/ha)
January	340	560	450
February	530	700	615
March	780	1,020	900
April	1,020	1,120	1,070
May	1,070	1,210	1,140
June	1,110	1,180	1,145
July	1,000	1,040	1,020
August	1,030	1,110	1,070
September	1,090	1,140	1,115
October	1,070	1,180	1,125
November	650	800	725
December	410	660	535
TOTAL	10,100	11,720	10,910

A shortage criteria was used which was based on the number of months of shortage during the operating period, the average yearly shortage in applied water, and the pattern of the shortages. The operation program was developed to limit the number of months of shortage to less than 6 percent of the operating period. A month was considered to be short if less than 100 percent of the requirement was supplied. The average yearly shortage was limited to five percent of the annual requirement. The effect of the shortage pattern on crop yields was considered. The maximum one-year and two-year shortage as well as the consecutive-months pattern of shortages were evaluated. It was concluded that the estimated yields could be obtained, on the average, with the shortage pattern resulting from the operation studies.

Downstream Releases

A release of 25 MCM per year for the Yarmouk Triangle, specified by the JVA, was included in the reservoir operation studies.

Municipal and Industrial (M&I) Requirements

Allocations of water for M&I use have been made for the Jordan Valley and the Irbid governorate. These requirements for domestic, industrial, and livestock use also will be met without shortages. Requirements have been estimated for the year 2,000 as explained in the following sections. The requirements are based on an estimate of population and per-capita use.

The monthly distribution of the M&I requirements was apportioned as follows:

Month	Percent of Total	Month	Percent of Total
Jan	6	Jul	11
Feb	6	Aug	10
Mar	7	Sep	10
Apr	8	Oct	8
May	11	Nov	7
Jun	10	Dec	6

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Jordan Valley. An estimate of the "optimum" population of the Valley in 1987 was given the the Jordan Valley Development Plan. From 1987 to 2000 the population was assumed to increase at a rate of about three percent per year. The present per-capita use in the Valley is estimated by the JVA to be 70 liters per day (lpd). This per-capita rate is expected to increase 1.0 lpd per year. The following tabulation shows the derivation of M & I requirements for the Jordan Valley.

Year	Population	Per-Capita Use (lpd)	Requirement (MCM/yr)
1976	70,000	70	1.79
1987	156,800	81	4.64
2000	230,000	94	7.89 Use 8.0

Irbid Governorate. A supplementary supply of M&I water was to be provided for the Irbid Governorate. The quantity of this supplemental supply was based on a 1976 population of 150,000 persons and a 1976 per-capita use of 80 lpd. It was assumed that the population would increase at a rate of 3 percent per year and that the per-capita use would increase at a rate of 1.0 lpd per year. The M&I requirement for the Irbid Governorate in the year 2000 for a population of 305,000 people is estimated to be about 12 MCM/yr.

Amman. The JVA has directed that operation studies for King Talal Dam include provision for 10 MCM per year for M&I use in Amman. It is assumed that the 10 MCM/yr for Amman represents a net depletion rather than the total diversion from the reservoir. Amman lies almost wholly within the Zarqa River watershed and it is assumed that all but 10 MCM/yr of the withdrawal will return to the system.

Stage II Water Supply

The Stage II demands are met from three sources. The major source is the flow generated above Maqarin Dam which is controlled and released from the reservoir. The second source is the flow in the Yarmouk River between the Maqarin site and the intake to the EGMC, referred to as the interflow. This water consists of flows from the Wadi Raqqad and springs draining into the Yarmouk River. The third source is three small side wadis, Wadis Yabis, Kufrinja, and Rajib.

Inflow to Maqarin Reservoir

The inflow to Maqarin Reservoir is discussed in Chapter V; a tabulation of the recorded data is given in Appendix A, Hydrology and shown graphically on Exhibit 19 of this report. The recorded data have been adjusted to reflect historical and projected future changes in diversion above the Maqarin site. The adjusted mean annual runoff is 240.3 MCM.

Interflow

A study was done to estimate the amount of the interflow which could be diverted into the EGMC. A perusal of the daily records of the interflow showed that in most months, a major portion of the runoff occurred in short periods and with a rate of flow that exceeded the capacity of the EGMC. Using about 20 months of daily records, a relationship between monthly runoff and divertable flow was established. Divertable flow is considered to be the sum of daily runoff volumes limited by the capacity of the EGMC which was taken as 20 m^3/s or 52 MCM/mo.

Side Wadis

Three wadis, Wadi Yabis, Wadi Kufrinja, and Wadi Rajib were included in the operation study as contributing directly to the EGMC. Surplus flow from the Zarqa River Project also was included. The amount of water contributed to the Project

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operation was difficult to assess because the streamflow records were for average monthly flows and did not indicate the amount of water included in flash-type floods which would not be available for diversion. It was decided to base the estimate of water that could be diverted on the summer flows, which as a rule do not contain any flood flows, and on interpretation of some of the stage-time graphs that are available. The maximum contribution of these side wadis and the Zarqa River was assumed to equal the average of the monthly runoff for the five month period June through October. The maximum and average contribution is shown below.

	Maximum Contribution (MCM/mo.)	Average Contribution (MCM/mo)
Wadi Yabis	0.2	0.18
Wadi Kufrinja	0.3	0.25
Wadi Rajib	0.4	0.37
Zarqa River	2.8	0.15
Interflow	52.0	7.91

Operation Program Results

The operation procedure was to meet as much of the irrigation and M&I requirements as possible from the uncontrolled side-wadi flow, and from the interflow. Any remaining requirement would be met with releases from Maqarin Reservoir. The Yarmouk Triangle releases were met from the interflow or releases from Maqarin Reservoir.

Stage II Development

Irrigation. A curve of the total area irrigated versus normal maximum water surface elevation at Maqarin Dam is shown on Exhibit 20. It can be seen that the Stage II

demand can be met from a reservoir at El. 150 with a total reservoir volume of 320 MCM. A reservoir at El. 193 with a total volume of 720 MCM will control the entire water resource at Maqarin. Reservoir yield versus reservoir elevation also is shown on Exhibit 20.

Power and Energy Production. Monthly energy production also is computed in the system operation program.

Energy production was calculated using the required releases and excess discharge up to the capacity of the generators. It was assumed for the studies that all of the areas to be irrigated will be located below the damsite. The M&I requirements for the Jordan Valley will be released through the powerplant; however, the M&I allocation for Irbid will be taken directly from the Maqarin reservoir and not released through the powerplant.

The turbines are sized to discharge the maximum irrigation and M&I demand.

The powerplants for which energy production was determined are as follows:

Powerplant at Maqarin Dam. The powerplant will be located downstream of the dam. Average tailwater level is at El. 8 m. Maximum and minimum reservoir elevations are El. 150 and El. 90 respectively.

Powerplant at King Talal Dam. The powerplant will be located immediately downstream from the dam. The reservoir was operated between the design estimates of maximum and minimum pool, El. 164 and El. 123, respectively. The average tailwater level is assumed to be El. 80 based on available mapping.

The results of the energy generation studies are given in Table VII-4.

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Table VII-4

ENERGY PRODUCTION

Location of Powerplant	Installed Capacity (MW)	Average Energy Production (GWh/yr)	Minimum Dependable Capacity (MW)
Maqarin (Stage II)	20	58	12.8
King Talal	2	8.7	1.0

Other Studies

In addition to the studies done for Stage II development studies also were done to evaluate existing conditions, alternatives to the recommended Stage II development, conditions that would occur during the transition to Stage II development, and the potential for further development (Stage III). The results of these studies are given in Appendix C, Operation Studies.

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Chapter VIII

POWER DEVELOPMENT

Introduction

The power features of the Stage II development of the Jordan Valley Project consist of a 20-MW plant at Maqarin Dam and a 2.0-MW plant at King Talal Dam. These power plants will come on-line in 1983. This chapter is to show that the power and energy production of these two plants can be absorbed under the interconnected system load curve at the time they will enter service. A review of the power market for the Amman and Irbid areas is presented with a forecast of future peak load and energy requirements for the years 1977-1990.

Power Market

Service Areas and Interconnections

The areas which will be served by the power features of Stage II of the Jordan Valley Irrigation Project are the Amman area which is served by the Jordan Electric Power Company (JEPCO), and the Irbid area which is served by the Irbid District Electric Company (IDECO). The Jordan Electricity Authority (JEA) is presently a bulk electricity supplier to JEPCO and will have responsibility for bulk power supply to both systems after their interconnection, scheduled for 1979. The southern portion of Jordan may be interconnected at a later date and there are plans for interconnections with Syria; but, because these interconnections are not formally committed, they are not included in the analysis presented in this chapter.

Historical Demand

The historical peak demand and energy sales, and average yearly growth rates are shown in Table VIII-1. In 1974, about 36 percent of the JEPCO sales were for domestic use, 40 percent for general commercial use, and 24 percent for industrial use.

Table VIII-1

HISTORICAL DEMAND AND GROWTH RATES

Year	JEPCO Peak Demand (MW)	JEPCO Energy Sales (GWH)	IDECO Peak Demand (MW)	IDECO Energy Sales (GWH)	TOTAL Peak Demand (MW) [a]	TOTAL Energy Sales (GWH)
1965	15.7	63.4	1.5	3.3	17.2	66.7
1970	29.8	101.2	2.9	6.9	32.7	108.1
1974	46.4	178.7	7.7	14.0	54.1	192.7
1975	57.4	-	8.8	-	66.2	-
1976	71.4	-	10.7	-	82.1	-
Compound growth rates, percent per annum						
1965-1970	13.7	9.8	14.1	15.8	13.7	10.1
1970-1974	11.7	15.3	27.6	19.2	13.4	15.5
1965-1974	12.8	12.2	19.9	17.3	13.5	12.5

a/ Coincidence factor assumed to be 1.0

Future Requirement

A recent report by Kuljian[1/] contains estimates of the future power requirements for the Irbid and Amman areas.

1/ Feasibility Study, Hussein Thermal Power Station Extension, Unit No. 4 and 5, Zarqa, Jordan, Kuljian, May 1975.

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The results of the studies of the future power and energy requirements are shown in Table VIII-2.

Table VIII-2

FUTURE REQUIREMENTS

Year	Peak Demand (MW)			Energy Requirement (GWh)		
	IDECO	JEPCO	TOTAL[a/]	IDECO	JEPCO	TOTAL
1980	18.0	156.4	174.4	72.6	754.0	826.6
1985	32.2	255.8	288.0	124.4	1208.0	1332.2
1990	49.6	416.0	465.6	190.5	1997.0	2187.5

a/ Coincidence factor assumed to be 1.0.

Jordan Valley Pumping Requirements

About 18 pumping stations will be installed along the EGMC to develop head for transporting water to the farms and for operating the sprinkler irrigation system in the conversion area and the new land area. Several additional pumps may be required for service to the potential lands. The power requirement for this pumping system is estimated to be 6.6 MW. This requirement is based on all pumps pumping at peak rates. The energy requirement is estimated to be about 31 GWh per year. The energy requirement is based on average irrigation water supply conditions.

Existing and Committed Units

Existing Units. The power supply system presently consists of a series of diesel power plants under the admini-

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stration of JEPCO and IDECO, and the Hussein Thermal Power Station under the administration of the JEA. The Hussein Power Station will become the main supply center for the northern part of Jordan in the near future. At the end of 1976, two gas turbine units totaling 33.6 MW were in operation in this plant and two 33-MW steam units were ready to come on line. Table VIII-3 shows the location, type, and installed capacity of the existing units in 1976.

Table VIII-3

GENERATION PLANTS IN NORTH JORDAN (1976)

	Location	Type	Installed Capacity (MW)
Hussein Thermal Power Station	Zerqa	Gas	33.6
		Steam	66.0
JEPCO Power Stations	Amman	Diesel	44
IDECO Power Stations	Irbid	Diesel	12.5
Total			156.1

Committed Units. A third 33-MW steam unit for the Hussein Station is in construction and scheduled to enter service in 1978. In addition, the Kuljian Report recommends the addition of one 66-MW unit in 1980 and another in 1981. It was assumed that these units are already committed.

Power Balance. On the basis of the peak load requirements shown in Table VIII-2, the existing and committed

units previously discussed, the scheduled retirement of diesel units, and the future expansion plans suggested by Kuljian, a power balance for the years 1977 through 1990 is given in Table VIII-4.

Table VIII-4

POWER BALANCE 1977-1990
(MW)

Year	Peak Demand	Additional Capacity	Total Installed Capacity
1977[a]	102.4	-	156.1
1978[a]	123.5	+33(S)	189.1
1979	146.6	-	189.1
1980	174.4	+66(S)	255.1
1981	193.[illegible]	+66(s),-11.1(D)	310.0
1982	215.9		310.0
1983	234.0	+66(S) +22(H)	398.0
1984	259.3	-	398.0
1985	288.0	-	398.0
1986	318.6	+100(S)	498.0
1987	353.5	-	498.0
1988	388.3	+100(S)	598.0
1989	426.8	-	598.0
1990	465.6	+100(S)	698.0

a/ For 1977 and 1978, the power balance is given as the combined demand of Amman and Irbid although the interconnection will not be in service until 1979.

(S)-steam, (H)-Hydropower, (D)-Diesel

The 22 MW of installed capacity in the Jordan Valley Stage II development amounts to about 10 percent of the projected peak demand in 1983. The system growth will absorb the Stage II capacity in less than one year.

System Supply

Stage II Power and Energy Production

The hydroelectric power installations that are recommended for construction during the Stage II development are described in Chapters II and III. The Maqarin plant with two 10-MW units will be connected to the Interconnected System through a substation at Irbid by a 31 km 66-kV single-circuit transmission line. The King Talal plant with one 2.0-MW unit installed will be connected to a substation along the Amman-Salt transmission line by a 9 km, 33-kV single-circuit transmission line. Construction of the powerplants will be completed in 1982 and the generating units will come on the line in 1983.

The average annual energy production as a result of the reservoir operation studies described previously is 58 GWh at Maqarin and 8.7 GWh at King Talal.

The firm power is defined for the purpose of this study as the power which can be obtained 95 percent of the time. The firm power at Maqarin is calculated to be 12.8 MW and the firm power at King Talal is about 1.0 MW.

Operation of the Maqarin Power Plant

Monthly operation studies of the Maqarin reservoir have been performed with a computer model. The objective was to meet in priority the municipal and industrial water requirements, then the irrigation requirements. The results of these operation studies show that there is no required

release during the month of February and sometimes no required release in January and March. System characteristics were evaluated on the basis of monthly peak demand curves and a daily-load curve for a summer day and a winter day. A study of the monthly peak-load variation indicates that the summer months have a higher peak demand than the general trend would predict for these months. The yearly peak occurs in the summer for the Amman and Irbid areas except in 1975 when the peak occurred at the end of the year. The analysis of the summer daily-load curve for JEPCO shows that there is a three-hour evening peak. Peaking capacity which could provide generation during three hours would be able to meet about 25 percent of the system peaking requirements. In 1982, this peak requirement will amount to about 50 MW of generating capacity. The 12.8 MW of firm power at Maqarin can serve part of the peaking demand.

The operation studies show that the required monthly releases range from about 3.0 m^3/s (260,000 m^3/day) to 12.0 m^3/s (1,140,000 m^3/day) during the summer season. The low requirements occur when the reservoir level is high and the high requirements occur when the reservoir level is low. A daily operation study shows that if the release is made to meet the evening peaking requirements about 130,000 m^3 of the daily requirement must be shifted from the 21-hour non-peaking hours to the 3-hour peak. This peak discharge will be reregulated in the river channel downstream from Maqarin. Hydraulic studies were done to evaluate the flow attenuation which would occur in the Yarmouk River between Maqarin Dam and the intake to the EGMC. Various combinations of releases from Maqarin Reservoir and interflow were studied. The river section and friction factor were assumed on the basis

of a field inspection. For all the combinations anticipated, the attenuation would be sufficient to allow diversion of the power release into the EGMC. The diverted flows will be regulated in the EGMC so that all areas will receive the entire demand when required. A description of the regulation is given in Appendix K, Irrigation Facilities.

The Maqarin units will enter service in 1983 and the firm capacity of 12.8 MW will be available during that summer. The 12.8 MW capacity represents about 5 percent of the peak demand in 1983, and this percentage is of a similar order of magnitude as the difference between summer and winter peak. Thus the firm hydro capacity is dependable during the peak months. With the addition of 22 MW of installed capacity in 1983, it may be possible to delay for one year from 1983 the installation of a 66-MW steam unit as recommended by Kuljian.

Evaluation of the Development of Hydro-power

Most of the power and energy demand will be served grom steam generating units by 1983. Therefore, the capacity and energy benefits for the hydro plant were evaluated on the basis of the equivalent cost of producing power and energy that would otherwise be produced by steam units. Details of the benefit evaluation are given in Appendix H, Economic Analyses.

Capacity Benefit. The capacity benefit is based on the the cost of an alternative source of power supply. The cost presented in a recent report by Kuljian[2/] for a 66-MW steam unit was used. The capacity benefit consists of two components: 1) an initial benefit which represents the cost of alternative development plus a cost for fuel reserve, and 2) an annual benefit which represents the fixed operating cost for interim

2/ See Footnote 1.

replacements, insurance, the fixed component of operation and maintenance (O&M), the fixed component of the fuel cost, and administration and general expenses.

The cost of alternative development was taken as the construction cost of the 66-MW steam unit with a 30-year useful life which is estimated to be JD 184/kW. The cost of a fuel reserve for 75 days of operation at a plant factor of 50 percent is JD 6/kW. The initial benefit is, therefore, JD 190 per kW. The fixed annual operating benefit is estimated to be JD 6.4 per kW.

Energy Benefit. The energy benefit is comprised of a fuel and lubrication cost and an allowance for O&M relating to these variable operating costs. The fuel cost is based on the international price of Bunker "C" fuel (JD 3.67/bbl), a heating value of 147,500 BTU/gal, and an assumed average heating rate of 10,500 BTU/kWh. The energy benefit is summarized as follows:

Item	Value in Fils/kWh
Energy fuel	5.7
Lubricating Oil	1.0
O&M	0.2
Total Energy Benefit	6.9

Benefit-Cost Analysis. A benefit-cost analysis was done for separable power costs and an internal rate of return was calculated.

The construction costs, OM&R costs, and the capacity and energy benefits are as follows:

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	(Values in JD 10^3) Maqarin Powerplant	King Talal Powerplant
Construction Cost (1977)	5,251	599
OM&R (incremental)	45	13
Capacity Value		
Initial Value	2,430	190
Annual Value	82	6
Energy Value (Annual)	400	60

The present worth of these costs and benefits for the indicated discount rates are shown in the following tabulation:

	(JD x 10^3) Maqarin Powerplant		King Talal Powerplant	
Discount Rate	10%	20%	10%	20%
PW of Costs	4,628	3,663	573	426
PW of Benefits	5,609	2,953	650	313
B/C	1.21	0.81	1.13	0.73

The internal rate of return for power development at Maqarin Dam is about 15 percent. Power development at King Talal Dam will provide an internal rate of return of about 12 percent.

In a preceeding section the power and energy requirements for the irrigation system were defined. These requirements (6.6 MW and 31 GWh/yr) are less than the capacity of the Maqarin Powerplant (12.8 MW and 58 GWh/yr). If the powerplants at Maqarin Dam and King Talal are installed, the JVA has the option of generating its own power requirements and selling the remainder in bulk to the JEA. Because the

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Maqarin powerplant will not be generating at all times when energy is required in the Valley, some energy will be purchased from the JEA. It is suggested that an arrangement be made with the JEA whereby an exchange of energy can be made.

If the Project generates its own power requirement, the operation cost for the irrigation system will be reduced by about 40 percent thereby partially alleviating the financial burden of the JVA.

It is apparent that power development is a viable addition to the irrigation project and, therefore, has been included in all Project evaluations.

Chapter IX

ECONOMIC AND FINANCIAL ANALYSIS

Economic Justification

The economic justification of the Jordan Valley Irrigation Project Stage II development has been measured by a comparison of benefits and costs over a 50-year period beginning with the first year of project construction. A financial analysis also was conducted including an evaluation of the payment capacity of farmers, a preliminary Project repayment analysis, a cash flow analysis, and a cost allocation. The financial analysis is summarized in a subsequent section of this chapter.

The internal rate of return for the project using direct benefits and costs amounts to 13.4 percent. If indirect benefits and costs are included, the internal rate of return increases to 15 percent. Assuming an interest rate of 10 percent, the project has a benefit-cost ratio of 1.4 using direct benefits and costs only. With indirect benefits and costs added, the benefit-cost ratio increases to 1.6.

To evaluate the various elements and assess the overall viability of the Project the following economic analyses were performed.

1. The economic justification of the Stage II development including irrigation of 25,353 ha, power generation at Maqarin Dam and King Talal Dam, and M&I water supply.

2. The economic justification of the major components of the Stage II development.

a. Irrigation of 25,353 ha.

   i. Irrigation of 12,842 ha of land converted from surface to sprinkler irrigation.

   ii. Irrigation of 12,511 ha of land not presently included in any project and, for the most part, unirrigated.

b. Development of hydroelectric power at Maqarin Dam and King Talal Dam.

c. Allocation of storage in Maqarin Reservoir for M&I water supply.

Project Costs

Cost estimates of Project facilities are based on plans and schemes presented in detail in Chapters II, III, and IV. The construction and annual operation costs for the storage, irrigation and power facilities are based on January 1977 prices. A summary of the construction costs are given in Table IX-1. The annual expenditures were developed in conjunction with the construction schedule. The irrigation system was constructed at a rate of 6,000 ha per year. The installation schedule for the irrigation system is shown below:

	Conversion Area (ha)	New Land (ha)	Potential Lands (ha)	Total (ha)
1980	4,457	1,543	-	6,000
1981	3,000	3,000	-	6,000
1982	3,000	3,000	-	6,000
1983	2,385	3,021	594	6,000
1984	-	-	1,353	1,353
Total	12,842	10,564	1,947	25,353

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Table IX-1

CONSTRUCTION COSTS FOR ECONOMIC ANALYSIS

(JD x 1,000)

		MAJOR WORKS					IRRIGATION SYSTEM COSTS			
Year	Storage Facilities	Powerplant at Maqarin	Diversion at Adasiye and and Side Wadis	Powerplant King Talal	Miscell-aneous Costs a/	Main Canal Extension & Repair	Converted Lands	New Lands	Potential Lands	Total
1979	8,637	-	-		950	1,520				11,107
1980	27,175	480	348	-	310	869	9,105	2,980		41,267
1981	21,573	2,871		360	160		5,983	5,560		36,507
1982	13,506	1,900		239	163		5,983	5,560		27,351
1983							5,233	5,933	2,473	13,639
1984									5,688	5,688
TOTAL	70,891	5,251	348	599	1,583	2,389	26,304	20,033	8,161	135,559

a/ Access, Land Acquisition, Operators Camp.

The cost for relocating the Himma branch of the Hejaz Railroad has been excluded from the project costs. With the filling of the reservoir, the railroad right-of-way will be flooded. To relocate the railroad around the reservoir will cost about JD 8.1 million using 1977 prices. The relocation is necessary because of treaty agreements and it was assumed that complying with these agreements has a benefit equal to the cost of the relocation and that the cost of the relocation is not a Project cost.

A breakdown by major components of the annual operation and maintenance costs at full Project development are shown in Table IX-2. The O&M cost for the irrigation facilities is based on supplying the power and energy requirements for the irrigation system from Project facilities.

Table IX-2

ANNUAL OPERATION AND MAINTENANCE COST
AT FULL DEVELOPMENT
(JD x 1,000)

	Annual Operation Cost
Storage Facilities	205
Power Facilities	58
Irrigation System (Including subsurface drainage)	984
Total	1,247

The schedule of annual disbursements for O&M is shown on Table IX-3.

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Table IX-3

SCHEDULE OF OPERATION AND MAINTENANCE COSTS BY YEAR

(JDx1000)

Year	Storage Facilities	Power Facilities Maqarin	Power Facilities King Talal	Sub-Surface Drains	Irrigation System	Total
1979	-	-	-	-	-	-
1980	-	-	-	-	-	-
1981	-	-	-	-	229	229
1982	-	-	-	-	481	481
1983	205	45	13	-	527	790
1984	205	45	13	-	787	1,050
1985	205	45	13	130	854	1,247
To 2004	205	45	13	130	854	1,247
2005	205	45	13	-	854	1,117
2006	205	45	13	-	854	1,117
2007	205	45	13	-	3,953 a/	4,011
2008	205	45	13	-	3,953 a/	4,011
2009	205	45	13	-	854	1,117
To 2029	205	45	13	-	854	1,117

a/ Includes allowance for replacement of pumping facilities.

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Project Benefits

Irrigation Benefits. Irrigation benefits are defined as the increase in net farm income that can be attributed to the Project. Present and future land use and farm incomes expected under with and without project conditions provide the basis for estimating the irrigation benefits.

The irrigation benefits by land condition and location on a per hectare basis are shown in Table IX-4. Details on the development of these benefits are given in Chapter VI and in Appendix G, Agricultural Development.

Table IX-4

IRRIGATION BENEFITS PER HECTARE

Land Condition	Location	Benefit (JD/ha)
Irrigated	EGCP	590 - 873
Irrigated	Southern Valley	1,324
Dryland	EGCP	1,448
Dryland	Southern Valley	1,474

It was assumed that the projected full development benefits can be reached in 4 years for lands that are presently irrigated in the EGCP and in 7 years for the remaining lands. It was further assumed that the benefit build-up will occur at a constant or linear rate during the development periods beginning in the year after installation of the sprinkler system. The total irrigation benefits by year for the conversion area and for the new lands are shown in Table IX-5.

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Table IX-5

ECONOMIC COSTS AND BENEFITS
FOR STAGE II DEVELOPMENT

(JD X 1,000)

		COSTS			BENEFITS					
Order	Year	Construction	OM&R	Total	Power Maqarin Dam	Power King Talal Dam	Municipal and Industrial	Irrigation Conversion	Irrigation New Lands	Total
0	1979	11,107		11,467						
1	1980	41,267		41,267						
2	1981	36,507	229	36,736	500	90		969		1,559
3	1982	27,351	481	27,557	678	100		2,521		3,299
4	1983	13,639	790	14,429	226	66	803	4,605	1,560	7,260
5	1984	5,688	1,050	6,738	226	66	835	7,045	3,871	12,043
6	1985	-	1,247	1,247	226	66	872	8,534	6,460	16,158
7	1986	-	1,247	1,247	226	66	909	9,422	9,048	19,672
8	1987	-	1,247	1,247	226	66	947	9,759	11,637	22,635
9	1988	-	1,247	1,247	226	66	986	9,587	14,226	25,091
10	1989	-	1,247	1,247	226	66	1,027	9,352	16,815	27,486
11	1990	-	1,247	1,247	226	66	1,069	9,054	17,844	28,259
12	1991	-	1,247	1,247	226	66	1,114	8,755	18,121	28,283
13	1992	-	1,247	1,247	226	66	1,160	8,362	18,121	27,936
14	1993	-	1,247	1,247	226	66	1,208	8,362	18,121	27,984
15	1994	-	1,247	1,247	226	66	1,259	8,362	18,121	28,035
16	1995	-	1,247	1,247	226	66	1,310	8,362	18,121	28,086
17	1996	-	1,247	1,247	226	66	1,365	8,362	18,121	28,141
18	1997	-	1,247	1,247	226	66	1,419	8,362	18,121	28,195
19	1998	-	1,247	1,247	226	66	1,478	8,362	18,121	28,254
20	1999	-	1,247	1,247	226	66	1,538	8,362	18,121	28,314
21	2000	-	1,247	1,247	226	66	1,600	8,362	18,121	28,376
22	2001	-	1,247	1,247	226	66	1,600	8,362	18,121	28,376
23	2002	-	1,247	1,247	226	66	1,600	8,362	18,121	28,376
24	2003	-	1,247	1,247	226	66	1,600	8,362	18,121	28,376
25	2004	-	1,247	1,247	226	66	1,600	8,362	18,121	28,376
26	2005	-	1,117	1,117	226	66	1,600	8,362	18,121	28,376
27	2006	-	1,117	1,117	226	66	1,600	8,362	18,121	28,376
28	2007	-	4,011	4,011	226	66	1,600	8,362	18,121	28,376
29	2008	-	4,011	4,011	226	66	1,600	8,362	18,121	28,376
30	2009	-	1,117	1,117	226	66	1,600	8,362	18,121	28,376
31	2010	-	1,117	1,117	226	66	1,600	8,362	18,121	28,376
32	2011	-	1,117	1,117	726	156	1,600	8,362	18,121	28,376
33	2012	-	1,117	1,117	904	166	1,600	8,362	18,121	28,376
34	2013	-	1,117	1,117	226	66	1,600	8,362	18,121	28,376
To 48	2027	-	1,117	1,117	226	66	1,600	8,362	18,121	28,376
49	2028	-	1,117	1,117	-74	6	1,600	8,362	18,121	28,376

Power Benefits. The derivation of the power and energy benefit and the evaluation of the development of hydropower have been discussed in Chapter VIII and in Appendix H, Economic Analysis. The capacity benefit consists of an initial benefit of JD 190/kW and an annual benefit of JD 6.4/kW. The energy benefit amounts to 6.9 fils/kWh.

The power and energy remaining after the Project requirements are met and which is saleable to the JEA are shown in Table IX-6.

Table IX-6

POWER SALEABLE TO JEA

	Dependable Capacity MW	Energy GWh
Maqarin Powerplant	12.8	58
King Talal Powerplant	1.0	8.7
Total	13.8	66.7
Project Requirements	6.6	31.0
Saleable to JEA	7.2	35.7

The power benefits are tabulated by year in Table IX-5.

Municipal and Industrial Benefits. Provision has been made in the design of Maqarin Dam to supply 20 MCM/yr of water for municipal and industrial use, 12 MCM/yr to the Governorate of Irbid and 8 MCM/yr to the Valley. The Government's decision to withdraw water from the reservoir for these purposes is made with the knowledge that no cheaper alternative sources are available. It is recognized that

water is becoming an increasingly scarce resource in Jordan and that the cost of developing new sources of supply is constantly rising. The incremental cost for the Project to supply 20 MCM/yr is estimated to be JD 11 million. Consumption of the water is expected to rise over the 17-year period from 1983 to 2000. From year 2000 onward the full amount will be withdrawn. In the absence of reliable information on the future pricing of municipal and industrial water, the benefits have been estimated on the basis of a present-day (1977) value of 80 fils/m^3. This is about what is currently charged at Irbid and is viewed as a very conservative (low) estimate of the value of water at Maqarin damsite. Because there are no viable alternative sources, the lowest alternative cost could not be determined. The JVA has indicated that there is no other source of water supply for Irbid except the Yarmouk River. As a measure of what the users might be willing to pay, 80 fils/m^3 represents a very conservative (low) value. The maximum annual benefit from M&I supply will be equivalent to JD 1,600,000 per year. The M&I benefits are tabulated by year in Table IX-5.

Flood Control Benefits. The Project facilities will afford a degree of flood protection as a result of the routing effect of the reservoirs on the winter floods. Historically, the heavy winter rains have caused much flooding in the Zor. Flood damage is caused largely by the flows of the Yarmouk River. The damage occurs to growing crops, private and public installations, and is measured also in terms of bank erosion and loss of top soil. The ponding and flooding often causes a public health hazard because of the proliferation of water-borne vectors. No information on the value of flood damage is available and, therefore, no estimate

of benefit accruing to the Project facilities was made. The specific costs of repairing damage to irrigation structures caused by flooding has averaged about JD 1,000 per year over the past five years.

As a measure of the effect of the Project facilities on flood flows, during the 22-year operating period used for these studies, Maqarin Reservoir spilled only 12 months.

Evaluation of the Stage II Development

Table IX-5 summarizes the projected incidence of construction and OM&R costs, and benefits from irrigation, power, and municipal and industrial water supply.

The total present worth of the cost and benefit streams of Stage II development for indicated discount rates is shown in Table IX-7. The development includes irrigation of 25,353 ha, generation of a total of 66.7 GWh of energy, of which 31 GWh will be used by Project facilities and 35.7 GWh will be sold to the JEA, and the supply of 20 MCM/year for M&I use. As previously indicated, the internal rate of return for the Project is 13.4 percent. At a 10 percent interest rate, the ratio between benefits and costs is 1.4. It is evident that the Project is a sound and worthwhile investment. The present worth of costs and benefits at various discount rates are shown on Exhibit 21.

Irrigation Increment. An evaluation was made of the economic justification of the irrigation increment and each of the irrigation components. The cost of the storage facility used in the evaluation of overall irrigation development is for a raisable structure which impounds a reservoir capable of continuing the supply to the lands in the conversion area and irrigating the new lands. From an operation study, a reservoir at El. 130 (Crest El. 139)

Table IX-7

PRESENT WORTH OF COSTS AND BENEFITS
(JDX1000)

Year	Total Costs including OM&R	Present Worth of Total Costs 10%	15%	20%	Total Benefits	Present Worth of Total Benefits 10%	15%	20%
1979	11,107	11,107	11,107	11,107	-	-		
1980	41,267	37,515	35,884	34,389	-	-		
1981	36,736	30,360	27,777	25,511	1,559	1,289	1,179	1,083
1982	27,557	20,910	19,299	16,106	3,299	2,479	2,169	1,909
1983	14,429	9,855	8,150	6,958	7,260	4,959	4,151	3,501
1984	6,738	4,184	3,350	2,708	12,043	7,478	5,988	4,840
1985	1,247	704	539	418	16,158	9,121	6,986	5,411
1986	1,247	640	469	348	19,672	10,095	7,395	5,490
1987	1,247	582	408	290	22,635	10,560	7,400	5,264
1988	1,247	529	354	242	25,091	10,641	7,132	4,863
1989	1,247	481	308	201	27,486	10,597	6,794	4,439
1990	1,247	437	268	168	28,259	9,904	6,074	3,803
1991	1,247	397	233	140	28,283	9,012	5,286	3,172
1992	1,247	361	203	117	27,936	8,092	4,540	2,611
1993	1,247	328	176	97	27,984	7,369	3,955	2,180
1994	1,247	298	153	81	28,035	6,711	3,445	1,820
1995	1,247	271	133	67	28,086	6,112	3,001	1,519
1996	1,247	247	116	56	28,141	5,567	2,615	1,268
1997	1,247	224	101	47	28,195	5,071	2,278	1,059
1998	1,247	204	88	39	28,254	4,620	1,985	884
1999	1,247	185	76	33	28,314	4,209	1,730	739
2000	1,247	168	66	27	28,376	3,834	1,508	617
2001	1,247	153	58	23	28,376	3,486	1,311	514
2002	1,247	139	50	19	28,376	3,169	1,140	428
2003	1,247	127	44	16	28,376	2,881	991	357
2004	1,247	115	38	13	28,376	2,619	862	297
2005	1,117	94	30	10	28,376	2,381	750	248

Table IX-7

PRESENT WORTH OF COSTS AND BENEFITS
(JDX1000)

Year	Total Costs including OM&R	Present Worth of Total Costs 10%	15%	20%	Total Benefits	Present Worth of Total Benefits 10%	15%	20%
2006	1,117	85	26	8	28,376	2,164	652	207
2007	4,011	278	80	24	28,376	1,968	567	172
2008	4,011	253	70	20	28,376	1,789	493	143
2009	1,117	64	17	5	28,376	1,626	429	120
2010	1,117	58	15	4	28,376	1,478	373	100
2011	1,117	53	13	3	28,966	1,372	331	85
2012	1,117	48	11	3	29,k54	1,255	290	71
2013	1,117	44	10	2	28,376	1,111	245	58
2014	1,117	40	8	2	28,376	1,010	213	48
2015	1,117	36	7	2	28,376	918	185	40
2016	1,117	33	6	1	28,376	834	161	33
2017	1,117	30	6	1	28,376	759	140	28
2018	1,117	27	5	1	28,376	690	122	23
2019	1,117	25	4	1	28,376	627	106	19
2020	1,117	22	4	1	28,376	570	92	16
2021	1,117	20	3	1	28,376	518	80	13
2022	1,117	19	3	0	28,376	471	70	11
2023	1,117	17	2	0	28,376	428	61	9
2024	1,117	15	2	0	28,376	389	53	8
2025	1,117	14	2	0	28,376	354	46	6
2026	1,117	13	2	0	28,376	322	40	5
2027	1,117	12	1	0	28,376	292	35	4
2028	1,117	10	1	0	28,016	263	30	4
Total		121,902	108,965	99,414		173,462	95,476	59,541

would be required. In addition, costs were included for the repair and extension of the EGMC, the diversion facilities, and the irrigation facilities. The irrigation benefits will begin in 1981 and will reach a maximum in 1991.

Irrigation development alone will provide an internal rate of return of 14 percent. The benefit-cost ratio for an interest rate of 10 percent is about 1.5.

Irrigation of the Converted Area. An evaluation was made of the economic justification of the sprinkler irrigation system component on 12,842 ha that are under the command of the EGMC. The cost of the diversion dam at Adasiye, repair of the EGMC, and the irrigation system were used in the analysis. The benefits will result from (1) the controlled application of water and other farm inputs which will increase yields, and (2) the saving of water which will permit an increase of the overall cropping intensity from 106 percent to 128 percent.

The benefits will begin in 1981 and reach a maximum in 1987. The benefits will decrease slightly until 1992 and then remain stable. The decrease results from subtracting the net income that would occur without the Project.

Development of the conversion area will provide an internal rate of return of 25 percent. The benefit cost ratio at 10 percent is 2.5. The internal rate of return and benefit cost ratio for the conversion are relatively high because no storage cost have been charged to this increment and much of the infrastructure investment has already been made.

Irrigation of the New-Land Area. An evaluation was made of supplying irrigation water to 12,511 ha within the Project service area that are outside the service area of

the EGMC and, for the most part, are not currently irrigated. To irrigate these lands, a storage facility at Maqarin is required to regulate the flows of the Yarmouk River. The costs for the storage facility, the repair and extension of the EGMC, the diversion facilities, and the irrigation facilities were used in this analysis. The irrigation benefits will begin in 1983 and will reach a maximum in 1991, seven years after the installation of the irrigation facilities has been completed.

Development of the new lands will provide an internal rate of return of 11.3 percent. The benefit cost ratio for an interest rate of 10 percent is about 1.2. Considering the large portion of the costs of Maqarin dam that was charged to the new lands increment, an internal rate of return of 11.3 percent is regarded as very attractive.

Power Development Increment. The evaluation of power development as an addition to Stage II development was considered in Chapter VIII. The powerplant at Maqarin Dam has a dependable capacity of 12.8 MW and generates an average of 58 GWh of energy each year. At King Talal Dam, the dependable capacity is 1.0 MW and the average energy generation is 8.7 GWh per year.

As shown in Chapter VIII, the internal rate of return for power development at Maqarin Dam is about 15 percent; at King Talal Dam, it is 12 percent. The benefit-cost ratios at 10 percent for power development at Maqarin Dam and King Talal Dam are 1.2 and 1.1 respectively. The total power increment has an internal rate of return of 14 percent.

Municipal and Industrial Water Supply Increment. The economic evaluation for M&I water supply is based on supplying 20 MCM per year to the Jordan Valley and Irbid. The cost

associated with the M&I supply is the incremental cost of raising the dam from the single-purpose irrigation height to the height required to supply both irrigation and M&I requirements. It will be necessary to raise the dam 19 m at a cost of about JD 11 million.

The internal rate of return for the M&I component is about 10.3 percent. The benefit-cost ratio for an interest rate of 10 percent is 1.0.

Summary of Economic Analyses. A summary of the results of the economic analyses is shown in Table IX-8.

Table IX-8
SUMMARY OF ECONOMIC ANALYSES

	Internal Rate of Return	B/C at 10 percent
Stage II Development	13.4	1.4
Irrigation Increment	14.0	1.5
Power Increment	14.0	1.2
M&I Water Increment	10.3	1.0
Irrigation Components		
Conversion Area Increment	25.0	2.5
New Land Area Increment	11.3	1.2

Sensitivity Analyses

The basic estimates used in the economic evaluation may be adjusted to account for variations in the magnitude of costs and benefits, in the rate of construction of the facilities, and in the time required to reach full production. Sensitivity studies were conducted to determine the effect of these possible variations on the overall viability of the

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Project. The analyses included single and multi-variate tests using assumptions other than those anticipated in the Project evaluation.

A summary of the sensitivity tests is shown in Table IX-9.

Table IX-9

SENSITIVITY ANALYSES
INTERNAL RATE OF RETURN

	Single-Variate	IRR (percent)
1.	Project Evaluation	13.4
2.	Low Summer Water Use Pattern	13.3
3.	Vegetable - Intensive Pattern	16.0
4.	Irrigation System Construction Rate at 4000 ha/yr	13.0
5.	Construction Costs Increased by 10 percent	12.5
6.	Benefit Build-Up Period of 7 to 10 years	12.0
7.	Yields reduced 10 percent	11.4
8.	Yields reduced 20 percent	9.3
9.	Production Costs increased 15 percent	13.0
10.	Farmgate prices increased 20 percent	17.0
11.	M&I benefit increased 25 percent	14.0
12.	Project evaluation including cost of railroad relocation	12.9
	Multi-Variate	
1.	Irrigation System Construction Rate - 4000 ha/yr Benefit Build-Up Period of 7 to 10 years Yields reduced by 10 percent	10.0
2.	Farmgate Prices reduced by 10 percent Production Costs increased by 15 percent	10.7
3.	Yields reduced by 10 percent Construction costs increased by 10 percent	10.7
4.	Vegetable - Intensive Pattern Yields increased by 10 percent Farmgate Prices increased by 10 percent	20.0

The general conclusion from the sensitivity analysis is that substantial variations could occur in key variables without significantly influencing project justification or viability.

Indirect and Intangible Benefits

Substantial indirect and intangible benefits also will accrue to the Project. Indirect benefits are all benefits, other than those previously discussed, that can be expressed in monetary terms. Intangible benefits are all remaining benefits which cannot be expressed in monetary terms.

Indirect Benefits. Indirect benefits have been measured on the basis of the with and without project principle. Indirect benefits have been separated into three categories. The first category, stemming benefits, measures the profits earned on commodities produced on the project and sold directly to retail merchants, and the profits obtained when more extensive handling is required between the farmer and the merchant. The second category, induced benefits, represents the profits of all enterprises supplying goods and services for the increased production on the project. The third category, public benefits, include the benefits from settlement, employment, and new investment opportunities; increased tax revenues; and stabilization of the economy.

The monetary value of annual indirect benefits are shown in Table IX-10. The total value of the indirect benefits is JD 22,600,000.

The stemming benefits are estimated to have a value of JD 7 million per year. The farm products sold directly to retail businesses are expected to result in average profits on sales of 10 percent. Farm products which will require more extensive handling are expected to return a profit of

Table IX-10

ESTIMATED ANNUAL INDIRECT BENEFITS AT FULL DEVELOPMENT

Item	Increased Value	Indirect Benefit Factor	Estimated Benefits to the Economy JD
Stemming Benefits			
Increased Sales of Farm Products to Retail Businesses	JD 30,000,000	10%	3,000,000
Increased Sales of Farm Products to Processors	JD 10,000,000	25%	4,000,000
Subtotal, Stemming Benefits			7,000,000
Induced Benefits			
Increased Purchases For Production Purposes	JD 8,500,000	15%	1,300,000
Public Benefits			
Farm Settlement Opportunities	3,000	JD 1,000	3,000,000
Permanent Employment Opportunities	9,600	JD 500	4,800,000
New Investment Opportunities	JD 150,000,000	2%	3,000,000
Increased Tax Revenues	---	--	2,100,000
Stabilization of the Economy	JD 28,376,000	5%	1,400,000
Subtotal, Public Benefits			14,300,000
Total Annual Indirect Benefits			22,600,000

about 25 percent to the middleman. The induced benefits, totaling JD 1.3 million per year, represent a total profit by the enterprises supplying the services amounting to 15 percent of the purchase price.

The public benefits, totaling JD 14.3 million annually, result from settlement opportunities on 3,000 farms, and permanent employment opportunities for an additional 9,000 workers. In addition, new investment oportunities occur a result of the difference between the anticipated return on the farm investment (10 percent) and the return that could be obtained from registered development bonds (8 percent). Revenues from land, municipalities, and income taxes are expected to increase by JD 523,000 per year. Indirect taxes for such items as customs, excise, licenses, and fees are estimated to equal three times the direct taxes or JD 1.6 million for a total of JD 2.1 million per year. Stabilizing the economy of the region by providing a dependable irrigation supply has been valued at five percent of the direct benefits at full Project development.

Intangible Benefits. Although intangible benefits cannot be expressed in monetary terms, they can equal or exceed the importance of direct or indirect benefits in determining whether a Project should be constructed. These intangible benefits include:

1. Contribution in Easing Balance of Trade Problems
2. Balancing the Economy
3. Meeting Food Requirements
4. Improved Living Standards
5. Efficiencies in Providing Public Services

An adverse balance of trade situation has been a problem in Jordan's economy for several years. Implementation of Stage II will result in an estimated increase of annual gross crop value of JD 51 million per year. The production will both reduce the amount of agricultural imports and increase the amount of exports. In addition, the import cost of oil will be reduced by about JD 400,000 per year because of the generation of hydroelectric power by project facilities.

The balance among sectors of the economy will be improved by increasing the percent of the labor force in production versus service-oriented occupations. In addition, opportunities in the Valley will tend to decentralize the population base and help stem the influx of people to an already congested Amman.

An improvement in the dietary standards will be possible with the availability of increased amounts of animal protein, dairy products, and fresh fruits and vegetables.

Increased earnings, improved commercial activity, and increased public and private investment will improve the living standards in the Valley.

Closer settlement in the Valley made possible with the high productivity of irrigated farming will permit public services to be provided more efficiently.

Associated Developments and Indirect Costs

Stage II is an integral part of a comprehensive rural development program for the Jordan Valley. This program is described in detail in the Jordan Valley Development Plan 1975-1982. A summary of this program and an analysis of those elements associated with Stage II development are presented in Appendix G, Agricultural Development. A

summary of the capital requirements derived in this analysis is presented in Table IX-11.

Table IX-11

SUMMARY OF CAPITAL REQUIREMENTS FOR DEVELOPMENTS ASSOCIATED WITH STAGE II

Item	Capital Cost (1000 JD)
Agriculture	
Livestock	10,600
Farm Machinery Pools	6,500
Marketing Facilities	2,000
Research and Extension	300
Portable Sprinkler Equipment	3,500
Farm Credit	4,900
Social Infrastructure	
Public Utilities	8,000
Housing	24,300
Social Services	7,500
Other	10,400
TOTAL	78,000

It is readily apparent from Table IX-11 that the success of the Stage II development will require substantial capital investment in associated facilities, programs, and infrastructure. It is estimated that related agriculture, social infrastructure, and other investments will require capital in the amount of JD 78 million.

The balance of trade advantages discussed in the intangible benefit section will be partly offset during the

construction period by the foreign exchange required to construct the project facilities. The anticipated foreign exchange requirements for construction amount to a total of about JD 138 million.

These estimates of indirect costs for Stage II development are made primarily to emphasize the order of magnitude of the amounts involved. As previously mentioned, these costs will be incurred as an integral part of the comprehensive development plan for the Jordan Valley. A large number of international loans have already been made that will provide many of the facilities and programs required. The timely completion of these associated development is extremely important to the success of the Stage II development.

Evaluation of Indirect Costs and Benefits

An estimate was made of the internal rate of return for the indirect costs and benefits discussed previously. It is realized that the indirect benefits do not necessarily result from the expenditure of the indicated indirect costs. Also, there is some limited double counting since the costs of amortizing some investments, such as machinery, are included as a farm production cost in the direct benefit analysis. However, the comparison does provide a general indication of the economic impact of associated developments. The internal rate of return for the cost and benefit streams shown in Table IX-12, is 17 percent. For a 10 percent interest rate, the benefit-cost ratio is 1.9.

A second evaluation was made combining the indirect costs and benefits with the direct costs and benefits. The internal rate of return for this condition is 15 percent; the benefit-cost ratio for an interest rate of 10 percent is 1.6.

Table IX-12

SUMMARY OF INDIRECT COSTS AND BENEFITS
(JD X 1,000)

Year	Indirect Costs	Indirect Benefits
1979	10,000	-
1980	10,000	-
1981	15,000	-
1982	15,000	-
1983	10,000	2,000
1984	10,000	4,000
1985	8,000	7,000
1986	-	10,000
1987	-	13,000
1988	-	16,000
1989	-	19,000
1990 To 2028	-	21,000
	-	22,600

Financial Analyses

The financial analyses included (1) the preparation and analysis of budgets for representative farm units to determine the amounts of income that can be available for payment of Project costs; (2) a preliminary Project repayment analysis using various assumed interest rates and percentages of investment recovery over a 35-year loan period; (3) a cash flow analysis based on an assumed interest rate of 3.5 percent and initial irrigation, power, and M&I water charges of 10 fils/m^3, 12 fils/Kwh, and 30 fils/m^3, respectively; and (4) an allocation of costs among Project purposes using the separable costs remaining benefits method. The purpose

of the analysis is to provide JVA officials with the necessary information to formulate repayment policies, determine financial feasibility, and make arrangements for financing.

The analysis of payment capacity on representative farm units indicate that substantial amounts of residual income will be available for payment of Project costs by year 7 of Project development. For example, by year 7 the residual annual income meeting other obligations on a four-hectare general farm on new lands is JD 4,011. This amounts to about JD 1003 per hectare or 128 fils/m^3 of irrigation water. However, prior to reaching full development farmers on new lands may experience serious financial problems unless such assistance as intermediate-term credit and a grace period on payment of Project costs are provided. The farmers in the conversion areas will have less difficulty in becoming established during the development period and will attain payment capacities similar to those on new lands by year 7.

The Preliminary Project repayment analysis, indicates that Project costs, including escalation, can be paid by anticipated revenues from the sale of irrigation water, hydroelectric power, and M&I water. For example, a 35-year loan at 3.5 percent interest with a 10-year grace period could be repaid along with the annual operation and maintenance costs with initial charges of 11.0 fils/m^3 for irrigation, 12.0 fils/Kwh for power, and 30 fils/m^3 for M&I water. It was assumed that variable-price contracts will be negotiated with the Project beneficiaries and that the initial charges would escalate at a rate of 4 percent per year through the period of analysis. If the interest rate on the loan is 7 percent, an initial water charges for irrigation of 17.5

fils/m^3 would be required to fully recover investment and O&M costs. Since these rates are considerably less than the estimated residual farm income available for payment of water charges, it is evident that the Project is financially feasible if measures are taken to avert financial problems for farmers on new land during the initial 4 or 5 years.

The cash flow analysis illustrates the flow of Project disbursements and revenues by year under a specific set of financial assumptions. The analysis serves as an example and also a guide for financial negotiations until more definite information becomes available on interest rates and repayment policies.

The cost allocation shows an equitable distribution of Project costs among Project purposes. It is anticipated that this may be of use to JVA officials in establishing pricing policies for the irrigation water, hydro-electric power, and M&I water service available from the Project.

Farm Budgets and Payment Capacity

Farm budgets have been prepared for four conditions as follows:

Farm Type	Location	Area
General	Conversion Area	4 ha
General	Southern Valley	4 ha
Fruit	Conversion Area	3 ha
Fruit	Southern Valley	3 ha

The budgets for these farms are developed in Appendix G, Agricultural Development, and analyzed in Appendix I, Financial Analyses. The farm budgets show residual returns to water after charges for basic production costs, value of family labor, a management allowance, portable sprinkler equipment cost, and equity accumulation. These residual returns to

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water, which are summarized in Table IX-13, are available if necessary for payment of Project costs.

The value of family labor was assumed to be JD 1,000 which is equivalent to the average per-capita income (JD 200) for a family of five persons. The management allowance is equal to 10 percent of the sales revenue less basic production costs and value of family labor. The sprinkler equipment cost represents repayment of a loan to purchase the equipment over eight years at 7.0 percent interest on the outstanding balance.

It is apparent that the farmers in the conversion area on both the general and fruit farms would receive a substantial residual income with which to pay Project costs. For example, the residual income available on the four-hectare general farm in the conversion area is sufficient to pay a water charge equivalent to 25 fils/m^3 in year 1 and this increases to 127 fils/m^3 by year 7. This is more than the water charges necessary to recover investment costs and pay Project O&M costs as determined in the "Project Repayment" section of this chapter.

Farmers in the Southern Valley (New Lands) may have serious financial problems during the initial four or five-year period unless special assistance such as substantial intermediate-term credit and a grace period for water charges is provided. However, when these farms reach full development, the residual income will be sufficient to pay water charges comparable to those on the conversion-area lands.

Project Repayment

A preliminary analysis was conducted using a mathematical model which compared the total disbursements and revenues for the project and computed a surplus or deficiency. The model was used to evaluate the financial feasibility of the Project which includes irrigation of the new and converted land areas, and construction of storage and power facilities.

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Table IX-13

RESIDUAL RETURN TO WATER BY YEAR
DURING DEVELOPMENT PERIOD

Year	General Farm				Fruit Farm			
	Conversion Area		Southern Valley		Conversion Area		Southern Valley	
	JD/Farm	Fils/m^3	JD/Farm	Fils/m^3	JD/Farm	Fils/m^3	JD/Farm	Fils/m^3
1	774	25	(1,099)[a/]	-	1,661	41	(6,322)	-
2	1,841	59	(171)	-	2,923	72	(1,425)	-
3	2,910	93	666	21	4,083	101	(332)	-
4	3,979	127	1,502	48	5,244	130	(395)	
5	3,979	127	2,339	75	5,244	130	(510)	
6	3,979	127	3,176	102	5,244	130	2,498	55
7	3,979	127	4,011	128	5,244	130	6,002	133

a/ ( ) indicates deficit

It was assumed that the loan period would cover 35 years including a grace period of 10 years. The grace period begins in the first year of construction. No interest is paid until the end of construction, and interest only is paid from the end of construction to the end of the grace period. The studies were done assuming interest rates of zero, 3.5 percent, and 7.0 percent.

The 1977 foreign component of the construction costs was escalated over the construction period at a rate of 8.0 percent per year; the national currency costs at a rate of 12 percent per year. Interest during construction was assumed to equal the loan rate. Operation and maintenance costs were escalated at a rate of 3.0 percent per year. The revenues from irrigation, power, and M&I water charges were escalated at a rate of 4.0 percent per year from 1981. The initial charge for irrigation water was varied from 6.0 fils/m^3 to 20 fils/m^3. The initial power and M&I charges were 12 fils/kWh and 30 fils/m^3 respectively.

The initial irrigation water charges necessary to recover the full amount of operation and maintenance costs and portions of the investment costs ranging from 25 to 100 percent are summarized in Table IX-14 and in Exhibit 22. The variation in initial water charges corresponding to the three rates of interest assumed in the analysis also can be determined from the table. For example, at an interest rate of 3.5 percent, an initial irrigation water charge of 11.0 fils/m^3, subsequently escalated at a rate of 4 percent per year, would be necessary to recover the full investment and O&M costs over the 35-year loan period. At 7 percent interest, an irrigation water charge escalated from an initial rate of 6 fils/m^3 would pay the full O&M costs plus 25 percent of the capital costs over the 35-year period.

Table IX-14

INITIAL IRRIGATION WATER CHARGES CORRESPONDING TO VARIOUS REPAYMENT ASSUMPTIONS

Investment Cost Recovery	O&M Cost Recovery	Initial Water Charge at No Interest	Initial Water Charge at 3.5% Interest	Initial Water Charge at 7% Interest
Percent	Percent	fils/^{3}	fils/m^3	fils/m^3
100	100	6.1	11.0	17.5
75	100	5.0	8.5	13.5
50	100	3.6	6.5	10.0
25	100	2.5	4.0	6.0

Cash Flow Analysis

Table IX-15 shows the estimated cash flow for the Project for an interest rate of 3.5 percent and an initial water charge of 10 fils/m^3, an initial power charge of 12 fils/Kwh, and an initial M&I water charges of 30 fils/m^3. The assumptions about escalation are the same as those discussed above in the "Project Repayment" section. The analysis serves only as an example of the Project disbursements and revenues by year. Information is not yet available on the interest rate and repayment policies that will be used in financing the Project. A disbursement schedule for the escalated costs without allowance for interest during construction is shown below:

Year	Disbursement Schedule for Escalated Costs
	JD x 10^6
1979	14.30
1980	57.30
1981	57.26
1982	45.50
1983	23.34
1984	10.65
Total	208.75

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Table IX-15

CASH FLOW ANALYSIS
(JDX1000)

Year	Total Payments		O&M Costs	Total	Total Revenues				Annual Net Revenues
	Principal	Interest			Irrigation	M&I	Power	Total	
1979	-	-	-	-	-	-	-	-	
1980	-	-	-	-	-	-	-	-	
1981	-	-	173	173	420	-	-	420	247
1982	-	-	297	297	731	-	-	731	434
1983	-	4,113	1,188	5,301	1,959	300	404	2,663	(2,638)
1984	-	5,564	1,543	7,107	2,734	326	420	3,480	(3,627)
1985	-	7,340	1,839	9,179	3,016	353	438	3,807	(5,372)
1986	-	7,340	1,894	9,234	3,137	383	455	3,975	(5,259)
1987	-	7,340	1,951	9,291	3,263	415	472	4,150	(5,141)
1988	-	7,340	2,009	9,349	3,393	450	491	4,334	(5,015)
1989	389	7,340	2,069	9,798	3,529	487	511	4,527	(5,271)
1990	1,933	7,326	2,132	11,391	3,670	528	532	4,730	(6,661)
1991	3,455	7,259	2,195	12,909	3,817	571	553	4,941	(7,968)
1992	4,717	7,138	2,262	14,117	3,969	620	575	5,164	(8,953)
1993	5,474	6,972	2,330	14,776	4,128	671	598	5,937	(9,379)
1994	5,943	6,781	2,399	15,123	4,293	727	622	5,642	(9,481)
1995	6,151	6,573	2,471	15,195	4,465	787	647	5,899	(9,296)
1996	6,636	6,358	2,546	15,270	4,644	852	672	6,168	(9,102)
1997	6,589	6,135	2,622	15,346	4,829	922	700	6,451	(8,895)
1998	6,820	5,904	2,701	15,425	5,023	998	727	6,748	(8,677)
1999	7,058	5,666	2,782	15,506	5,223	1,081	757	7,061	(8,445)
2000	7,305	5,418	2,866	15,589	5,432	1,170	787	7,389	(8,200)
2001	7,561	5,163	2,951	15,675	5,650	1,216	818	7,684	(7,991)
2002	7,826	4,898	3,040	15,764	5,876	1,264	851	7,991	(7,773)
2003	8,100	4,624	3,131	15,855	6,111	1,315	886	8,312	(7,543)
2004	8,383	4,341	3,225	15,949	6,335	1,367	921	8,643	(7,306)
2005	8,676	4,047	3,025	15,748	6,609	1,422	958	8,989	(6,759)

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Table IX-15 (cont.)

CASH FLOW ANALYSIS
(JDX1000)

Year	Total Payments		O&M		Total Revenues				Annual Net
	Principal	Interest	Costs	Total	Irrigation	M&I	Power	Total	Revenues
2006	8,980	3,744	3,115	15,839	6,874	1,479	996	9,349	(6,490)
2007	9,294	3,429	3,209	15,932	7,149	1,538	1,036	9,723	(6,209)
2008	9,620	3,104	3,305	16,029	7,435	1,600	1,077	10,112	(5,917)
2009	9,956	2,767	8,875	21,598	7,732	1,664	1,120	10,516	(11,082)
2010	10,305	2,419	8,977	21,701	8,041	1,731	1,165	10,937	(10,764)
2011	10,666	2,058	9,082	21,806	8,363	1,800	1,210	11,373	(10,433)
2012	11,039	1,685	9,190	21,914	8,897	1,872	1,260	11,829	(10,085)
2013	11,425	1,299	9,301	22,025	9,045	1,946	1,311	12,302	(9,723)
2014	10,906	899	9,417	21,222	9,407	2,024	1,363	12,794	(8,428)
2015	7,671	517	9,535	17,723	9,783	2,105	1,418	13,306	(4,417)
2016	4,503	248	9,657	14,408	10,175	2,189	1,474	13,838	(570)
2017	1,963	91	4,311	6,363	10,582	2,277	1,533	14,392	8,027
2018	634	22	4,441	5,097	11,005	2,367	1,595	14,967	9,870
2019	0	0	4,574	4,574	11,445	2,463	1,658	15,566	10,992
2020	0	0	4,712	4,712	11,903	2,561	1,725	16,189	11,477
2021	0	0	4,853	4,853	12,379	2,664	1,794	16,837	11,984
2022	0	0	4,999	4,999	12,874	2,771	1,865	17,510	12,511
2023	0	0	5,149	5,149	13,389	2,881	1,941	18,211	13,062
2024	0	0	5,303	5,303	13,925	2,996	2,018	18,939	13,636
2025	0	0	5,462	5,462	14,482	3,116	2,098	19,696	14,234
2026	0	0	5,626	5,626	15,061	3,241	2,182	20,484	14,858
2027	0	0	5,795	5,795	15,664	3,370	2,270	21,304	15,509
2028	0	0	5,969	5,969	16,290	3,506	2,360	22,156	16,187
2029	0	0	6,148	6,148	16,943	3,645	2,455	23,043	16,895
2030	0	0	6,332	6,332	17,619	3,791	2,553	23,963	17,631
2031	0	0	6,522	6,522	18,324	3,943	2,655	24,922	18,400

Cost Allocation

The objective of a cost allocation is to distribute the costs of a multiple-purpose project, such as Stage II, equitably among the several purposes served. The costs of a multiple-purpose project include the specific or separable costs of individual features that serve only a single purpose and the joint costs of features that serve more than one purpose. The costs to be allocated include the investment costs, the interest during construction, and the annual operation, maintenance and replacement costs. The cost of relocating the Himma branch of the Hejaz Railroad is not included in the costs to be allocated since is was assumed that this is not a reimbursable Project cost.

For purposes of this discussion, the following definitions of terms are adopted:

1. Specific costs are the costs of individual physical features and other costs that serve only a single purpose.

2. Joint costs are the costs of individual physical features and other costs that serve more than one purpose.

3. Separable Costs are the costs which could be omitted from the project if one purpose of the project were excluded. They may also be costs incurred for structures serving several but not all purposes. In some cases specific costs and separable costs are identical.

4. Justifiable expenditure is the lesser of benefits or alternative costs and is the maximum allocation assignable to any purpose.

5. Remaining joint costs comprise that portion of joint costs which remain to be distributed after the total of separable costs for all project purposes has been deducted from the cost of the multiple-purpose project.

6. Investment costs for allocation purposes are the costs necessary to construct the project and place it in operation. They include investigation costs, construction costs, related items such as transitional development costs, and interest during construction.

7. Operation, maintenance, and replacement costs are the costs necessary to ensure the continued operation of the project throughout the period of analysis.

The separable costs - remaining benefits method of cost allocation was used. In this method, each project purpose is assigned its separable cost plus a share of joint costs proportionate to the remainders found by deducting the separable cost of each purpose from the justifiable expenditure for that purpose. The cost allocation is presented in Table IX-16. A concurrent allocation was made of investment costs and capitalized annual costs with present worths taken at the beginning of project operation using 10 percent interest. As is apparent from Table IX-16, all Project costs are separable costs. Therefore, there are no joint costs to allocate among project purposes. Allocated construction costs are as follows: irrigation, JD 119,190,000; hydroelectric power, JD 5,369,000; and M&I water, JD 11,000,000.

Table IX-16

COST ALLOCATION[a/]
(JD 1000)

Item	Irrigation	Hydro-electric Power	M&I Water	Total
Costs to be Allocated:				
Construction Costs				135,559
Interest During Construction				28,842
O&M Costs				12,812
Total (Present Worth)				177,213
Benefits	235,300	8,218	11,650	255,168
Alternative Costs	Exceeds benefits	4,781	Exceed benefits	
Justifiable Expenditure	235,300	8,218	11,650	255,168
Separable Costs				
Construction Costs	119,190	5,369	11,000	135,559
Interest During Construction	27,571	662	609	28,842
O&M Costs	12,239	573	-	12,812
Total	159,000	6,604	11,609	177,213
Remaining Justifiable Expenditure	76,300	1,614	41	77,955
Percent Distribution	98	2	0	100
Remaining Joint Costs				
Construction Costs	0	0	0	0
Interest During Construction	0	0	0	0
O&M Costs	0	0	0	0
Total Allocated Costs				
Construction Cost	119,190	5,369	11,000	135,559
Interest During Construction	27,571	662	609	28,842
O&M Costs	12,239	573	-	12,812
Annual O&M Costs (Average)	1,240	58	-	1,298
Ratio of Benefits to Allocated Costs	1.48	1.24	1.00	1.44

a/ Concurrent allocation of investment costs and capitalized annual costs with present worths taken at the beginning of project operation using 10 percent interest.

Chapter X

PROJECT IMPLEMENTATION AND CONSTRUCTION

It is the intention of the JVA to implement the Stage II Project by 1984. The major steps required for implementation following this feasibility study are funding, design, award of construction and equipment supply contracts, and project construction. It is estimated that the storage and power facilities can be constructed by the end of 1982 and that the irrigation system, installed at a rate of about 6000 ha. per year, will be completed in 1984. The new lands will begin production in 1983, the year following completion of the dam. The initial part of the conversion area will begin production using a sprinkler irrigation system in 1981. This schedule allows 16 months for contract design and the preparation of tender documents; and seven months for bidding, evaluation, and award of contracts. The schedule for implementation of the Stage II project is shown on Exhibit 23.

Implementation

Construction of the Project has been scheduled for three separate general contracts: 1) the storage and power facilities; 2) development of the lands north of the Zarqa River (basically conversion of the existing surface irrigation system to a sprinkler irrigation system), and 3) development of the lands south of the Zarqa River (basically the installation of a sprinkler irrigation system on new lands), and extension of the EGMC.

Project Organization

The size and sophistication of the recommended Project will require that total responsibility be entrusted to a

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unified organization. The former Jordan Valley Commission has been amalgamated with the Jordan River and Tributaries Regional Corporation and part of the Natural Resources Authority to form the Jordan Valley Authority (JVA). This organization will be able to construct, develop, maintain and operate the Project.

The JVA has substantial experience in administering the construction of irrigation systems, and limited experience in the construction of major storage facilities. The JVA has included provision in the existing contract for Harza in association with Dar Al-Handasah to be responsible for consulting engineering services relating to the works require for the implementation of the Project. The responsibilities of the consultant will include design and preparation of tender documents, evaluation of bids, construction surveillan including review and approval of contractors drawings, and preparation of operation and maintenance manuals.

Operation and maintenance of the dam and irrigation facilities will be directed by the JVA. The consultant will assist in the establishment of an organization which would be equipped and trained to comply with the instructions contained in the operation and maintenance manuals. In the course of this assistance, the owner's staff shall be trained in the required skills. It is recommended that the JVA operate the powerplants and sell power and energy to the Jordan Electric Authority (JEA) on a contract basis. The contract should provide for exchange of energy with JEA for the times when energy generation does not correspond with the pumping requirements in the irrigation system. It will be necessary to make a detailed study of operation of the Jordan Valley Project hydrogeneration and pumping facilities together with generation and demand for the Jordan Electric

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Authority. This detailed study will provide the basis for an energy exchange agreement between JVA and JEA. A program should be established to provide the required training for operation and maintenance of the Project powerplants.

The farm support services will be provided by the Farmers' Association. The Association will be administered by a Board of Directors composed of 15 members. Five of the members will represent the JVA, the Agricultural Credit Corporation, the Marketing Organization, and the Cooperative Organization. The remaining members will be elected by the farmers. The Association is charged with the supply of major agricultural inputs including equipment, instruments and materials, fertilizers, seeds, and pesticides, provision of loans, undertaking of common agricultural operations, and the establishment and operation of agricultural marketing centers.

Suggestions for research and extension are included in Chapter VI. The farm support services programs should be implemented as soon as possible because it will be necessary to substantially upgrade the farming practices with respect to use of improved seeds, and increased use of fertilizers and pesticides in order to attain the yields that are estimated for full development conditions.

Preconstruction Activities

The initial steps for Project implementation will include decisions by the Government of Jordan with respect to Project size and development, and financing negotiations. The schedule presented in this report assumes an early committment for design funds. Based on information presented in this report, the Government of Jordan can enter negotia-

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tions with international financing institutions to assure that the necessary loans can be secured when construction contracts are to be awarded. By proceeding in this manner, the Government can continue with project implementation expeditiously without encountering delays due to investment needs.

The design phase of the preconstruction activities will include topographic surveys for all Project facilities, detailed studies of the method for irrigation supply, design level foundation exploration, construction materials testing, and hydraulic model testing. On the basis of the detailed field investigations and the associated laboratory testing, the final detailed designs of the project can be completed. The contract documents consisting of the bid drawings and specifications can then be prepared. The Government will then be able to advertise for tenders, negotiate the construction contracts, and enter into the construction phase for the Project. The construction schedule is shown on Exhibit 24.

Leaching Saline Soils

The schedule for construction will permit high-intensity cropping on some of the conversion lands in 1981; provide opportunity to use winter flows for leaching some of the saline lands prior to completion of the storage facilities; and have ready a significant area of new land when releases can be made from the reservoir.

By constructing the extension to the EGMC in the first year, leaching of some of the more saline soils can be done in the second and third years. At completion of the storage facilities about 4,000 ha of formerly saline soils will be leached and suitable for cultivation.

Maqarin Reservoir Filling

The Maqarin Project is scheduled for completion by the end of 1982. This will permit storing winter flows at the end of 1982 so that irrigation water can be supplied to new lands during the 1983 dry season. Under average flow conditions the reservoir will fill to the maximum operating level in about 6 years by storing unused inflows.

Construction

Storage and Power Facilities

Construction of the storage and power facilities at Maqarin, the King Talal powerhouse and the diversion structure at Adasiye is anticipated to be done by a major international contractor. However, the diversion structure could be constructed by the irrigation-system contractor because of its proximity to the conversion area. Electrical and mechanical equipment will be obtained by the JVA under separate contracts and supplied to the general construction contractors.

The construction period is anticipated to begin in July 1979 and continue through 1982, a total of three years and six months.

Access. Imported materials will enter Jordan at the port of Aqaba on the Gulf of Aqaba and be transported to the site on existing highways and secondary roads. Access to the Adasiye and King Talal sites will be by existing highways and construction roads.

Construction Diversion. The Yarmouk River at Maqarin will be diverted through a tunnel driven through the left abutment. The tunnel excavation plus concrete lining, and other works will require 10 months. River closure and diversion will occur in July 1980. It is anticipated that the river will be diverted for a period of 27 months before the tunnel can be closed to begin reservoir filling.

Maqarin Dam. Excavation for the dam will begin as soon as the contractor is able to mobilize equipment. A portion of the excavated material will be stockpiled locally for use in the fill. Total time for excavation is 12 months.

Maqarin Dam is a zoned embankment consisting of approximately 14 million m^3 of fill material. All materials will be placed and compacted by conventional methods. Total time for completion of the embankment is 30 months.

Maqarin Spillway. Spillway excavation will begin when the contractor is mobilized and is scheduled for completion in 15 months. The concrete required for the spillway will be placed beginning 12 months after excavation is started. Total time for the concrete placement is 18 months.

Maqarin Power Facilities. Time required to complete the tunnel and intake excavation is 12 months followed by 6 months to place the intake and penstock concrete.

Construction of the Maqarin powerhouse and installation of equipment will require 15 months. The work will be scheduled to correspond with the delivery of major generating equipment, which will be about 24 months after award of contracts. The transmission line to Irbid and substation facilities will be installed during the last nine months of powerplant construction.

King Talal Powerplant. The King Talal construction schedule will be similar to the Maqarin powerplant because it will depend primarily on the time required for delivery of the major generating equipment.

Diversion at Adasiye. The diversion dam at the EGMC intake near Adasiye is scheduled during the first dry season of Project construction. The diversion dam will be needed to keep shortages in the irrigation area to an acceptable

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level during construction of the storage facilities. In addition, leaching of lands in the New-Land area will be made easier with the installation of a diversion dam.

Irrigation System

Sprinkler irrigation facilities will be provided for 25,353 ha. It is expected that two construction contracts will be let to international contractors for the irrigation system, each working in a defined geographic area. It is assummed that, with proper logistics, each contractor can install a sprinkler irrigation system at the rate of 3,000 ha per year. Construction of the irrigation facilities will begin concurrently with the storage facilities in the first year of Project construction.

The first contract will cover installation of sprinkler facilities for about 13,755 ha of land in the northern part of the Valley. The area will include all of Land Groups C and part of D. The geographic break-point is at the end of the original EGCP, or at the beginning of the 8-Km Extension area. Construction done under the first contract will be completed early in 1984.

The second contract will provide for the installation of a sprinkler system on an additional 11,598 ha and will include the rest of Land Group D and all of Land Group A and B. This contract also is scheduled for completion in 1984.

The availability of pipe material will be one of the major problems which must be overcome to meet the proposed construction schedule. Neither asbestos-cement pipe nor aluminum pipe currently are manufactured in Jordan. To equip 6,000 ha each year it is expected that it will be necessary to import about 1000 km of asbestos-cement pipe of various diameters. The government may find it desirable to install a pipe factory to supply the contractors.

At completion of the storage facilities, about 9,000 ha of the more fertile new lands will be ready for cultivation. Therefore, many of the workers attracted to the Valley because of Project construction will be able to begin farming.

Chapter XI

STORAGE AND CONVEYANCE ALTERNATIVES

Introduction

Several alternative storage and conveyance schemes were studied in the process of selecting the project that is recommended for development. The alternative schemes were presented in an Interim Report dated October 1976. The most favorable of the basic alternatives are presented in this chapter to indicate the cost advantage of the recommended project. Each of the alternative schemes will provide the same Stage II irrigation development and will be constructed to permit full development of the water resource at a later time.

The ultimate development of the Jordan Valley Irrigation Project is discussed briefly in Chapter II. The storage and power facilities required for ultimate development are described in this Chapter. Finally, a preliminary analysis is given which shows the cost of storage facilities at Maqarin without provision for raising, compared to the cost of facilities which can be raised for ultimate development.

Alternatives to Stage II Development

The recommended Stage II development will require political accommodations which could delay implementation of the Project. Therefore, two contingency plans were developed which could be implemented under existing treaty arrangements.

Alternative 1.

If it is not possible to construct a diversion dam at Adasiye, diversion can be accomplished by constructing two intakes and two tunnels to the EGMC. Without a cross-river

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structure for water control at the irrigation intake, the regulated discharge from Maqarin must be large enough to serve the irrigation requirements with some water passing the intake. Hydraulic studies show that approximately 70 percent of the regulated flow can be diverted at the existing intake with some minor modifications on the left bank. Alternative 1 would include these modifications and a second tunnel similar to the existing EGMC tunnel to increase the percentage of flow that can be diverted to the irrigation area. The combination of the two intake tunnels will permit about 90 percent of the regulated flow to be used effectively. A plan of the uncontrolled diversion is shown on Exhibit 25.

Operation studies show that Maqarin reservoir with a normal maximum water surface at El. 160 (Crest El. 168) will provide enough regulation to meet the needs of the Stage II development with an allowance for passing 10 percent of the flow at the diversion tunnels.

The project at Maqarin with reservoir elevation 160 would be the same as the layout described for the recommended project, except for the height of dam and the spillway location, which is adjusted to accommodate the higher dam. The minimum reservoir elevation would be the same as for the recommended scheme, in order to provide for 50 years of sediment storage. The irrigation outlet works and turbines would have the same discharge capacity at minimum reservoir level as for the recommended arrangement. The generators and other electrical equipment would have 10 percent more capacity than needed with the recommended project to permit safe operation at maximum reservoir level and maximum water release of 20 m^3/s. The 22-MW powerplant will generate an average of 61 Gwh/yr.

The cost of the storage and power facilities for a project at Maqarin with reservoir elevation 160 is summarized on Table XI-1 and a detailed cost estimate is given in Appendix L, Cost Estimates. The internal rate of return for this alternative would be 12.9 percent.

Alternative 2

The second alternative to the recommended Stage II development consists of a 25 km concrete lined, 2.2 m diameter tunnel from Maqarin Reservoir to the Wadi Arab basin. A 40-MW powerplant, with average tailwater El.-155.5, would be located at the end of the tunnel. The powerplant would generate 85 Gwh/yr and would have a dependable capacity of 26 MW. A general plan of Alternative 2 is shown on Exhibit 26. The powerplant discharge would be collected in the Wadi Arab Reservoir and then released to the Stage II irrigation system. Releases would also be required down the Yarmouk River channel to fully meet the requirements of the Yarmouk Triangle and the project lands located in the northern portions of the service area.

This alternative would have no losses associated with the release of reservoir flows into the EGMC becuase of the control afforded by Wadi Arab Dam. Therefore, Maqarin reservoir at El. 150 will provide enough water to meet the needs of Stage II development. The storage facilities would be the same as those described for the recommended development.

The cost of a project which will serve the Stage II irrigation requirements by diverting water from the Maqarin reservoir directly to the Wadi Arab reservoir is shown on Table XI-2. No cost is included for storage and conveyance facilities on the Wadi Arab because it is assumed these facilities will be constructed as part of the Stage I development.

Table XI-1

STAGE II DEVELOPMENT - ALTERNATIVE 1
MAQARIN PROJECT (Res. El. 160)
(JD 1,000)

	Construction Cost		
	National Cost	Foreign Cost	Total Cost
Land, Relocation, and Access	2,552	4,617	7,169
Operators Camp	100	400	500
Diversion and Care of Water	1,194	2,322	3,516
Dam	12,862	21,967	34,829
Spillway	5,847	10,613	16,460
Outlet Works	161	256	417
Power Facilities (Maqarin)	1,372	2,737	4,109
Power Facilities (King Talal)	133	332	465
Adasiye Diversion	571	752	1,323
Side-Wadi Diversions	42	94	136
Irrigation Facilities	10,174	34,403	44,577
Subtotal Direct Cost	35,008	78,493	113,501
Contingencies	5,483	12,294	17,777
Total Direct Cost	40,491	90,787	131,278
Engineering and Adm.	8,070	12,104	20,174
Total Construction Cost - 1977	48,561	102,891	151,452
Escalation to end of Construction a/	28,000	39,498	67,498
Total Construction Cost	76,561	142,389	218,950

a/ Construction period assumed to be from July 1979 to December 1982.

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Table XI-2

STAGE II DEVELOPMENT - ALTERNATIVE 2
MAQARIN - WADI ARAB PROJECT
CONSTRUCTION COST
(JD 1,000)

	Total Cost
Land, Relocation & Access	6,597
Operators Village	500
Diversion and Control of Water	3,483
Dam and Diversion Facilities	31,374
Spillway	16,364
Outlet Works	413
Water Conductor	22,427
Power Facilities[a/]	2,880
Irrigation System	44,577
Subtotal Direct Cost	128,615
Contingencies	21,265
Direct Costs	149,880
Engineering and Administration	17,236
Construction Cost - 1977	167,116
Escalation to end of Construction	75,684
Total Construction Cost	242,800

a/ At Wadi Arab Reservoir and King Talal Dam.

Ultimate Development

Ultimate development of the Jordan Valley Project will provide a project that will fully use the water available from the Yarmouk River in coordination with the controlled flows from the tributaries of the Jordan River that enter the Valley south of the Yarmouk. The ultimate development will result when the third stage of the Jordan Valley Project

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is completed. The existing and on-going works which comprise Stage I are described in Chapter I and the recommend Stage II facilities are presented in Chapter III. Full development will require construction of the following major elements.

1. The Maqarin storage project raised to provide a reservoir at El. 193.
2. New generating equipment with a rated capacity of 28 MW installed in the Maqarin powerplant.
3. A storage project at the Khalid site with Reservoir El. 12.
4. A 10-MW powerplant at Khalid Dam
5. Sprinkler irrigation facilities, including mainline conveyance, for 5,147 ha.

Maqarin Dam, initially constructed for Stage II development, will be raised 42 m. The crest elevation of the initial structure will be El. 158 and the crest of the raised dam will be at El. 200. When Maqarin Dam is raised, the Stage II spillway will be covered by the higher dam. The dam will be constructed so the Stage II spillway will remain operable until the last dry season during the construction period. The dam can then be completed during a six-month period, while the reservoir is drawn down.

A new spillway, to be constructed farther up the abutment will include three gates and a flat chute similar to the Stage II chute. The Stage II spillway gates and hoists will be moved to the new spillway. The capacity of the spillway will be sufficient to pass the probable maximum flood with a discharge of 5,100 m^3/s using a surcharge of 5.2 m above normal maximum reservoir El. 193.

The low-level outlet, constructed in the diversion tunnel for the Stage II project, will be modified for use as

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part of the final project. The power intake will be raised to accomodate 100 years of sediment deposition.

Plans and sections of the ultimate development features at Maqarin are shown on Exhibit 27.

The Stage II powerplant will be modified to operate satisfactorily under the higher head conditions with the final reservoir. The plant will contain two new generating units with an installed capacity of 28 MW. The Stage II 66 kv transmission line from the powerplant to Irbid will serve the needs of the ultimate development.

Storage projects at the Khalid site and the Mukheibeh site were compared for use in the ultimate development. The comparison consisted of a review of the geologic information available in the Harza[1/] and Energoprojekt[2/] reports, a site inspection trip, and an appraisal-level cost study. The Khalid site appears to be more favorable both on the basis of the geologic inspection (Appendix E, Geology) and the cost study which indicated that the Mukheibeh dam would be about 50 percent more expensive than a dam with similar regulating capability at the Khalid site. Therefore, Khalid Dam was included in the ultimate development plan.

Khalid Dam will be located downstream from the confluence of Wadi Raqqad and the Yarmouk River. The dam crest will be at El. 20, 100 m above streambed. The dam will be a zoned earth and rockfill embankment structure with a total fill volume of 13,100 m^3. A chute-type spillway with a discharge capacity of 5,600 m^3/s will be located in the right abutment.

1/ Yarmouk-Jordan Valley Project, Master Plan Report, Michael Baher, Jr., Inc., Harza Engineering Company, 1955.

2/ Yarmouk Project, Khalid Bin Al Walid-Wadi Arab Scheme, Phase B, Preliminary Design, Energoprojekt, June 1967.

A low-level outlet will be provided through the power intake and the diversion tunnel. A plan and sections of Khalid Dam and the appurtenant works are shown on Exhibit 28.

A powerplant with an installed capacity of 10 MW will be located at the base of Khalid Dam on the right abutment. The plant will include two 5.0 MW generating units and will be connected to the national grid by a transmission line to the Maqarin substation.

A sprinkler irrigation system will be provided for 5,147 ha during Stage III to bring the total irrigated area of the Jordan Valley Project to 41,147 ha. In addition to the irrigated land, ultimate development of the Jordan Valley Project will provide 47 MCM/yr of water for municipal and industrial use in Irbid and towns in the Valley plus a supply to Amman that will result in a net consumption of 10 MCM/yr. The hydroelectric power projects developed in conjunction with the storage dams will produce 101 Gwh/yr of energy, on the average.

The construction cost of the Stage III storage and power facilities is shown on Table XI-3. The cost estimate is at the January 1977 price level, like all of the other costs given in this chapter. The costs shown for Maqarin are for raising the dam and spillway from crest El. 158 to El. 200, plus the cost of modifying the powerplant. As shown on Table XI-3, the cost of Stage III storage and power facilities is JD 131.9 million. The Stage II storage and power facilities are estimated to cost JD 86.9 million at the January 1977 price level giving a total cost of JD 218.8 million for the ultimate development storage and power facilities.

Table XI-3

STAGE III STORAGE AND POWER FACILITIES
CONSTRUCTION COSTS
(JD 1,000)

	Total Cost
Maqarin Storage Project	
Dam	21,464
Spillway	15,532
Power Facilities (Incremental)	755
Subtotal	37,751
Contingencies	7,550
Engineering and Administration	6,299
Subtotal Maqarin Storage Project	52,100
Khalid Storage Project	
Land, Relocation, and Access	12,440
Diversion and Care of Water	2,041
Dam	31,369
Spillway	8,938
Outlet Works	686
Power Facilities	1,840
Operators Village	500
Subtotal	57,814
Contingencies	11,563
Engineering and Administration	10,406
Subtotal Khalid Storage Project	79,783
Total Construction Cost (1977)	131,883
Escalation During Construction	59,117
Total Construction Cost	191,000

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Single Stage Project at Maqarin

A preliminary evaluation was made of the cost of constructing a project at Maqarin without provision for raising. Such a scheme is not recommended because the Yarmouk flows cannot be fully regulated without a large reservoir at Maqarin. Any construction scheme that would limit the ultimate level of Maqarin reservoir to substantially less than El. 193 would preclude full development of the resource. However, the costs estimated for the single-stage project give an indication of the portion of the initial Maqarin Project cost that is necessary for providing a project that can be raised.

The estimated costs of a single stage project at Maqarin are shown in Table IX-4 and are summarized in graphic form on Exhibit 29.

Table XI-4

SINGLE STAGE STORAGE AND POWER FACILITIES
CONSTRUCTION COSTS
(JD 1000)

	Crest of Dam	
	El. 158	El. 200
Land, Relocations and Access	6,597	8,477
Diversion and Care of Water	3,483	3,525
Outlet Works	413	581
Dam	25,683	51,580
Spillway	16,364	18,182
Power Facilities	4,497	4,051
Operators Village	500	500
Irrigation System	44,577	44,577[a/]
Subtotal	102,114	131,473
Contingencies	15,965	21,837
Subtotal	118,079	153,310
Engineering & Administration	17,711	22,990
Total	135,790	176,300

a/ Stage II irrigation facilities.

	51,137	80,796
	70,569	111,084
Jan 1979	82,566	129,168

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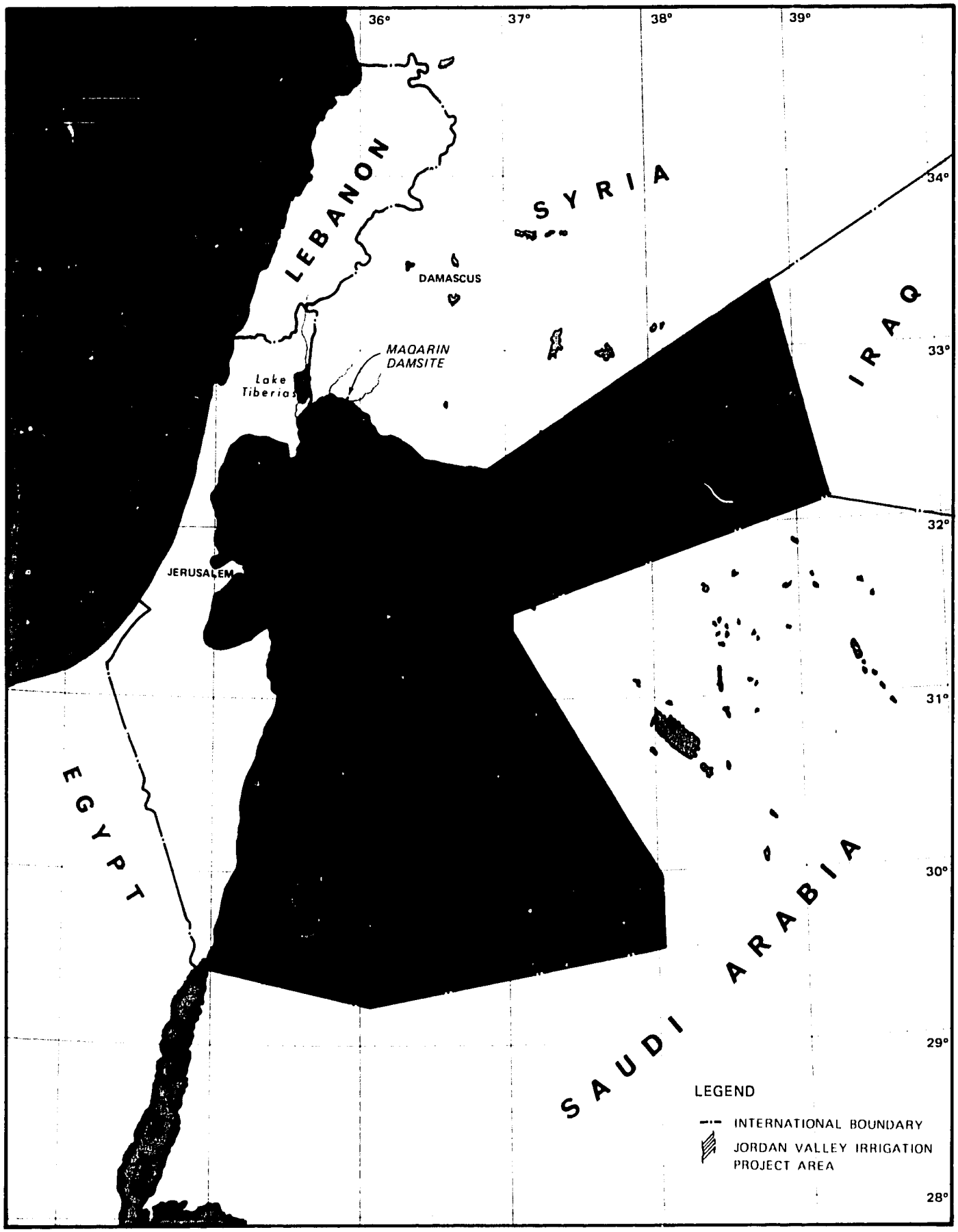

LOCATION MAP

JORDAN VALLEY IRRIGATION PROJECT

STAGE II

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

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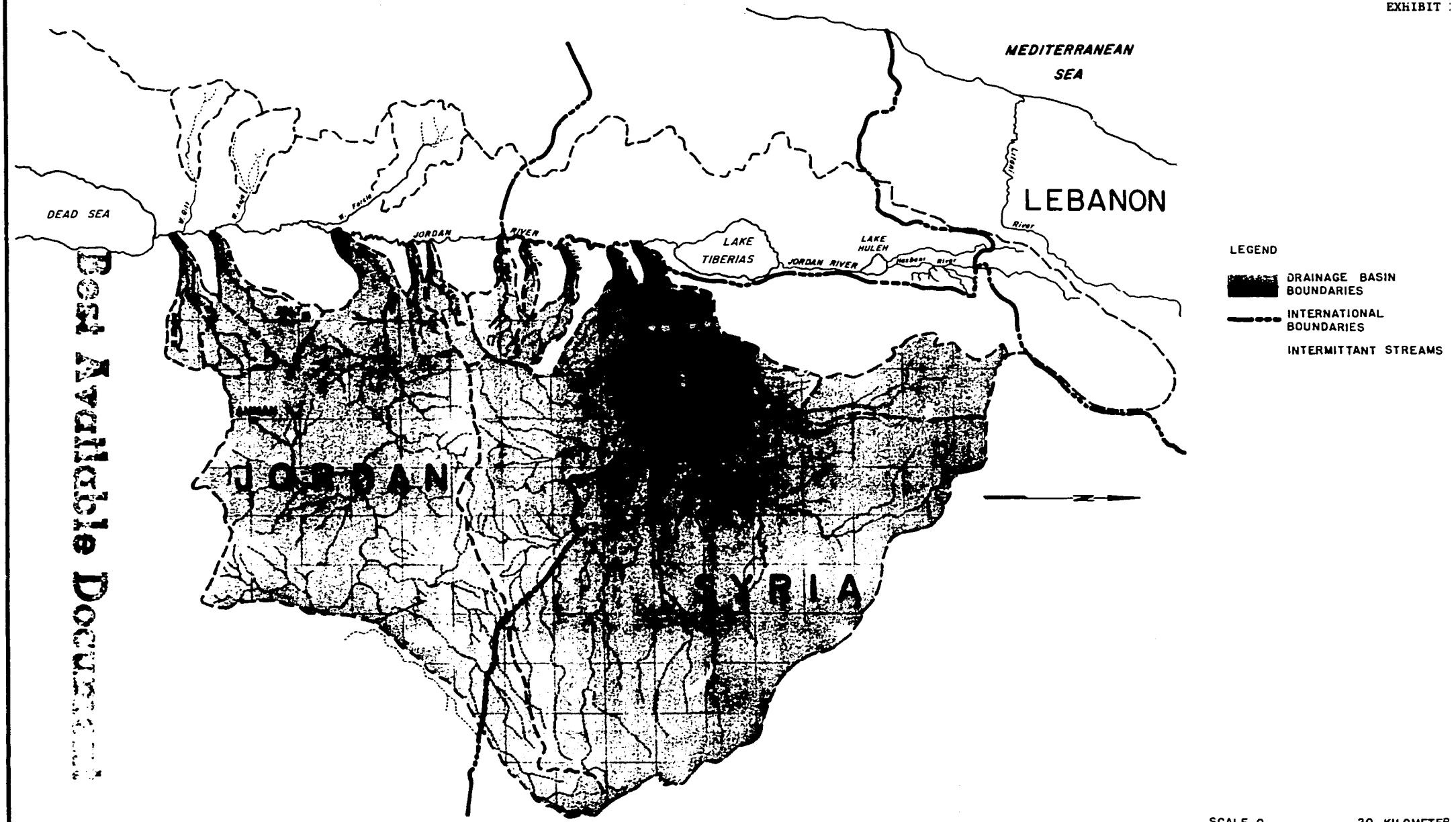
EXHIBIT

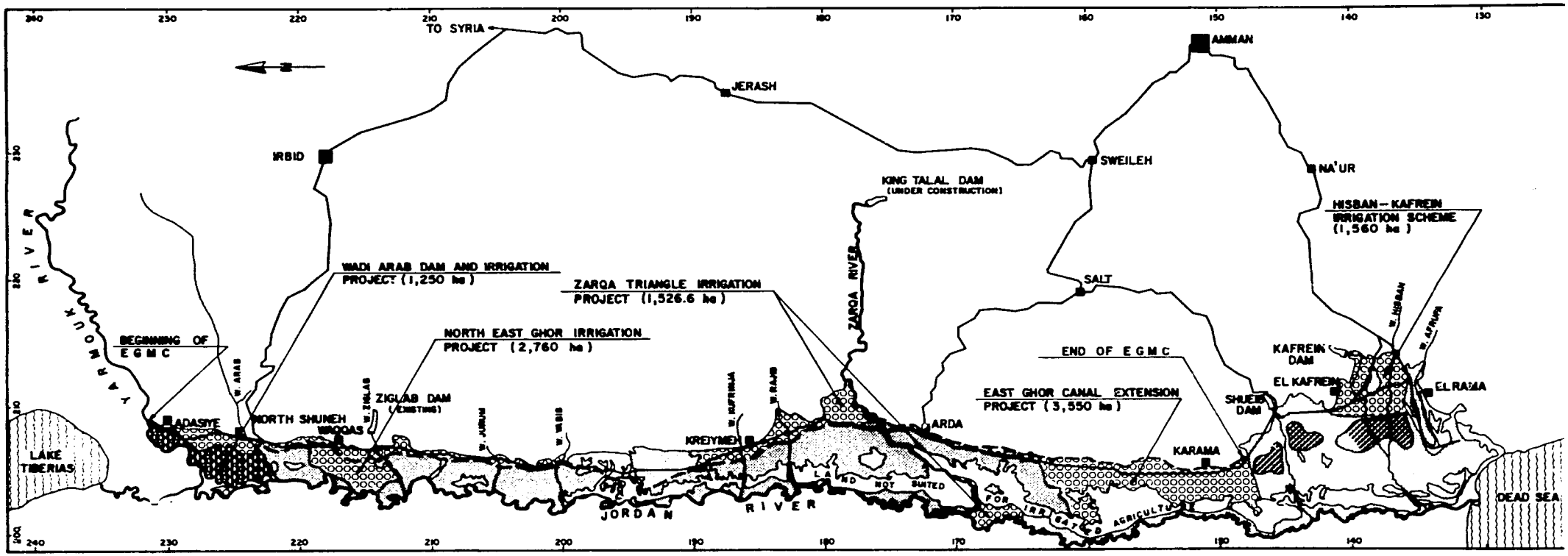


JORDAN RIVE
DRAINAGE BASIN BOUNDARIE
JORDAN VALLEY IRRIGATION PROJE
STAGE

Best Available Document

231

EXHIBIT



LEGEND

- ROADS
- EAST GHOR MAIN CANAL
- RIVERS
- SPRINKLER IRRIGATION PROJECTS UNDER CONSTRUCTION OR STUDY
- EAST GHOR CANAL PROJECT SURFACE IRRIGATION
- IRRIGABLE LANDS NOT INCLUDED IN PRESENT DEVELOPMENT
- AREAS IRRIGATED BY INDIVIDUAL WELLS

NOTES

1 – AREAS ARE NET IRRIGABLE

2 – GRID FIGURES ARE KILOMETERS

AREA ALLOCATION BY PROJECTS

	HECTARES
1 - EAST GHOR CANAL EXTENSION	3,550
2 - ZARQA TRIANGLE & ZOR	1,527
3 - NORTH EAST GHOR - NEW AREA	1,760
- CONVERSION	1,000
4 - HISBAN-KAFREIN	1,560
5 - WADI ARAB	1,250
TOTAL PROJECTS UNDER CONSTRUCTION OR STUDY	10,647

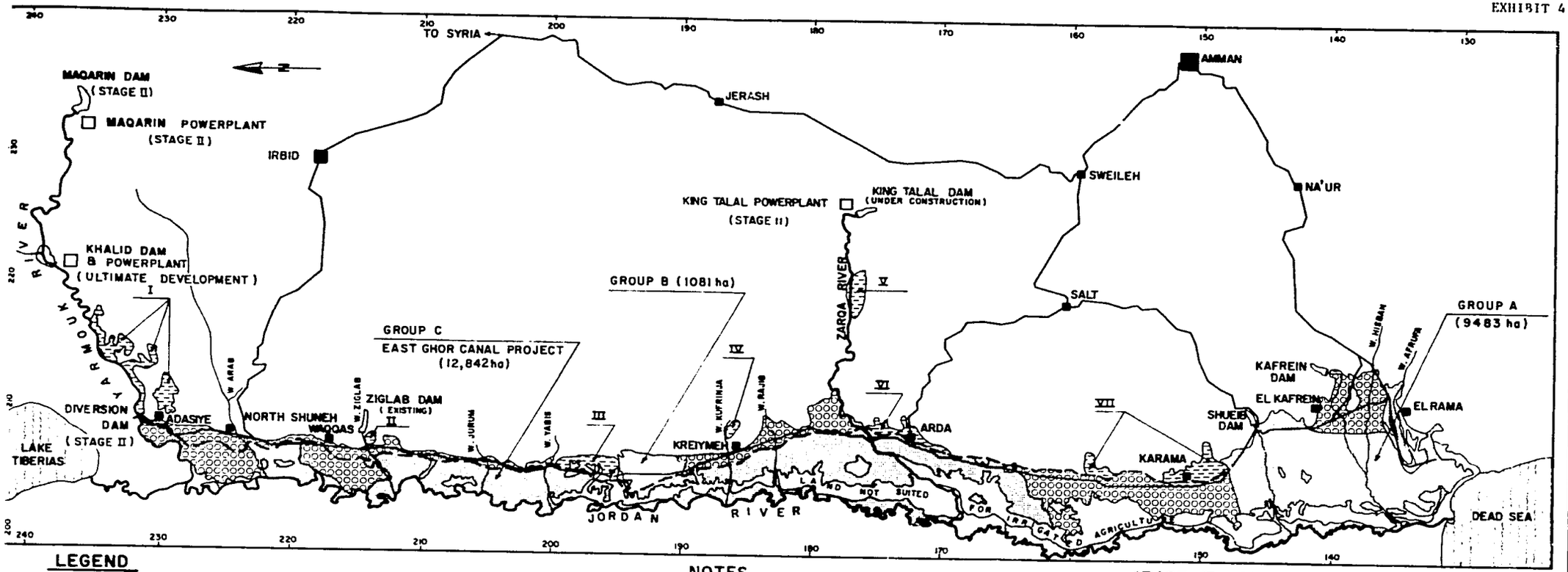
Dar Al-Handasah Consultants (Shair and Partners) January 1978

PRESENT DEVELOPME

JORDAN VALLEY IRRIGATION PROJ

STAGE

232



LEGEND

- ROADS
- EAST GHOR MAIN CANAL
- RIVERS
- STAGE I PROJECTS
- STAGE II – NEW LANDS – GROUPS A & B
- STAGE II – CONVERSION LANDS – GROUP C
- STAGE II – POTENTIALLY IRRIGABLE LANDS – GROUP D

NOTES

1 – GRID FIGURES ARE KILOMETERS

2 – POTENTIAL AREAS INCLUDE

	HECTARES
I – YARMOUK GORGE	331
II – ZIGLAB GORGE	50
III – BETWEEN KUFRINJA & YABIS	432
IV – KUFRINJA GORGE	100
V – ZARQA GORGE	216
VI – SOUTH OF ZARQA	233
VII – ABOVE 18 Km EXTENSION	525
TOTAL	1947

STAGE II PROJECT AREA

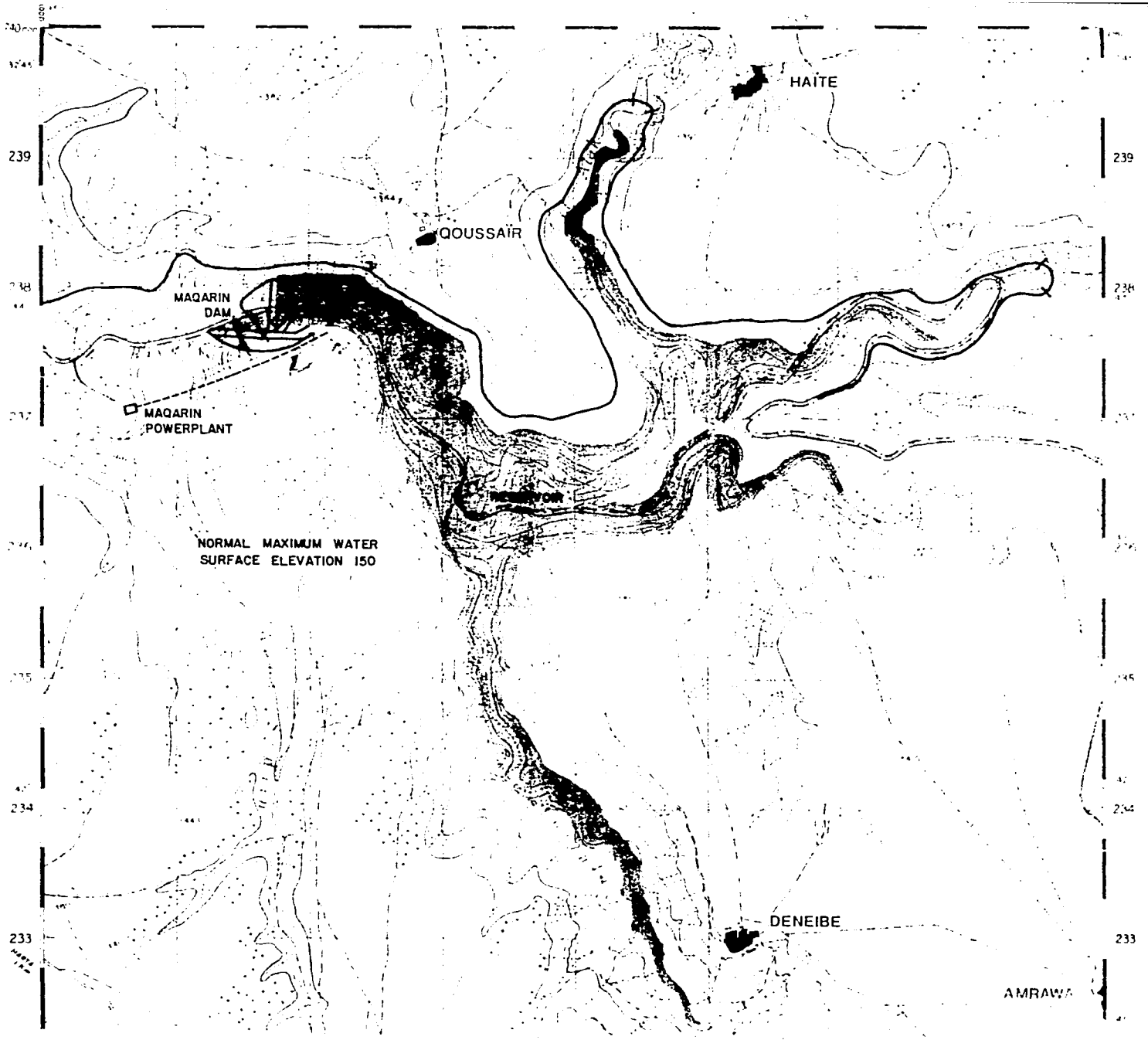
	HECTARES
CONVERSION LANDS (INCLUDES UPGRADED AREAS)	12,842
NEW LANDS	10,564
POTENTIALLY IRRIGABLE LANDS	1,947
TOTAL	25,353

TOTAL AREA

ON GOING PROJECTS	9,397
JAPANESE PROJECT ON WADI ARAB	1,250
STAGE II LANDS	25,353
TOTAL	36,000

Dar Al - Handasah Consultants (Shair and Partners) January 1978

GENERAL PLAN OF DEVELOPMENT
JORDAN VALLEY IRRIGATION PROJECT
STAGE II



LEGEND

- RELOCATED RAILROAD
- INTERNATIONAL BOUNDARY
- ROADS
- TRAILS

SCALE 0 1 KILOMETER

MAQARIN DAM
RESERVOIR AREA MAP
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

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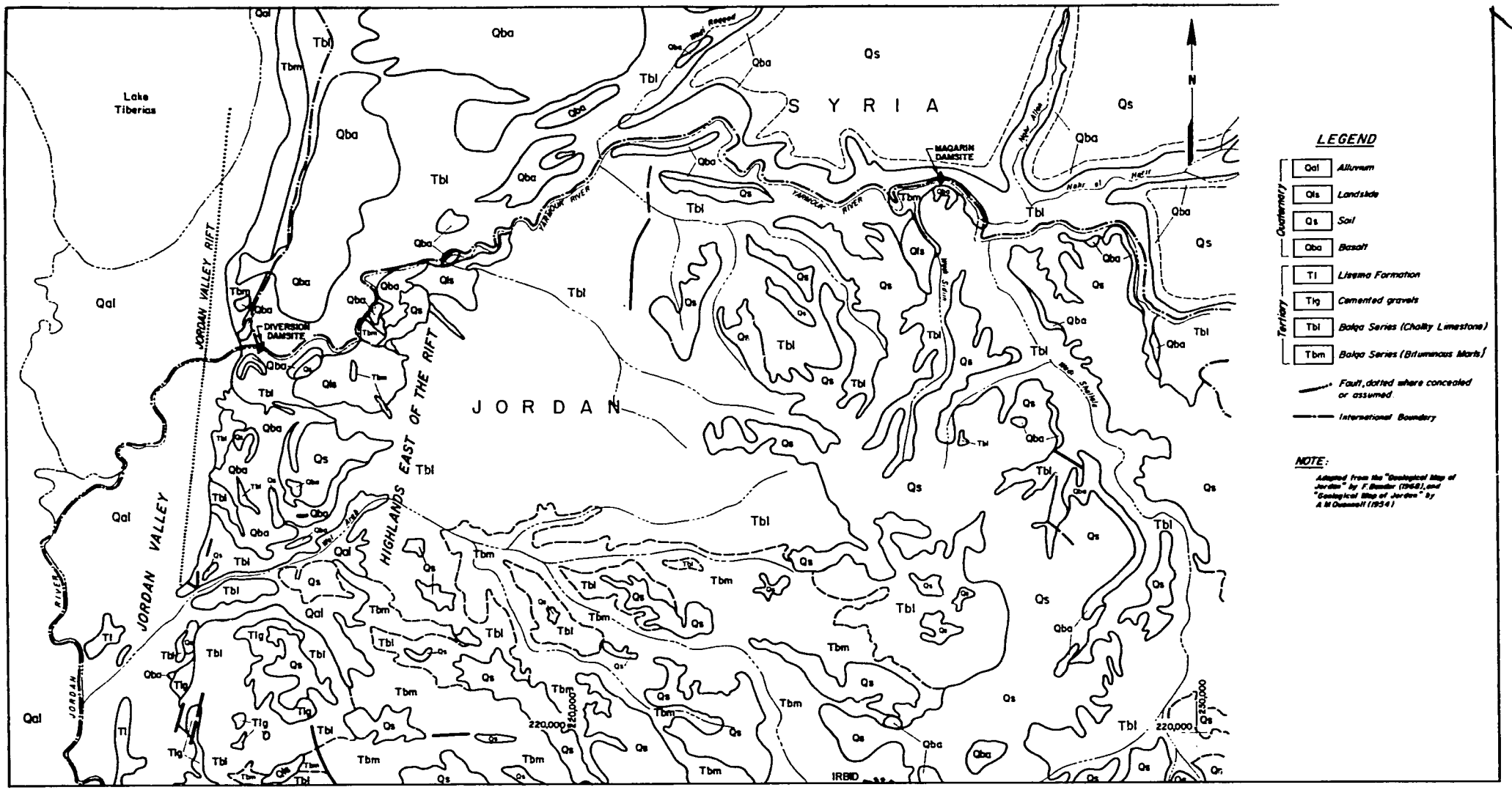
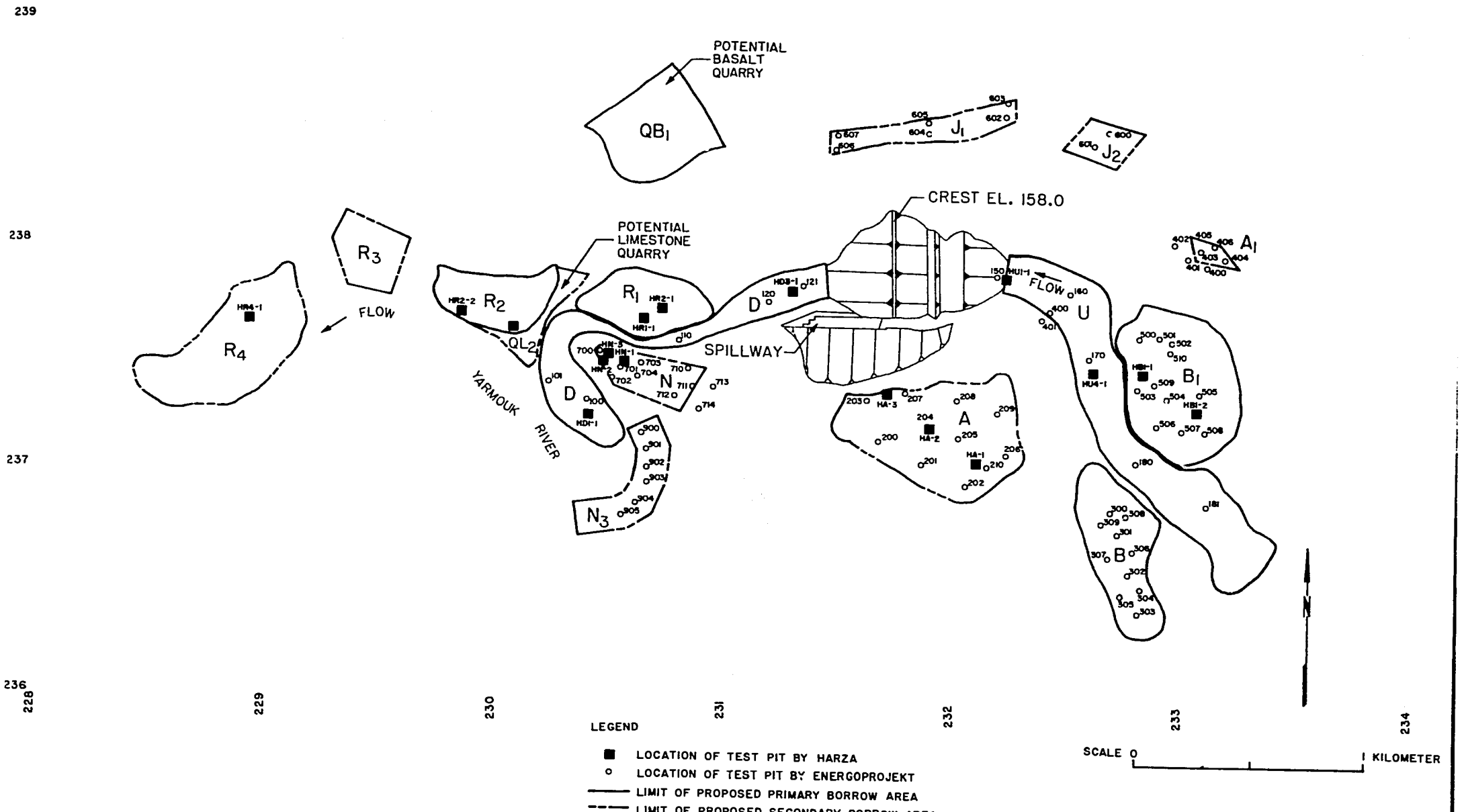


REGIONAL GEOLOGIC MAP
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

IARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

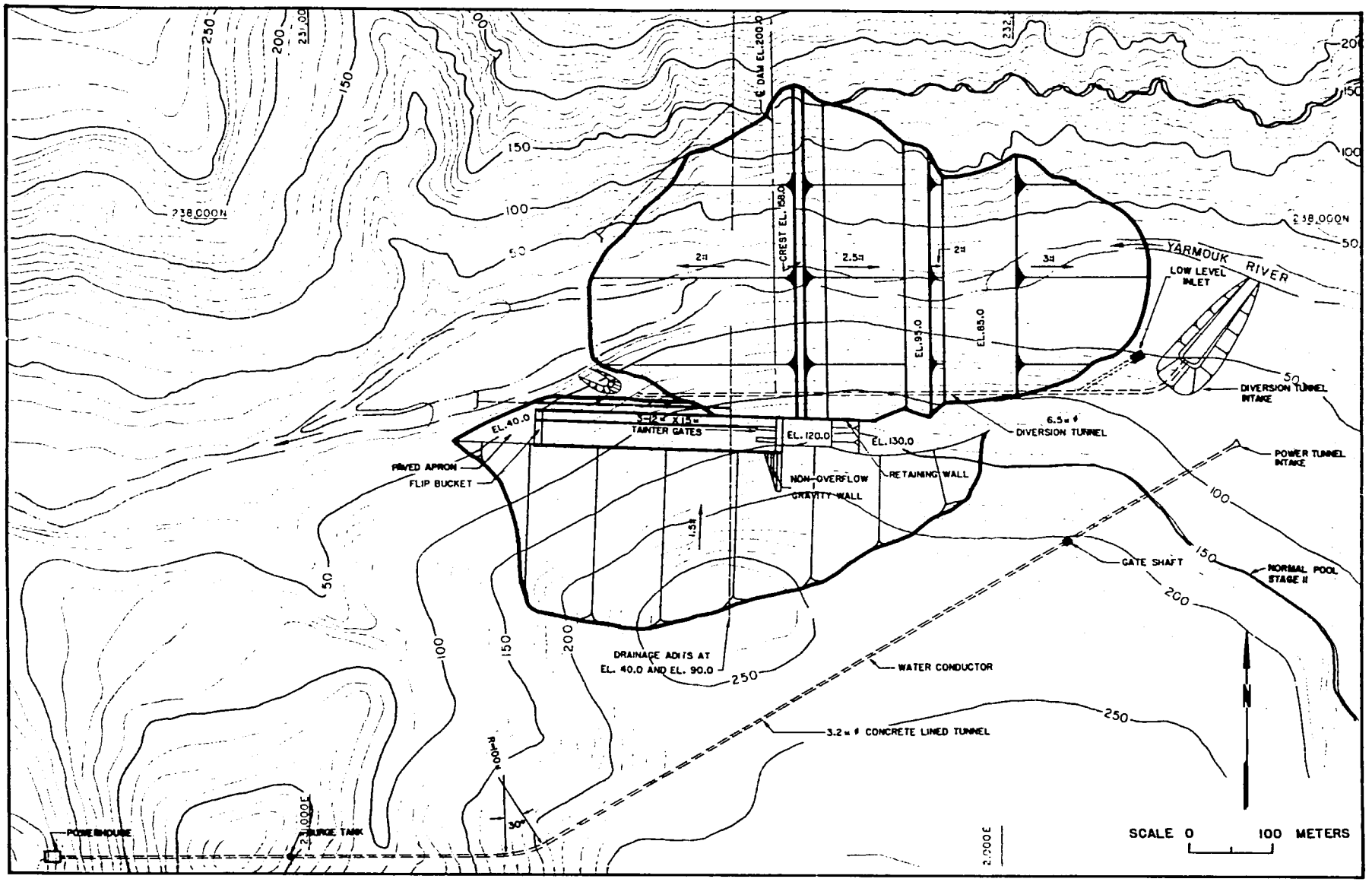
235



HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

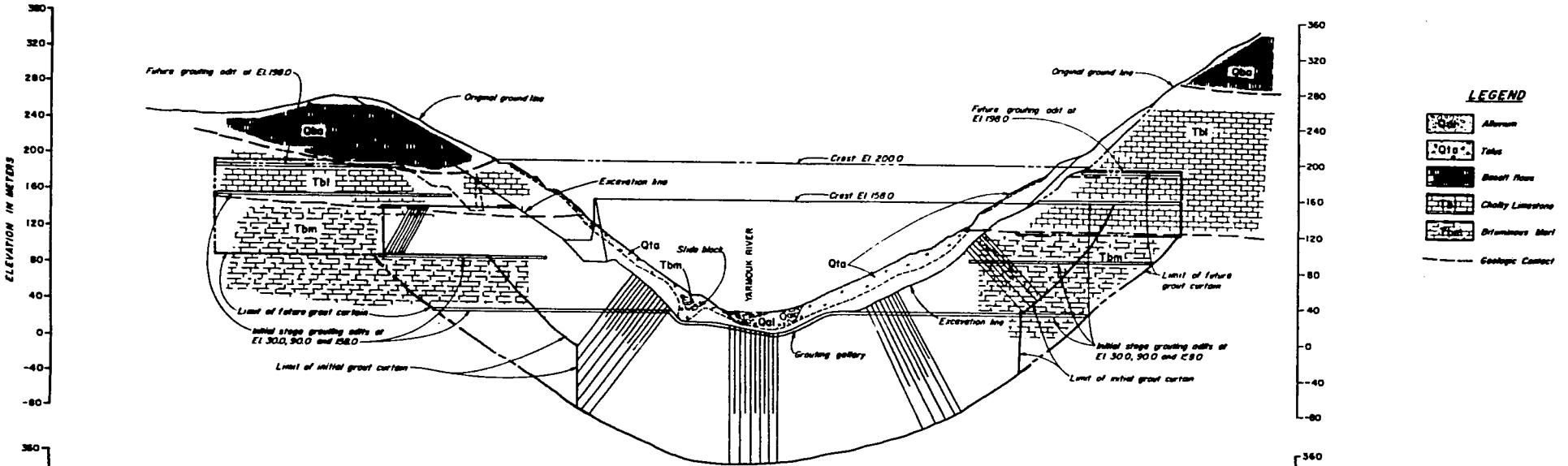
MAQARIN DAM
CONSTRUCTION MATERIALS EXPLORATION
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

236

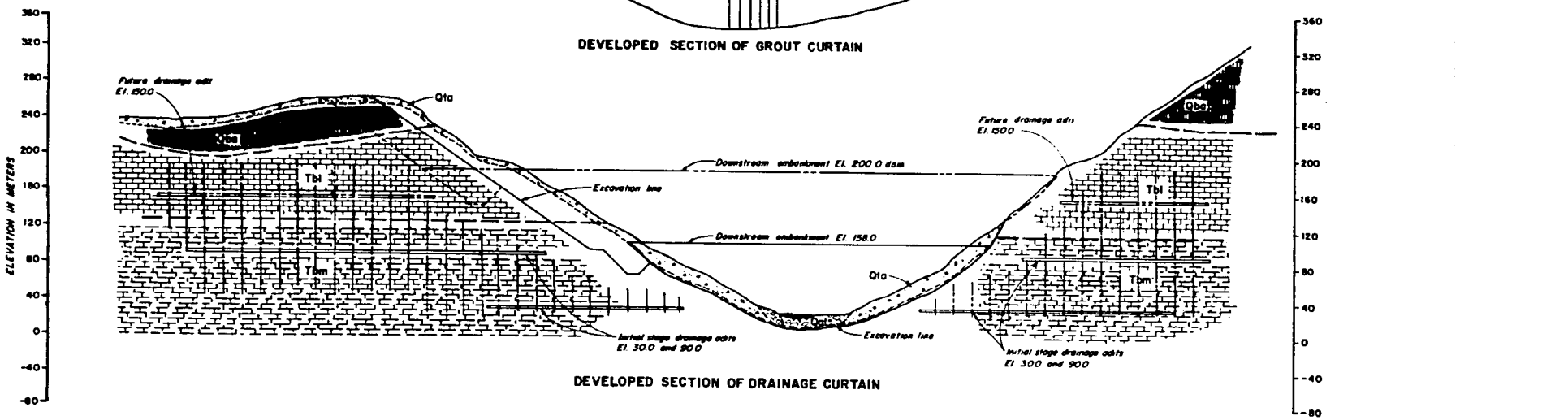


MAQARIN DAM
CREST ELEVATION 158.0
JORDAN VALLEY IRRIGATION PROJECT
STAGE I

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978



DEVELOPED SECTION OF GROUT CURTAIN



DEVELOPED SECTION OF DRAINAGE CURTAIN

SCALE 0 120 METE

MAQARIN DA
GROUT CURTAIN AN
DRAINAGE CURTAIN PROFILE
JORDAN VALLEY IRRIGATION PROJE
STAGE

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

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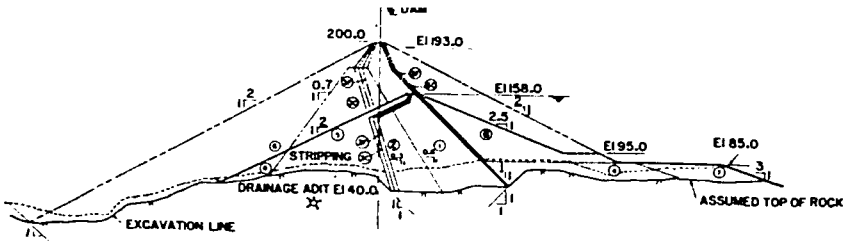
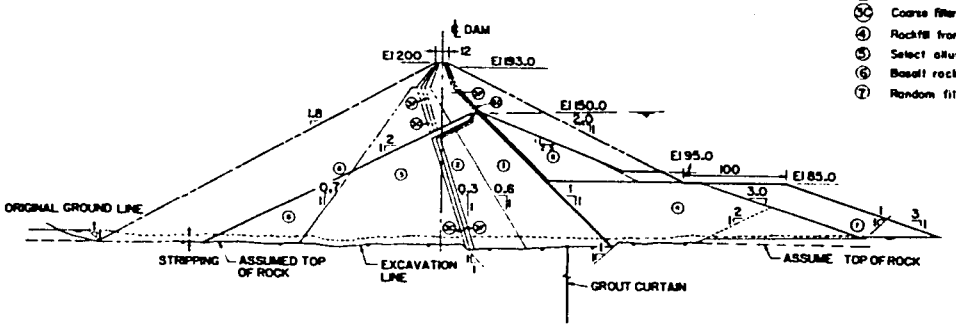


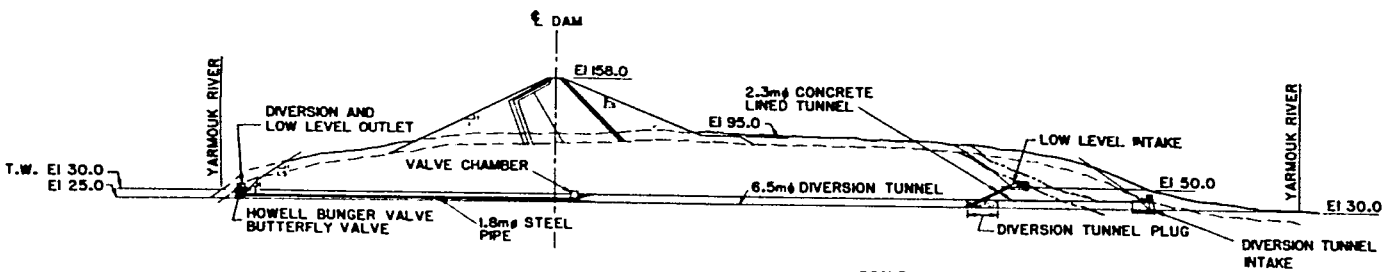
SECTION A–A

SCALE 0 50 METERS

1. Impervious clay
2. Impervious talus
3F. Fine filter
3C. Coarse filter
4. Rockfill from req'd exc.
5. Select alluvium
6. Basalt rockfill
7. Random fill

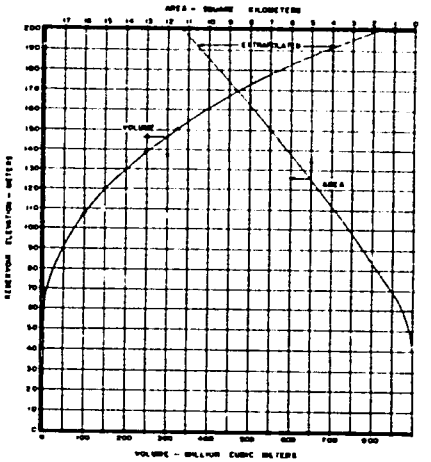


SECTION B–B

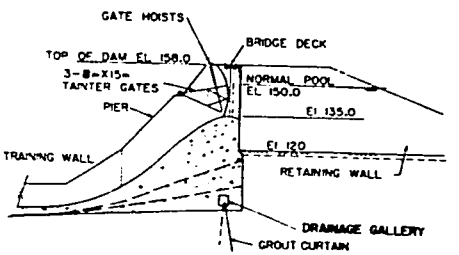


DIVERSION TUNNEL PROFILE

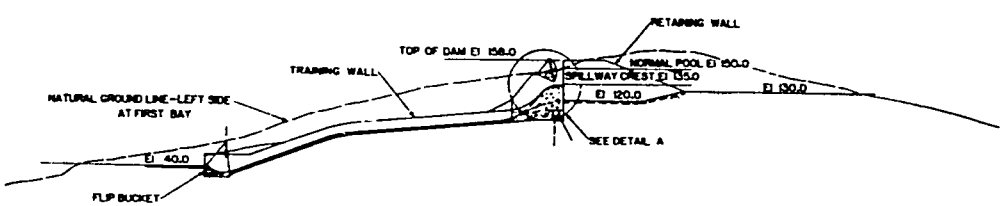
SCALE 0 100 METERS



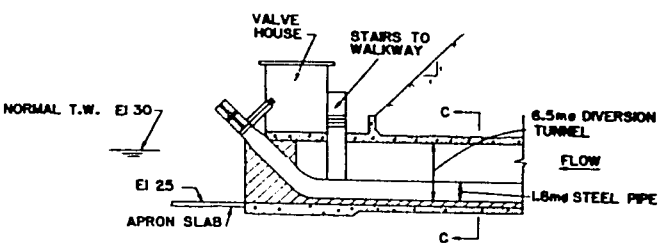
AREA VOLUME CURVE



DETAIL A



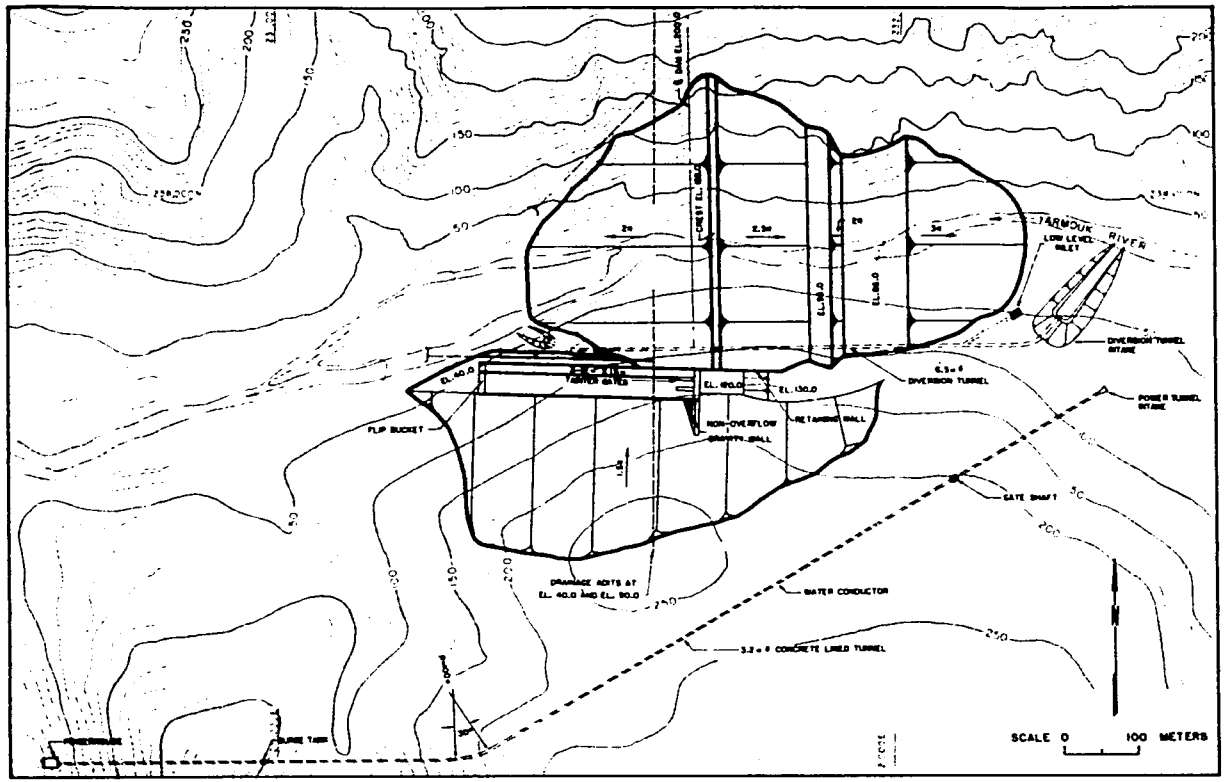
PROFILE OF SPILLWAY

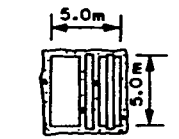


DIVERSION & LOW LEVEL OUTLET

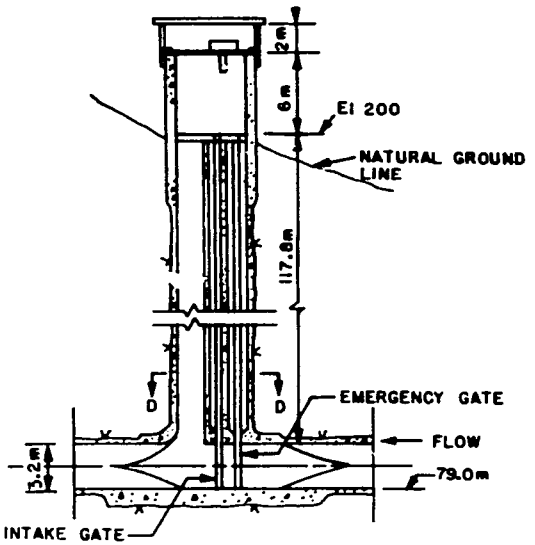
IARZA ENGINEERING COMPANY · JANUARY 1978

MAQARIN DAM
CREST ELEVATION 158.0
JORDAN VALLEY IRRIGATION PROJECT
STAGE II



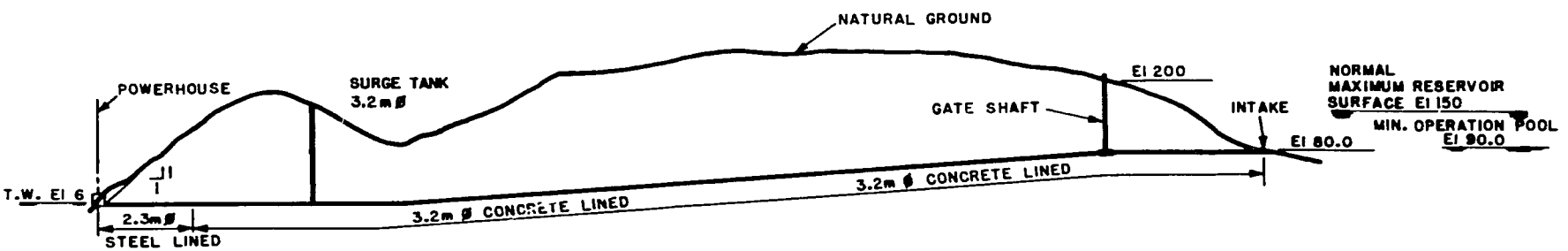


SECTION D-D



GATE SHAFT

SCALE 0 10 METERS



PROFILE

SCALE 0 50 METERS

MAQARIN POWERPL
PLAN AND SECTI
JORDAN VALLEY IRRIGATION PRO.
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HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

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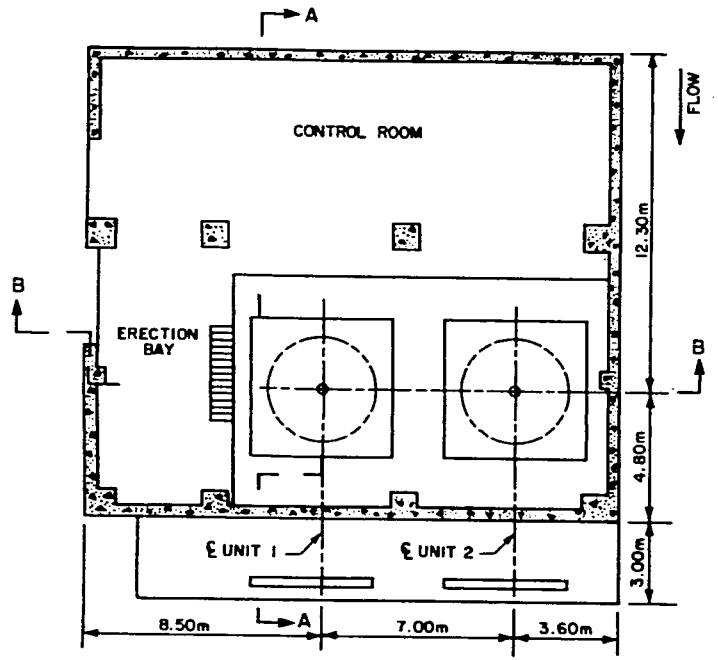
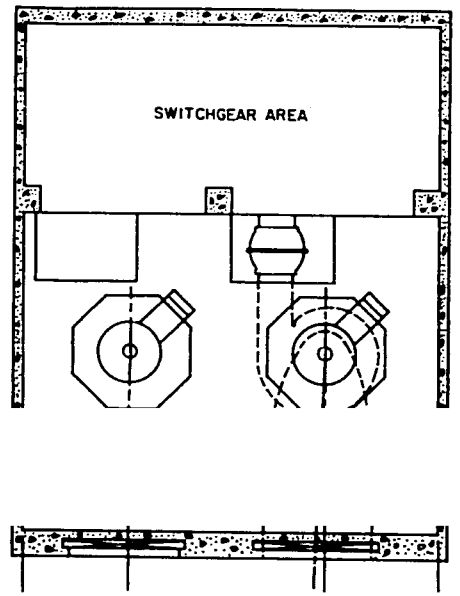
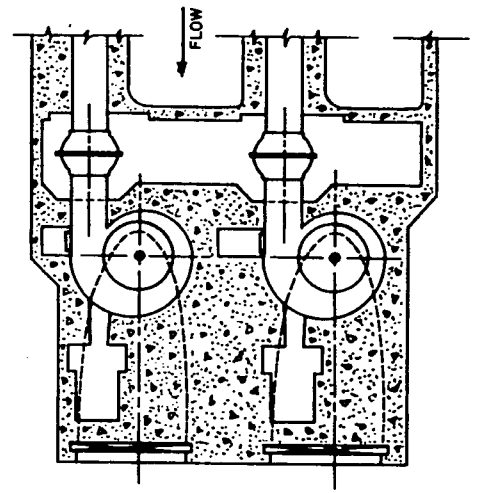
EXH
SHEET



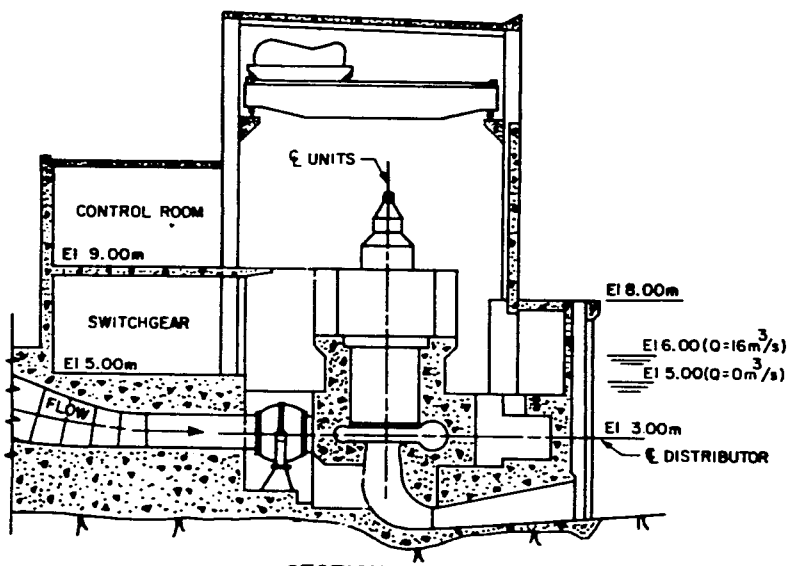
PLAN El 9.00m



PLAN El 5.00m



PLAN El 3.00m



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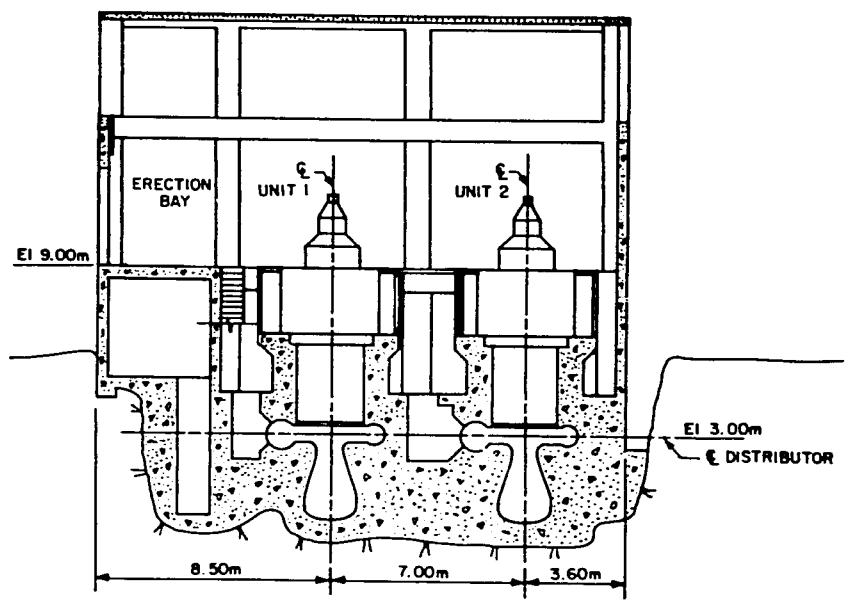

SECTION B–B

SCALE 0 5 METE

MAQARIN POWER P
PLAN AND SECT
JORDAN VALLEY IRRIGATION PR
STA

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

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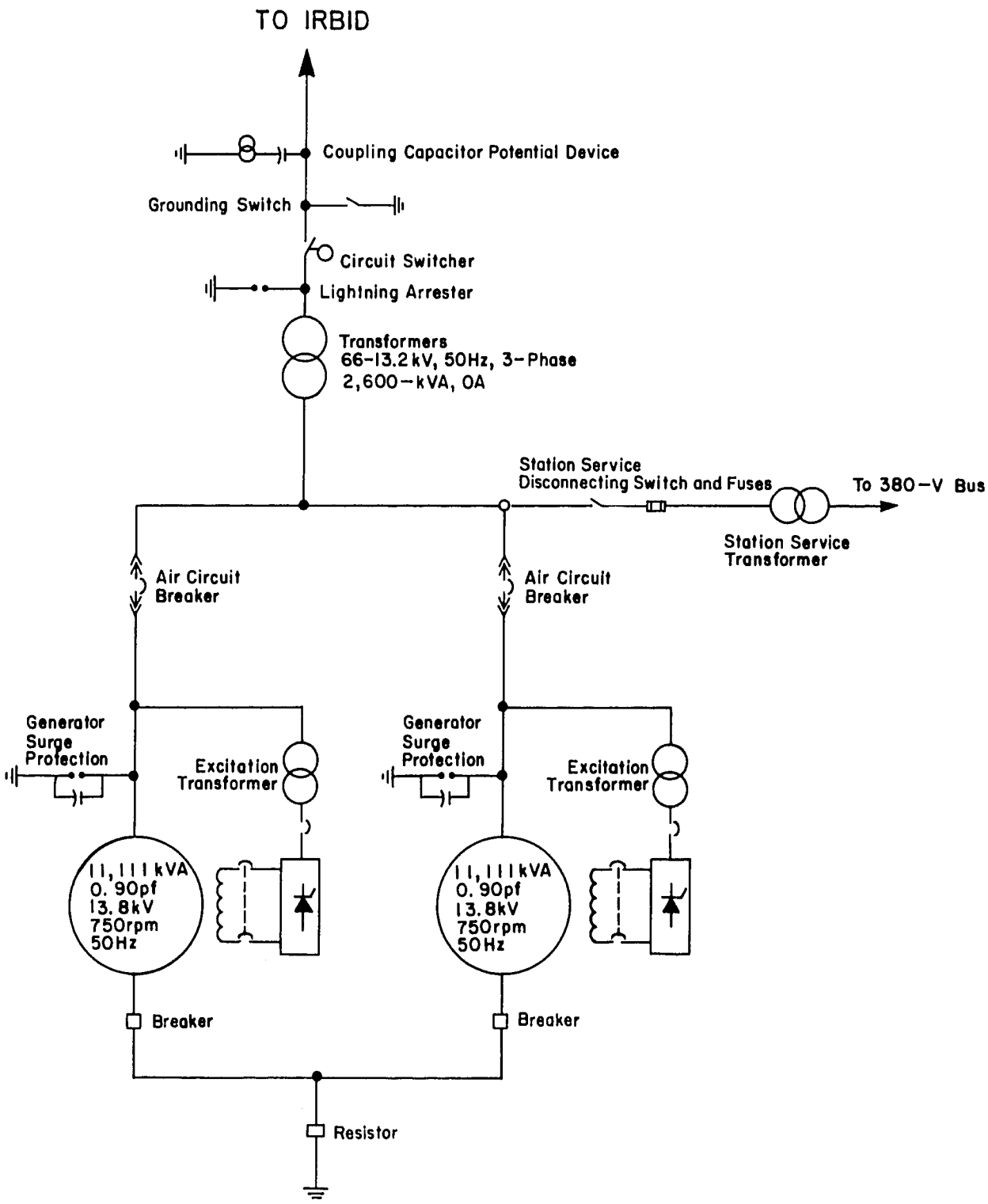
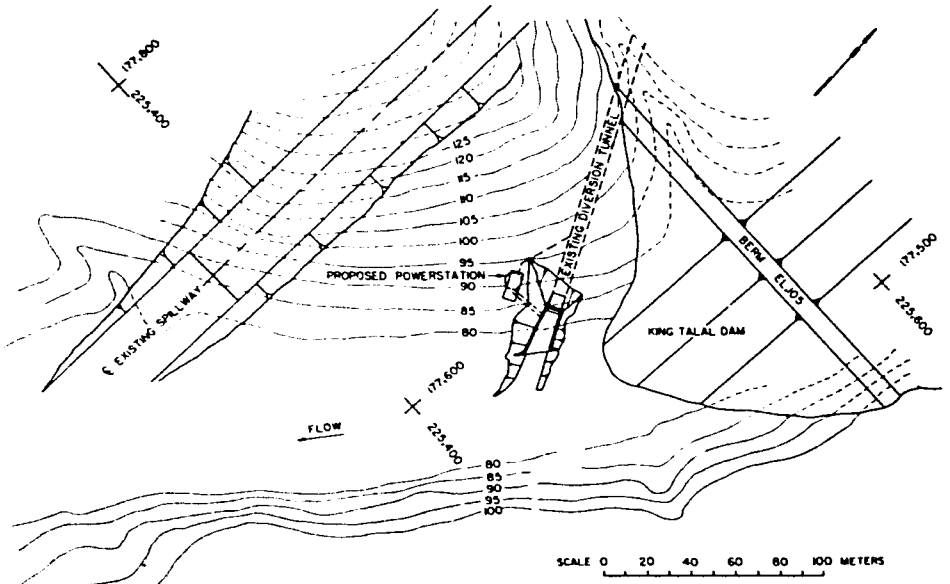
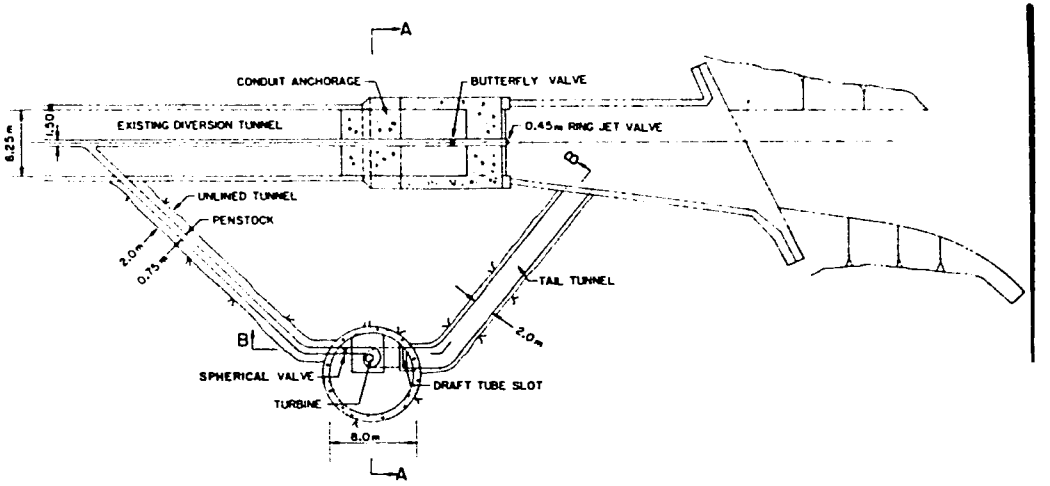


MAQARIN POWERPLANT
SINGLE LINE DIAGRAM

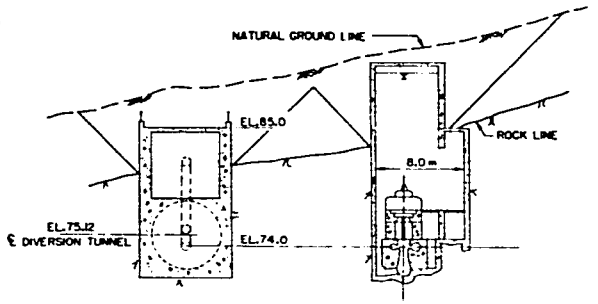
JORDAN VALLEY IRRIGATION PROJECT
STAGE II



PLAN



SECTIONAL PLAN



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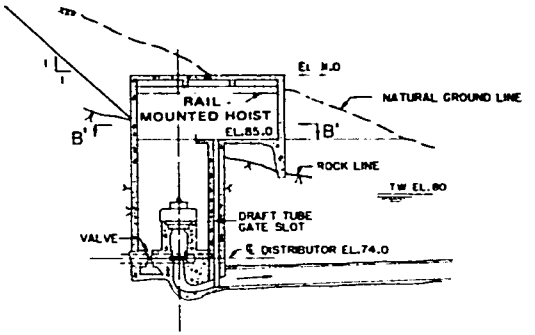
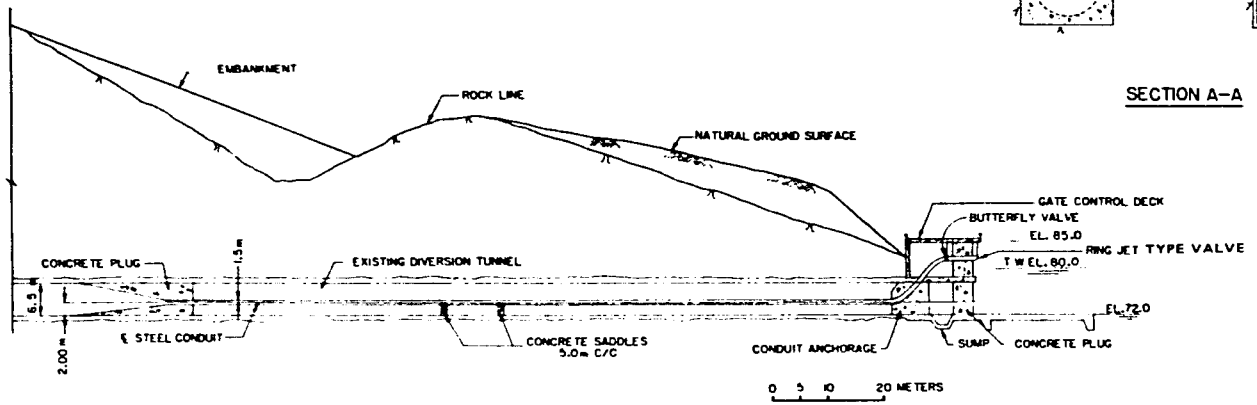
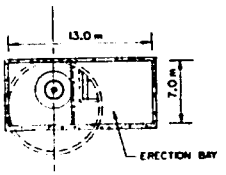


SECTION B–B



SECTION THRU DIVERSION TUNNEL



SECTION B'–B'

SCALE 0 5 10 15 20 METERS
EXCEPT AS INDICATED

KING TALAL POWERPLANT
PLAN AND SECTIONS
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

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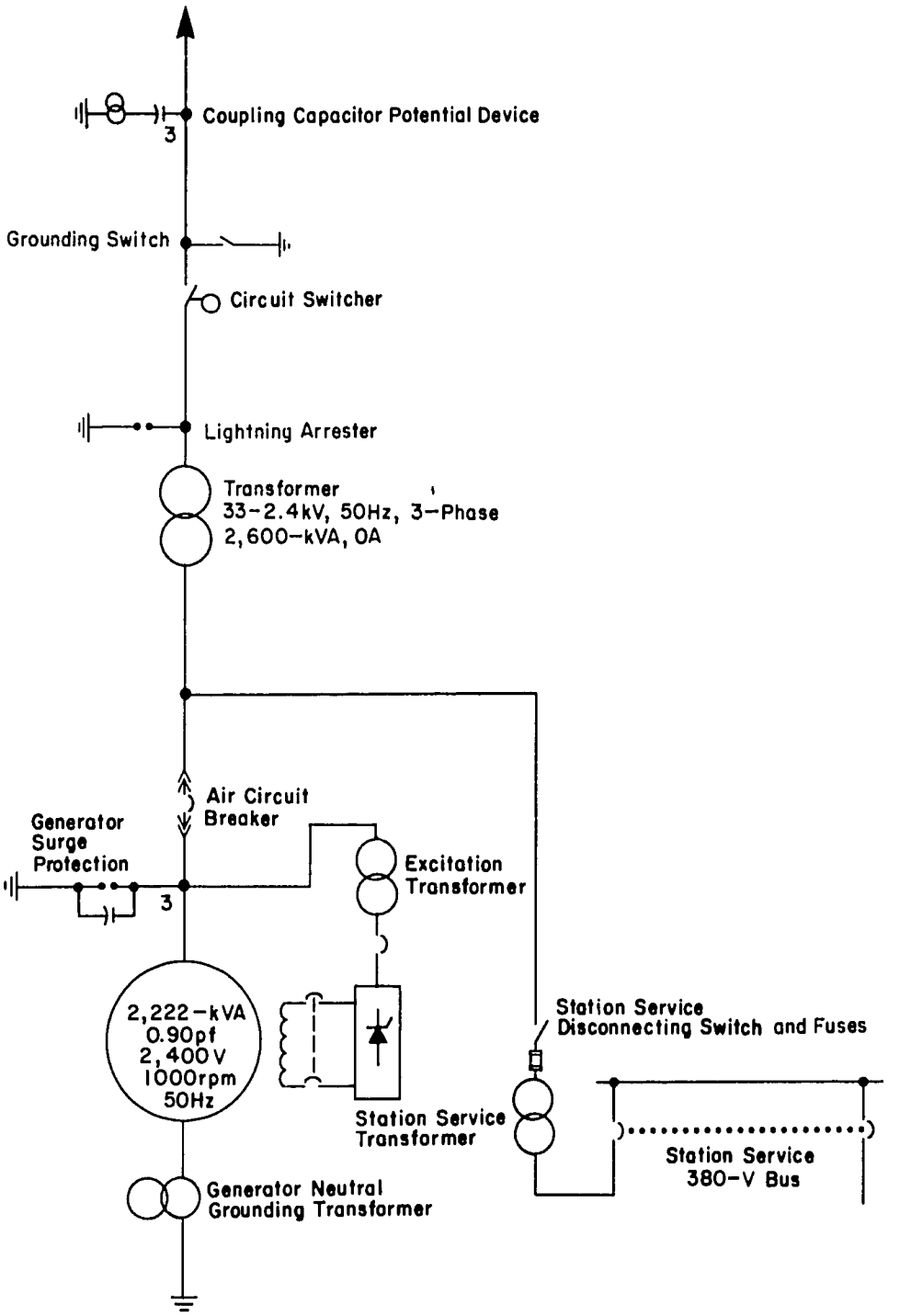
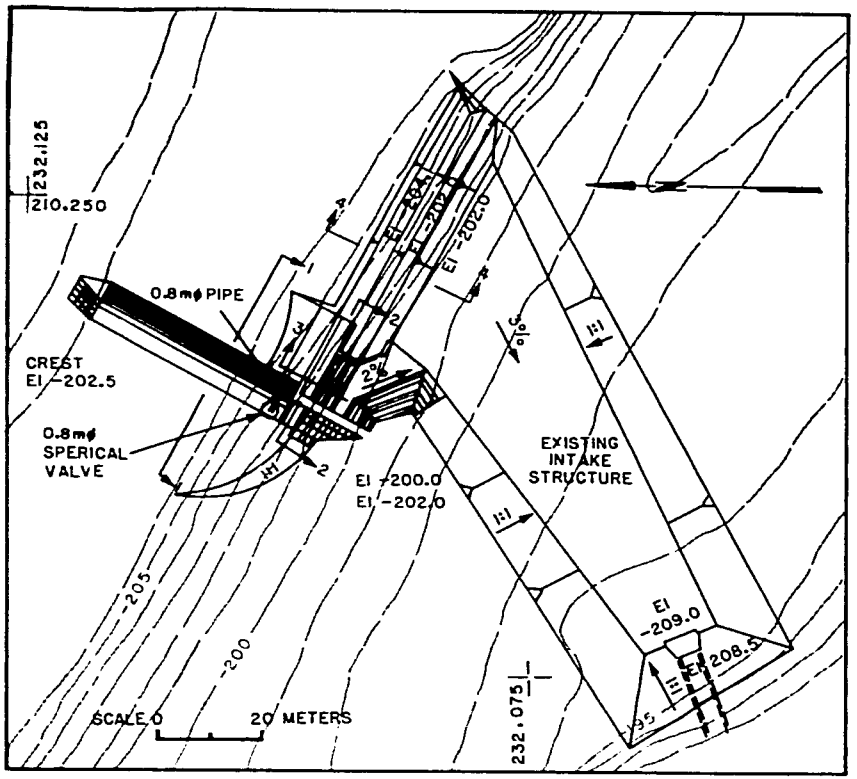
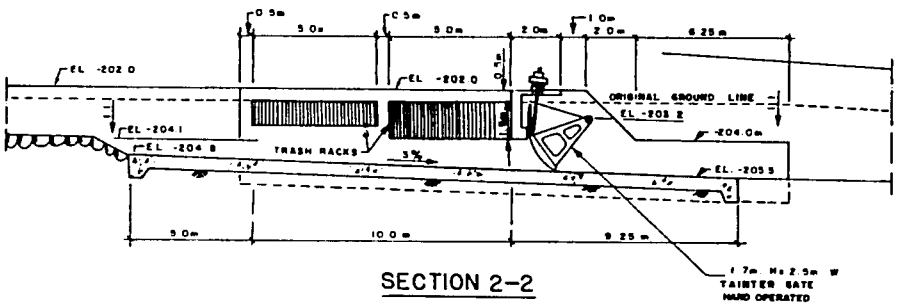


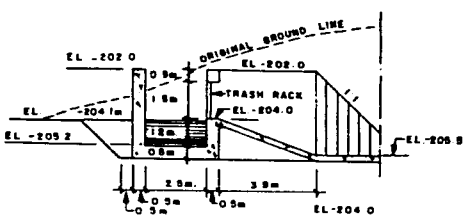
KING TALAL POWERPLANT
SINGLE LINE DIAGRAM

JORDAN VALLEY IRRIGATION PROJECT
STAGE II

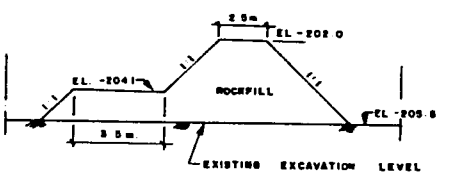




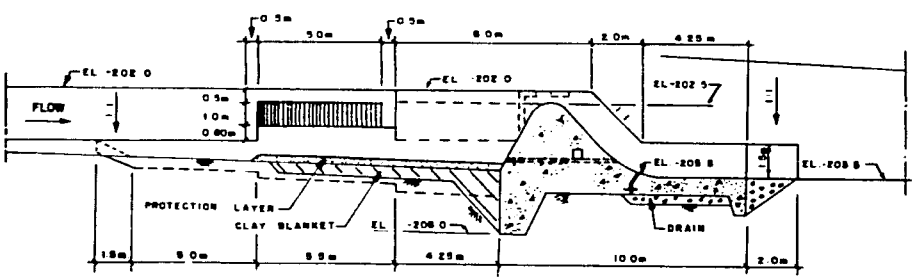
SECTION 2-2



SECTION 3-3



SECTION 4-4



SECTION 1-1

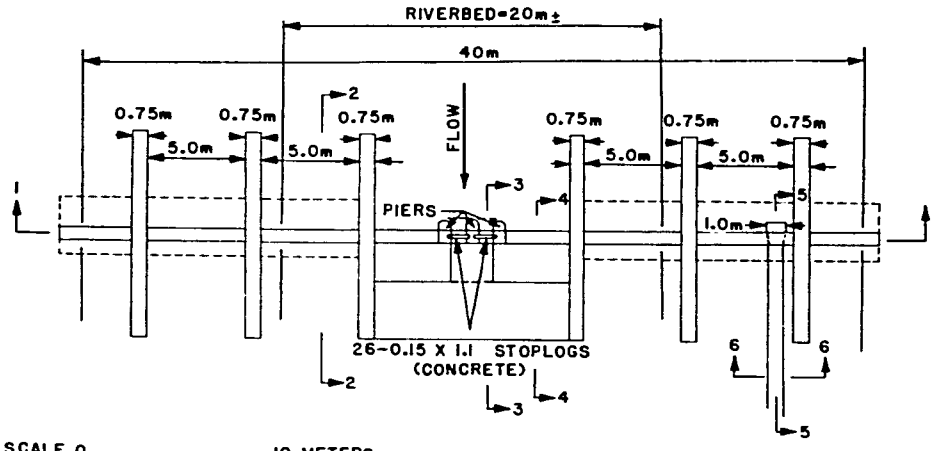
SOURCE DOCUMENT
"YARMOUK PROJECT-KHALID BIN AL WALID-WADI ARAB SCHEME", VOLUME VI, ENERGOPROJEKT, JUNE 1967.

SCALE 0 5 METERS

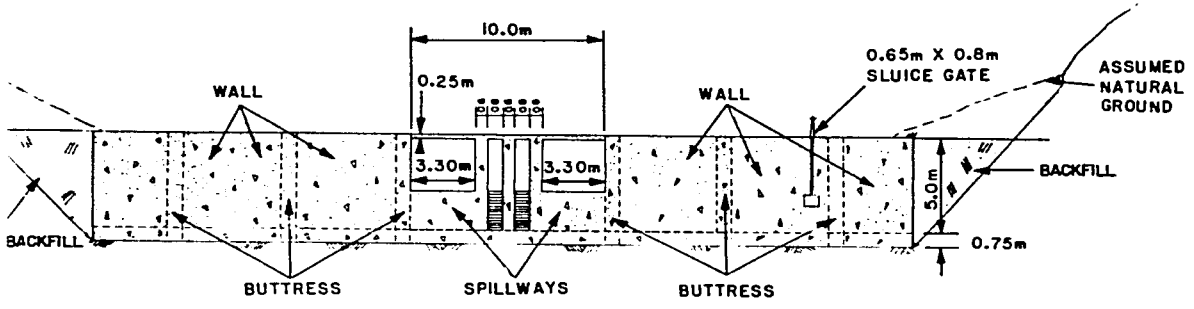
CONTROLLED DIVERSION STRUCTURE PLAN AND SECTIONS

JORDAN VALLEY IRRIGATION PROJECT
STAGE II

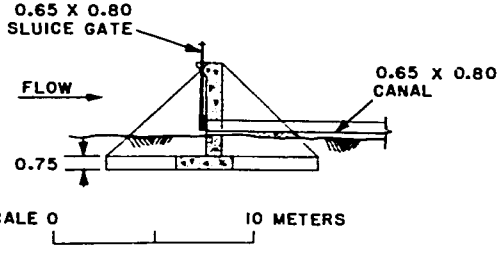
HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978



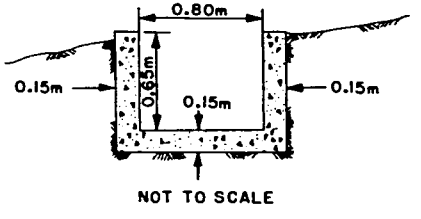
PLAN



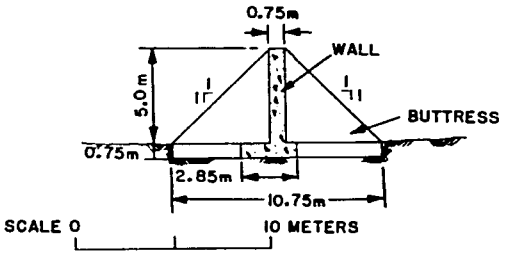
SECTION 1-1



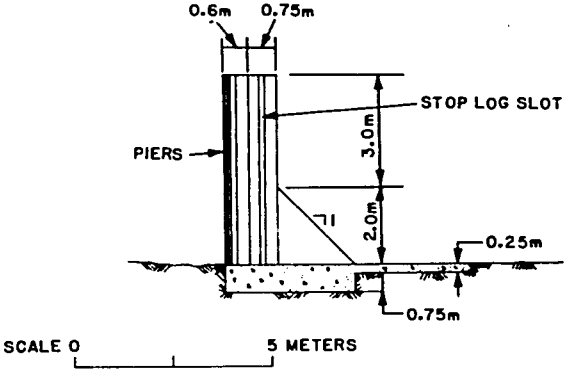
SECTION 5-5
DIVERSION ORIFICE



SECTION 6-6
DIVERSION CANAL



SECTION 2-2
BUTTRESS



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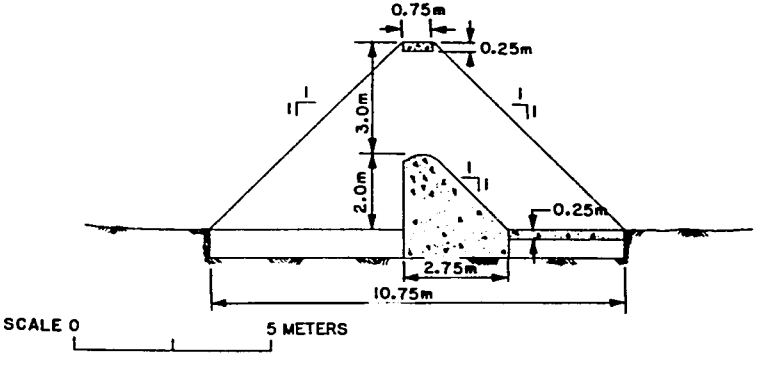

SECTION 4-4
UNCONTROLLED SPILLWAY

TYPICAL
SIDE WADI DIVERSION
PLAN AND SECTIONS

JORDAN VALLEY IRRIGATION PROJECT
STAGE II

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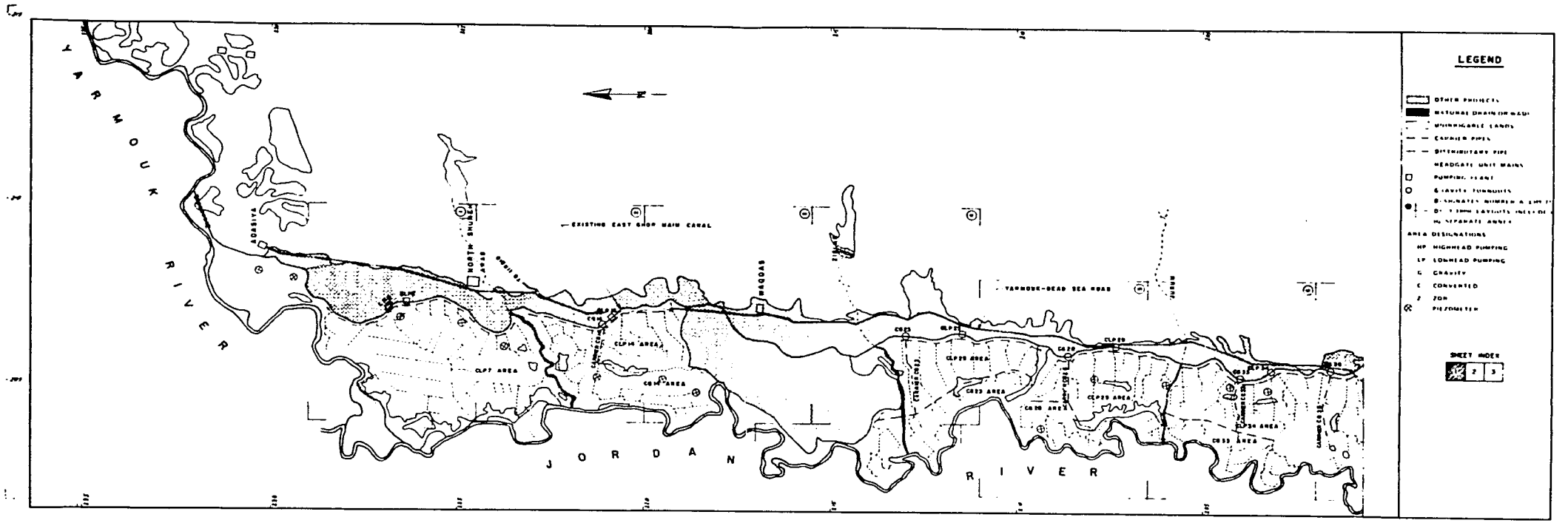
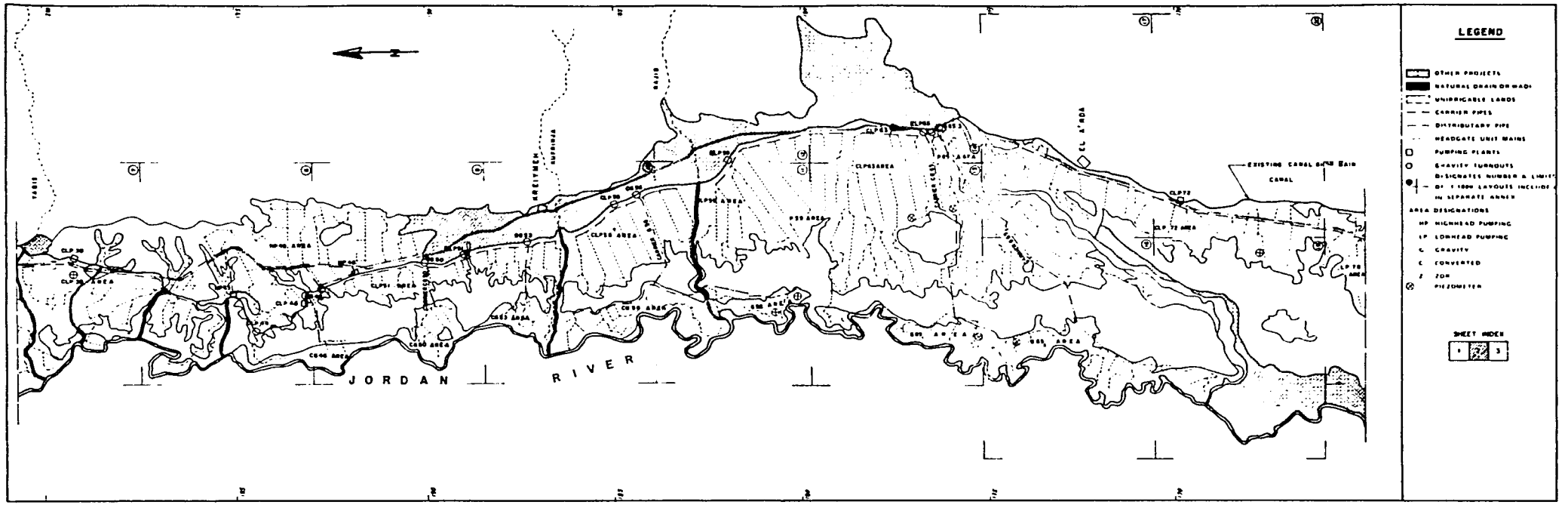


IRRIGATION DISTRIBUTION SYSTEM
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

DAR AL-HANDASAH CONSULTANTS (SHAIR & PARTNERS) · JANUARY 1978



IRRIGATION DISTRIBUTION SYSTEM
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

DAR AL-HANDASAH CONSULTANTS (SHAIR & PARTNERS) • JANUARY 1978

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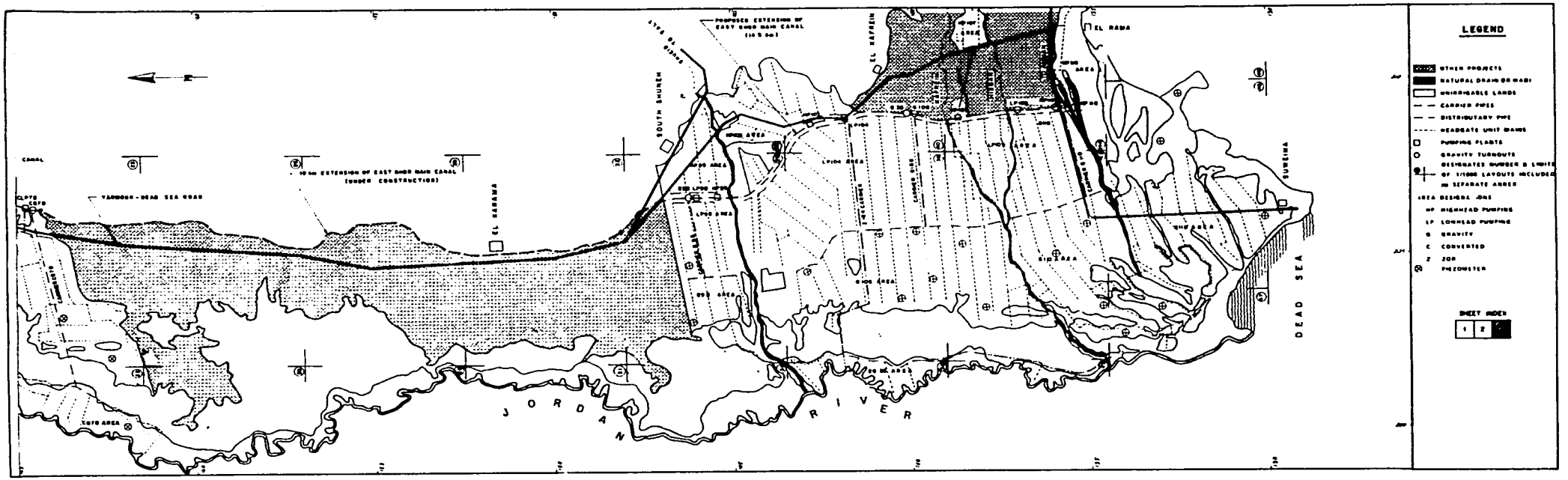

IRRIGATION DISTRIBUTION SYSTEM
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

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JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Diversion and Control of Water							
Diversion Portal and Tunnel							
Excavation, Common	37,600 m^3	0.25	9,400	0.50	18,800	0.75	28,200
Excavation, Rock	6,000 m^3	1.00	6,000	2.00	12,000	3.00	18,000
Concrete, Portal	1,900 m^3	21.00	39,900	41.00	77,900	62.00	117,800
Excavation, Tunnel	45,300 m^3	7.00	317,100	12.00	543,600	19.00	860,700
Concrete Tunnel	15,420 m^3	19.00	292,980	38.00	585,960	57.00	878,940
Consolidation Grouting	900 l.m.	56.00	50,400	80.00	72,000	136.00	122,400
Concrete Plug	1,000 m^3	11.00	11,000	20.00	20,000	31.00	31,000
Steel Supports	134,000 kg	0.20	26,800	0.30	40,200	0.50	67,000
Shotcrete & Wire Mesh	11,600 m^2	3.00	34,800	4.70	54,520	7.70	89,320
Rock Bolts	2,110 l.m.	3.00	6,330	6.00	12,660	9.00	18,990
Upstream Cofferdam							
Fill	267,600 m^3	0.75	200,700	1.75	468,300	2.50	669,000
Slurry Trench & Core	L.S.		22,000		49,000		71,000
Downstream Cofferdam							
Fill	37,800 m^3	0.75	28,350	1.75	66,150	2.50	94,500
Slurry Trench & Core	L.S.		17,000		38,000		55,000
Pumping	L.S.		25,000		28,000		53,000
Diversion Closure Gate	L.S.		89,000		194,000		283,000
Closure	L.S.		5,000		20,000		25,000
Subtotal			1,181,760		2,301,090		3,482,850

EXHIBIT 16
SHEET 1 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Main Dam							
Excavation - Common	2,374,000 m^3	0.30	712,200	0.60	1,424,400	0.90	2,136,600
Excavation - Rock	780,000 m^3	0.90	702,000	1.80	1,404,000	2.70	2,106,000
Consolidation Grouting	L.S.		77,280		115,920		193,200
Curtain Grouting	L.S.		444,900		667,300		1,112,200
Drainage Adits and Drains	L.S.		220,000		330,000		550,000
Special Foundation Inspection and Treatment	L.S.		350,200		650,500		1,000,700
Grouting Gallery and Adits	L.S.		280,000		420,000		700,000
Embankment							
Impervious Core	2,560,000 m^3	0.65	1,664,000	1.10	2,816,000	1.75	4,480,000
Impervious Talus	1,350,000 m^3	0.60	810,000	0.90	1,215,000	1.50	2,025,000
Fine Filter	300,000 m^3	1.40	420,000	2.55	765,000	3.95	1,185,000
Coarse Filter	260,000 m^3	1.40	364,000	2.55	663,000	3.95	1,027,000
Random Rockfill (from Req'd Excav.)	2,000,000 m^3	0.25	500,000	0.35	700,000	0.60	1,200,000
(from Borrow)	830,000 m^3	0.60	498,000	0.90	747,000	1.50	1,245,000
Alluvium	3,140,000 m^3	0.60	1,884,000	0.90	2,826,000	1.50	4,710,000
Basalt Rockfill (from Req'd Excav.)	227,000 m^3	0.25	56,750	0.35	79,450	0.60	136,200
(from Borrow	2,713,000 m^3	0.80	2,170,400	1.50	4,069,500	2.30	6,239,900
Random Fill	940,000 m^3	0.25	235,000	0.35	329,000	0.60	564,000
Instrumentation	L.S.		100,000		400,000		500,000
Subtotal			11,488,730		19,622,070		31,110,800

EXHIBIT 16
SHEET 2 of 14

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JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Spillway							
Approach Channel							
Open-Cut Excavation-Common	302,600 m^3	0.30	90,780	0.90	181,560	0.90	272,340
Open-Cut Excavation-Rock	1,125,200 m^3	0.55	618,860	1.10	1,237,720	1.65	1,856,580
Reinforced Concrete Training Wall	21,400 m^3	21.00	449,400	42.00	898,800	63.00	1,348,200
Mass Concrete in Training Wall	50,550 m^3	11.00	556,050	20.00	1,011,000	31.00	1,567,050
Ogee and Chute							
Open-Cut Excavation-Common	717,500 m^3	0.35	251,120	0.65	466,380	1.00	717,500
Open-Cut Excavation-Rock	1,794,500 m^3	0.80	1,435,600	1.20	2,153,400	2.00	3,589,000
Mass Concrete for Ogee	32,400 m^3	11.00	356,400	20.00	648,000	31.00	1,004,400
Reinforced Concrete for Piers	44,000 m^3	21.00	924,000	42.00	1,848,000	63.00	2,772,000
Reinforced Concrete for Floor Slab	20,600 m^3	25.00	515,000	45.00	927,000	70.00	1,442,000
Reinforced Concrete for Training Walls	12,100 m^3	21.00	254,100	42.00	508,200	63.00	762,300
Mass Concrete for Flip Bucket	6,100 m^3	12.00	73,200	23.00	140,300	35.00	213,500
Mass Concrete for Gravity Wall	7,400 m^3	11.00	81,400	31.00	229,400	42.00	310,800
Reinforced Concete for Bridge Deck	220 m^3	25.00	5,500	45.00	9,900	70.00	15,400
Compacted Backfill for Walls	56,000 m^3	0.08	44,800	0.90	50,400	1.70	95,200
Rock Anchors	6,800 LM	4.00	27,200	6.00	40,800	10.00	68,000
Spillway Gates 12m x 15m	3	38,500.00	115,500	71,500.00	214,500	110,000.00	330,000
Subtotal			5,798,910		10,565,360		16,364,270

EXHIBIT 16
SHEET 3 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Low Level Outlet							
Intake Portal							
Excavation - Common	12,000 m^3	0.30	3,600	0.60	7,200	0.90	10,800
Excavation - Rock	3,160 m^3	1.00	3,160	2.00	6,320	3.00	9,480
Reinforced Concrete	300 m^3	21.00	6,300	41.00	12,300	62.00	18,600
Trashrack and Support	43,000 kg	0.55	23,650	0.75	32,250	1.30	55,900
Inlet Tunnel 2.3 m Diameter							
Excavation	380 m^3	22.00	8,360	18.00	6,840	40.00	15,200
Concrete Lining	185 m^3	22.00	4,070	47.00	8,700	69.00	12,770
Steel Supports	5,000 kg	0.20	1,000	0.30	1,500	0.50	2,500
Outlet Conduit							
1.8 m Ø Steel Pipe	127,710 kg	0.40	51,080	0.50	63,850	0.90	114,930
1.8 m Ø Butterfly Valve	L.S.		11,300		22,700		34,000
Concrete Pedestal	150 m^3	21.00	3,150	42.00	6,300	63.00	9,450
Valve House							
Hollow Jet Valve 1.5 m Ø	L.S.		22,300		44,700		67,000
Spherical Valve 1.5 m Ø	L.S.		16,700		33,300		50,000
Concrete in Valve House	50 m^3	25.00	1,250	45.00	2,250	70.00	3,500
Mass Conc. for pipe Support	270 m^3	11.00	2,970	20.00	5,400	31.00	8,370
Subtotal			158,890		253,610		412,500

EXHIBIT 16
SHEET 4 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Powerplant - Maqarin Dam							
Gate Shafts							
Near Intake							
Excavation - Rock	1,630 m^3	26.00	42,380	22.00	35,860	48.00	78,240
Reinforced Concrete Lining	245 m^3	22.00	5,390	47.00	11,515	69.00	16,905
Reinforced Concrete Superstructure	40	22.00	880	48.00	1,920	70.00	2,800
Reinforced Concrete Foundation	130 m^3	22.00	2,860	52.00	6,760	74.00	9,620
Powerhouse							
Open-Cut Excavation-Common	3,200 m^3	0.35	1,120	0.65	2,080	1.00	3,200
Open-Cut Excavation-Rock	8,400 m^3	0.90	7,560	1.30	10,920	2.20	18,480
Reinforced Concrete	3,200 m^3	22.00	70,400	52.00	166,400	74.00	236,800
Intake							
Open-Cut Excavation - Common	1,000 m^3	0.30	300	0.60	600	0.90	900
Open-Cut Excavation - Rock	1,000 m^3	1.00	1,000	2.00	2,000	3.00	3,000
Reinforced Concrete - Intake	200 m^3	22.00	4,400	52.00	10,400	74.00	14,800
Trashrack and Supports	6,000 kg	0.55	3,300	0.75	4,500	1.30	7,800
Water Conductor (3.2 m Diameter)							
Tunnel Excavation	21,700 m^3	19.00	412,300	16.00	347,200	35.00	759,500
Steel Support	42,000 kg	0.20	8,400	0.30	12,600	0.50	21,000
Rock bolts	2,000 l.m.	3.00	6,000	6.00	12,000	9.00	18,000
Shotcrete & Wire Mesh	18,000 m^2	3.00	54,000	4.70	84,600	7.70	138,600
Concrete Lining	7,090 m^3	15.00	106,350	30.00	212,700	45.00	319,050
Steel Lining	103,000 kg	0.40	41,200	0.50	51,500	0.90	92,700
Concrete behind steel liner	1,100 m^3	15.00	16,500	25.00	27,500	40.00	44,000
Consolidation Grouting	1,770 l.m.	25.00	44,250	37.00	65,490	62.00	109,740
Surge Tank							
Shaft Excavation	2,380 m^3	36.00	61,880	22.00	52,360	48.00	114,240
Concrete Lining	920 m^3	22.00	20,240	47.00	43,240	69.00	63,480
Mechanical Equipment - Maqarin Dam							
Turbine - Governor	2 ea	45,000.00	90,000	255,000.00	510,000	300,000.00	600,000
Spherical Valve, 97 m Ø	2 ea	9,000.00	18,000	20,000.00	40,000	29,000.00	58,000
Miscellaneous Mechanical	L.S.		8,000		18,800		26,800
Gates	L.S.		21,000		46,000		67,000
Powerhouse Crane	L.S.		22,000		45,000		67,000
Beams, Valves, & Hoists	L.S.		6,000		13,000		19,000
Electrical Equipment - Maqarin Dam							
Generator	2 ea	20,000.00	40,000	177,000.00	354,000	197,000.00	394,000
Power Transformer	2 ea	5,000.00	10,000	13,000.00	26,000	18,000.00	36,000
Accessory Electrical	2 ea	25,400.00	50,800	54,500.00	109,000	79,900.00	159,800
Subtotal			1,176,510		2,323,945		3,500,455

EXHIBIT 16
SHEET 5 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Powerplant - King Talal Dam							
Water Conductor							
Excavation Tunnel	215 m^3	26.00	5,590	22.00	4,730	48.00	10,320
Reinforced Concrete Tunnel Lining	60 m^3	23.00	1,380	48.00	2,880	71.00	4,260
Reinforced Concrete Pedestal	10 m^3	23.00	230	48.00	480	71.00	710
Steel Pipe	14,000 kg	0.50	7,000	0.60	8,400	1.10	15,400
Powerhouse							
Open-Cut Excavation - Common	2,450 m^3	0.60	1,470	1.40	3,430	2.00	4,900
Excavation - Rock	800 m^3	1.00	800	2.00	1,600	3.00	2,400
Reinforced Concrete - Substructure	135 m^3	23.00	3,105	55.00	7,425	78.00	10,530
Reinforced Concrete - Superstructure Ring Wall	140 m^3	23.00	3,220	55.00	7,700	78.00	10,920
Miscellaneous	65 m^3	23.00	1,495	55.00	3,575	78.00	5,070
Steel Girder	1,530 kg	0.30	460	0.70	1,070	1.00	1,530
Outlet Structures							
Structural Concrete	75 m^3	23.00	1,725	55.00	4,125	78.00	5,850
Mechanical Equipment - King Talal Dam							
Turbine - Governor	1 ea	7,800.00	7,800	54,700.00	54,700	62,500.00	62,500
Butterfly Valve 0.82 m ø	1 ea	1,500.00	1,500	3,100.00	3,100	4,600.00	4,600
Miscellaneous Mechanical	1 ea	1,500.00	1,500	3,500.00	3,500	5,000.00	5,000
Ring Jet & Needle Valve	1	LS	12,000	LS	22,000	LS	34,000
Gates	1	LS	700	LS	1,300	LS	2,000
Beams and Hoists	1	LS	2,200	LS	4,000	LS	6,200
Butterfly Valve 0.5 m ø	1 ea	1,200.00	1,200	2,500.00	2,500	3,700.00	3,700
Electrical Equipment - King Talal Dam							
Generator	1 ea	8,200.00	8,200	46,800.00	46,800	55,000.00	55,000
Power Transformer	1 ea	2,000.00	2,000	5,000.00	5,000	7,000.00	7,000
Accessory Electrical	1 ea	27,000.00	27,000	64,000.00	64,000	91,000.00	91,000
Subtotal			90,575		252,315		342,890
Transmission Line - 66 kv	LS		187,000		346,400		533,400
Transmission Line - 33 kv	LS		42,700		79,000		121,700
Subtotal			229,700		425,400		655,100

EXHIBIT 16
SHEET 6 of 14 .

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Diversion near Adasiye							
Dam and Desilting Works							
Diversion and Control of Water	LS		8,100		9,500		17,600
Open-Cut Excavation - Common	2,175 m^3	0.30	655	0.60	1,305	0.90	1,960
Reinforced Concrete - Ogee	816 m^3	25.00	20,400	56.00	45,700	81.00	66,100
Reinforced Concrete - Walls	166 m^3	25.00	4,150	56.00	9,300	81.00	13,450
Reinforced Concrete - Slabs	4 m^3	25.00	100	56.00	225	81.00	325
Reinforced Concrete - Canal Lining	56 m^3	25.00	1,400	55.00	3,080	80.00	4,480
Rockfill	1,460 m^3	1.00	1,460	1.80	2,630	2.80	4,090
Compacted Backfill	265 m^3	1.00	265	2.00	530	3.00	795
Clayey blanket	280 m^3	0.70	195	1.50	300	2.20	615
Protective layer on blanket	200 m^3	2.00	400	3.00	600	5.00	1,000
Miscellaneous Civil Works	200 m^3	LS	3,800	LS	8,400	LS	12,200
Mechanical Equipment							
Tainter Gate & Hoist (1.7mx2.5m)	LS		1,400		2,600		4,000
Trashracks	200 kg	0.55	110	0.75	150	1.30	260
Miscellaneous Mechanical	LS		200		400		600
Subtotal			42,635		84,840		127,475
Wadi Rajib Diversion							
Buttress Embankments							
Open-Cut Excavation - Rock	240 m^3	1.50	360	2.50	600	4.00	960
Reinforced Concrete - Buttress	310 m^3	25.00	7,750	56.00	17,360	81.00	25,110
Spillway & Regulating Bays							
Open-Cut Excavation - Rock	30 m^3	1.50	45	2.50	75	4.00	120
Reinforced Concrete, Spillway, Regulating Bays, Top Slab, Piers	55 m^3	25.00	1,375	56.00	3,080	81.00	4,455
Reinforced Concrete - Aprons	10 m^3	25.00	250	56.00	560	81.00	810
Reinforced Concrete - Stop Logs	1 m^3	30.00	30	70.00	70	100.00	100
Diversion Canal (Length ≐ 400 m)							
Open-Cut Excavation - Rock	620 m^3	1.50	930	3.50	2,170	5.00	3,100
Reinforced Concrete - Canal	140 m^3	25.00	3,500	55.00	7,700	80.00	11,200
Compacted Backfill	260 m^3	1.00	260	2.00	520	3.00	780
0.65m x 0.8m clear opening Sluice Gate	1 ea		350		850		1,200
Hand-operated Hoist	1 ea		40		60		100
Miscellaneous Equipment	LS		60		140		200
Subtotal			14,950		33,185		48,135

EXHIBIT 16
SHEET 7 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Wadi Kufrinja Diversion							
Buttress Embankments							
Open-Cut Excavation - Rock	110 m^3	1.50	165	2.50	275	4.00	440
Reinforced Concrete - Buttress	150 m^3	25.00	3,750	56.00	8,400	81.00	12,150
Spillway & Regulating Bays							
Open-Cut Excavation - Rock	30 m^3	1.50	45	2.50	75	4.00	120
Reinforced Concrete - Spillway, Regulating Bays, Top Slab, Piers	55 m^3	25.00	1,375	56.00	3,080	81.00	4,455
Reinforced Concrete - Aprons	10 m^3	25.00	250	56.00	560	81.00	810
Reinforced Concrete - Stop Logs	1 m^3	30.00	30	70.00	70	100.00	100
Diversion Canal (Length ≐ 1700 m)							
Open-Cut Excavation - Rock	2,590 m^3	1.50	3,885	3.50	9,065	5.00	12,950
Reinforced Concrete - Canal	610 m^3	25.00	15,250	55.00	33,550	80.00	48,800
Compacted Backfill	1,100 m^3	1.00	1,100	2.00	2,200	3.00	3,300
0.65m x 0.8m clear opening Sluice Gate	1 ea		350		850		1,200
Hand-Operated Hoist	1 ea		40		60		100
Miscellaneous Equipment	LS		60		140		200
Subtotal			26,300		58,325		84,625
Wadi Yabis Diversion							
Rock Embankment							
Stripping & Clearing	700 m^3	0.30	210	0.60	420	0.90	630
Rockfill - Embankment	800 m^3	0.70	560	1.40	1,120	2.10	1,680
Removal Concrete Bulkhead	3 m^3		200		400		600
Reinforced Concrete - Stop Logs	1 m^3	30.00	30	70.00	70	100.00	100
Subtotal			1,000		2,010		3,010
Access Roads							
To Damsite and Powerhouse	LS		34,600		61,400		96,000
Bridge	LS		58,000		75,000		133,000
Subtotal			92,600		136,400		229,000
Operating Camp	LS		100,000		400,000		500,000
Land Acquisitions	1,300 ha		468,000				468,000
Relocations, R.R.	LS		1,800,000		4,100,000		5,900,000
SUBTOTAL STORAGE AND POWER FACILITIES			22,670,560		40,558,550		63,229,110

EXHIBIT 16
SHEET 8 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Main Canal							
Main Canal Extension							
Excavation - Common	140,000 m^3	0.45	63,000	1.05	147,000	1.50	210,000
Excavation - Rock	30,000 m^3	0.90	27,000	2.10	63,000	3.00	90,000
Compaction	140,000 m^3	0.45	63,000	1.05	147,000	1.50	210,000
Reinforced Concrete-Structures	4,500 m^3	9.20	41,400	30.80	138,600	40.00	180,000
Concrete - Canal Lining	11,000 m^3	8.70	95,700	29.30	322,300	38.00	418,000
Concrete - Blinding	600 m^3	6.40	3,840	21.60	12,960	28.00	16,800
Siphon Pipe	1,400 l.m.	7.50	10,500	42.50	59,500	50.00	70,000
Gravel Surfacing	44,000 m^2	0.31	13,640	0.39	17,160	0.70	30,800
Reinforcing Steel	350 tons	47.50	16,625	142.50	49,875	190.00	66,500
Metal Work	20 tons	100.00	2,000	300.00	6,000	400.00	8,000
Steel Gates	31	750.00	23,250	2,500.00	69,750	3,000.00	93,000
Rock Protection	1,000 m^3	4.00	4,000	1.00	1,000	5.00	5,000
Subtotal			363,955		1,034,145		1,398,100
Main Canal Repair	LS		164,000		326,000		490,000

EXHIBIT 16
SHEET 9 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
New Land Irrigation System							
Pressure-Pipe Network							
Asbestos-Cement Pipe - 1000 mm	3,000 l.m.	18.00	54,000	102.00	306,000	120.00	360,000
900 mm	4,000 l.m.	15.70	62,800	89.30	357,200	105.00	420,000
800 mm	1,000 l.m.	11.30	11,300	63.70	63,700	75.00	75,000
700 mm	7,000 l.m.	9.00	63,000	51.00	357,000	60.00	420,000
600 mm	9,500 l.m.	6.80	64,600	38.20	362,900	45.00	427,500
500 mm	6,500 l.m.	4.50	29,250	25.50	165,750	30.00	195,000
450 mm	10,000 l.m.	3.90	39,000	22.10	221,000	26.00	260,000
400 mm	15,000 l.m.	3.30	49,500	18.70	280,500	22.00	330,000
350 mm	9,500 l.m.	2.60	24,700	14.40	136,800	17.00	161,500
300 mm	57,500 l.m.	1.80	103,500	10.20	586,500	12.00	690,000
250 mm	80,000 l.m.	1.50	120,000	8.50	680,000	10.00	800,000
200 mm	67,000 l.m.	1.10	73,700	5.90	395,300	7.00	469,000
150 mm	20,000 l.m.	0.90	18,000	5.10	102,000	6.00	120,000
125 mm	17,000 l.m.	0.60	10,200	3.40	57,800	4.00	68,000
100 mm	44,000 l.m.	0.50	22,000	2.50	110,000	3.00	132,000
Fittings	LS		82,000		460,000		542,000
Valves	LS		37,300		209,000		246,300
Thrust Blocks	LS		44,700		251,000		295,700
Steel Pipe	300 tons	100.00	30,000	300.00	90,000	400.00	120,000
Farm Turnouts							
Single Turnout	740	105.00	77,700	595.00	440,300	700.00	518,000
Double Turnout	1,130	150.00	169,500	850.00	960,500	1,000.00	1,130,000
Subtotal			1,186,750		6,593,250		7,780,000
Farm Systems							
Fixed System	3,000	120.00	360,000	680.00	2,040,000	800.00	2,400,000
Portable System	3,000	35.00	105,000	315.00	945,000	350.00	1,050,000
Subtotal			465,000		2,985,000		3,450,000

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Pumping Stations							
HP - 43	LS		77,000		180,000		257,000
HP - 48	LS		150,000		350,000		500,000
LP - 98	LS		47,000		118,000		165,000
HP - 99	LS		63,000		148,000		211,000
HP - 103	LS		87,000		202,000		289,000
LP - 104	LS		120,000		280,000		400,000
HP - 107	LS		63,000		148,000		211,000
LP - 109	LS		82,000		190,000		272,000
HP - 110	LS		68,000		160,000		228,000
Subtotal			757,000		1,776,000		2,533,000
Drainage Works							
Surface Drains	10,600 ha	67.50	715,500	82.50	874,500	150.00	1,590,000
Observation Wells	50	90.00	4,500	110.00	5,500	200.00	10,000
Sub-surface Drains	230 ha	200.00	46,000	208.00	47,840	408.00	93,840
Subtotal			766,000		927,840		1,693,840
Clearing	LS		40,000		60,000		100,000
Gravel Surfacing	960,000 m^2	0.31	297,600	0.39	374,400	0.70	672,000
Fixtures	LS		30,000		70,000		100,000
Operator Housing	12	6,000.00	72,000	1,400.00	168,000	20,000.00	240,000
Automation of Main Canal	LS		18,100		162,500		180,600
Subtotal			457,700		834,900		1,292,600
Subtotal New Land System							
W/ Portable Farm System			3,632,450		13,116,990		16,749,440
W/o Portable Farm System			3,527,450		12,171,990		15,699,440

EXHIBIT 16
SHEET 11 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Potential Land Irrigation System							
W/ Portable Farm System	1,947 ha	1,000.00	1,947,000	2,400.00	4,672,800	3,400.00	6,619,800
W/o Portable Farm System	1,947 ha		1,927,530		4,497,350		6,424,880
Conversion Land Irrigation System							
Pressure-Pipe Network							
Asbestos-Cement Pipe 1,200 mm	7,800 l.m.	28.50	222,300	161.50	1,259,700	190.00	1,482,000
1,100 mm	900 l.m.	22.50	20,250	127.50	114,750	150.00	135,000
1,100 mm	2,700 l.m.	18.00	48,600	102.00	275,400	120.00	324,000
900 mm	4,000 l.m.	15.70	62,800	89.30	357,200	105.00	420,000
800 mm	2,500 l.m.	11.30	28,250	63.70	159,250	75.00	187,500
700 mm	4,000 l.m.	9.00	36,000	51.00	204,000	60.00	240,000
600 mm	9,500 l.m.	6.80	64,600	38.20	362,900	45.00	427,500
500 mm	24,500 l.m.	4.50	110,250	25.50	624,750	30.00	735,000
450 mm	29,000 l.m.	3.90	113,100	22.10	640,900	26.00	754,000
400 mm	38,000 l.m.	3.30	125,400	18.70	710,600	22.00	836,000
350 mm	26,000 l.m.	2.60	67,600	14.40	374,400	17.00	442,000
300 mm	37,500 l.m.	1.80	67,500	10.20	382,500	12.00	450,000
250 mm	83,000 l.m.	1.50	124,500	8.50	705,500	10.00	830,000
200 mm	114,500 l.m.	1.10	125,950	5.90	675,550	7.00	801,500
150 mm	42,000 l.m.	0.90	37,800	5.10	214,200	6.00	252,000
125 mm	35,500 l.m.	0.60	21,300	3.40	120,700	4.00	142,000
100 mm	109,500 l.m.	0.50	54,750	2.50	273,750	3.00	328,500
Fittings	LS		146,400		820,000		966,400
Valves	LS		66,600		372,800		439,400
Thrust Blocks	LS		79,900		447,400		527,300
Steel Pipes for Road Crossing	500 tons	100.00	50,000	300.00	150,000	400.00	200,000
Farm Turnouts							
Single Turnouts	1,800	105.00	189,000	595.00	1,071,000	700.00	1,260,000
Double Turnout	850	150.00	127,500	850.00	722,500	1,000.00	850,000
Subtotal			1,990,350		11,039,750		13,030,100
Provision to keep surface systems operating during construction	LS		280,000		280,000		560,000

EXHIBIT 16
SHEET 12 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Farm Systems							
Fixed System	3,500	120.00	420,000	680.00	2,380,000	800.00	2,800,000
Portable System	3,500	50.00	175,000	450.00	1,575,000	500.00	1,750,000
Subtotal			595,000		3,955,000		4,550,000
Pumping Stations							
CLP 14	LS		63,000		148,000		211,000
CLP 25	LS		56,000		131,000		187,000
CLP 29	LS		63,000		148,000		211,000
CLP 34	LS		63,000		148,000		211,000
CLP 38	LS		63,000		148,000		211,000
CLP 44	LS		15,000		32,000		47,000
CLP 46	LS		15,000		32,000		47,000
CLP 51	LS		63,000		148,000		211,000
CLP 55	LS		64,000		150,000		214,000
Subtotal			465,000		1,085,000		1,550,000
Drainage Works							
Upgrading Surface Drains	12,900 ha	20.00	258,000	20.00	258,000	40.00	516,000
Sub-surface Drains	270 ha	200.00	54,000	208.00	56,160	408.00	110,160
Subtotal			312,000		314,160		626,160
Clearing	LS		40,000		60,000		100,000
Fixtures	LS		30,000		70,000		100,000
Gravel Surfacing	1,550,000 m^2	0.31	480,500	0.39	604,500	0.70	1,085,000
Operator Housing	16	6,000.00	96,000	14,000.00	224,000	20,000.00	320,000
Main Canal Turnouts	19	750.00	14,250	2,250.00	42,750	3,000.00	57,000
Modification to Zarqa River Weir	LS		48,000		137,000		185,000
Automation of Main Canal	LS		15,200		136,500		151,700
Subtotal			723,950		1,274,750		1,998,700
Subtotal Conversion Land System							
W/ Portable Farm System			4,366,300		17,948,660		22,314,960
W/o Portable Farm System			4,191,300		16,373,660		20,564,960
SUBTOTAL IRRIGATION FACILITIES							
W/ Portable Farm System			10,473,705		37,098,595		47,572,300
W/o Portable Farm System			10,174,235		34,403,145		44,577,380

EXHIBIT 16
SHEET 13 of 14

JORDAN VALLEY IRRIGATION PROJECT

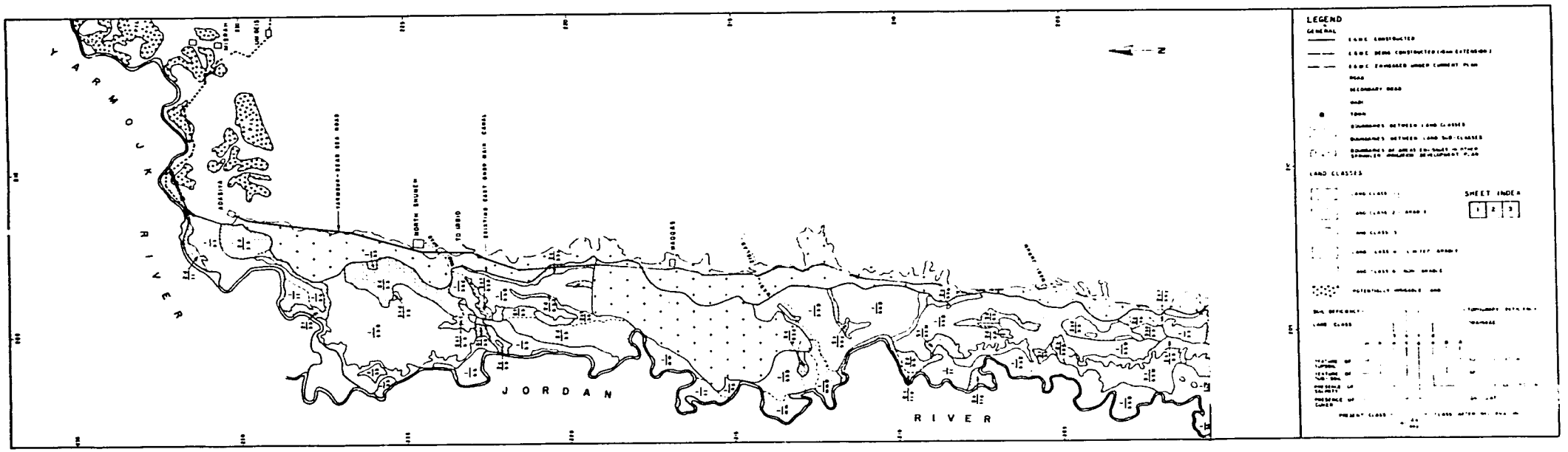
STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Without Portable Farm System							
Subtotal Direct Cost			32,844,795		74,961,695		107,806,490
Contingencies			5,095,105		11,624,505		16,719,610
Total Direct Cost			37,939,900		86,586,200		124,526,100
Engineering and Administration			7,670,000		11,503,900		19,173,900
Construction Cost - 1977			45,609,900		98,090,100		143,700,000
Escalation to end of Construction			26,980,000		38,070,000		65,050,000
TOTAL CONSTRUCTION COST			72,589,900		136,160,100		208,750,000
With Portable Farm System							
Subtotal Direct Cost			33,144,265		77,657,145		110,801,410
Contingencies			5,090,000		11,929,090		17,019,090
Total Direct Cost			38,234,265		89,586,235		127,820,500
Engineering and Administration			7,670,000		11,503,900		19,173,900
Construction Cost - 1977			45,904,265		101,090,135		146,994,400
Escalation to end of Construction			27,598,300		38,943,300		66,541,600
TOTAL CONSTRUCTION COST			73,502,565		140,033,435		213,536,000

EXHIBIT 17
SHEET 1 OF 3



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AR AL-HANDASAH CONSULTANTS (SHAIR & PARTNERS) · JANUARY 1978

LAND CLASSIFICATION
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

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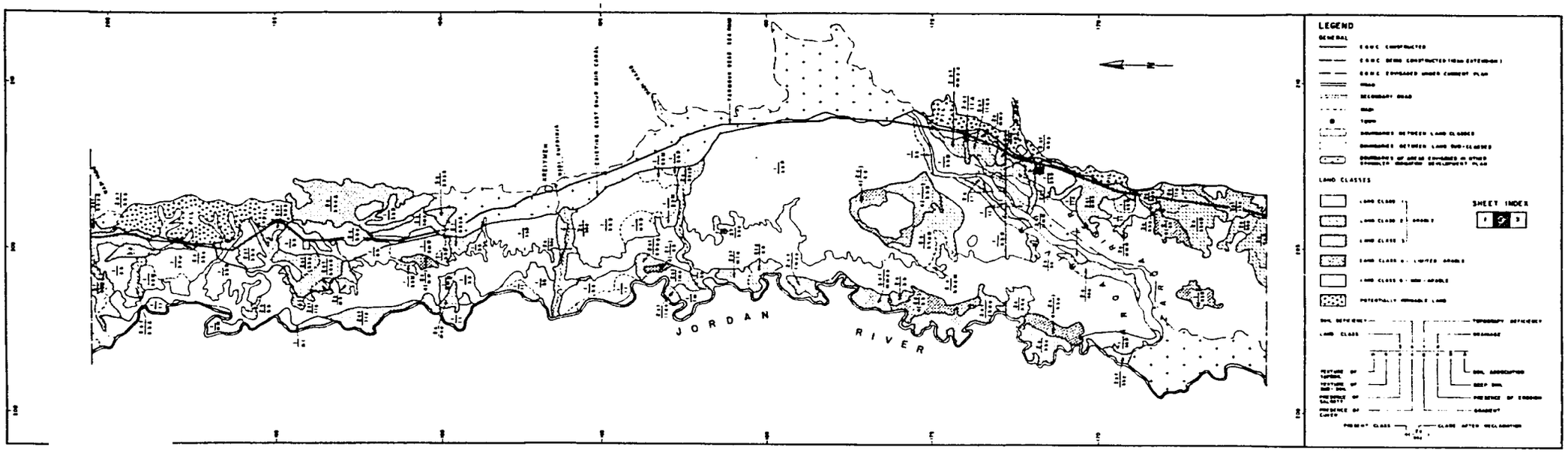

DAR AL-HANDASAH CONSULTANTS (SHAIR & PARTNERS) · JANUARY 1978

LAND CLASSIFICATI
JORDAN VALLEY IRRIGATION PROJ
STAGE

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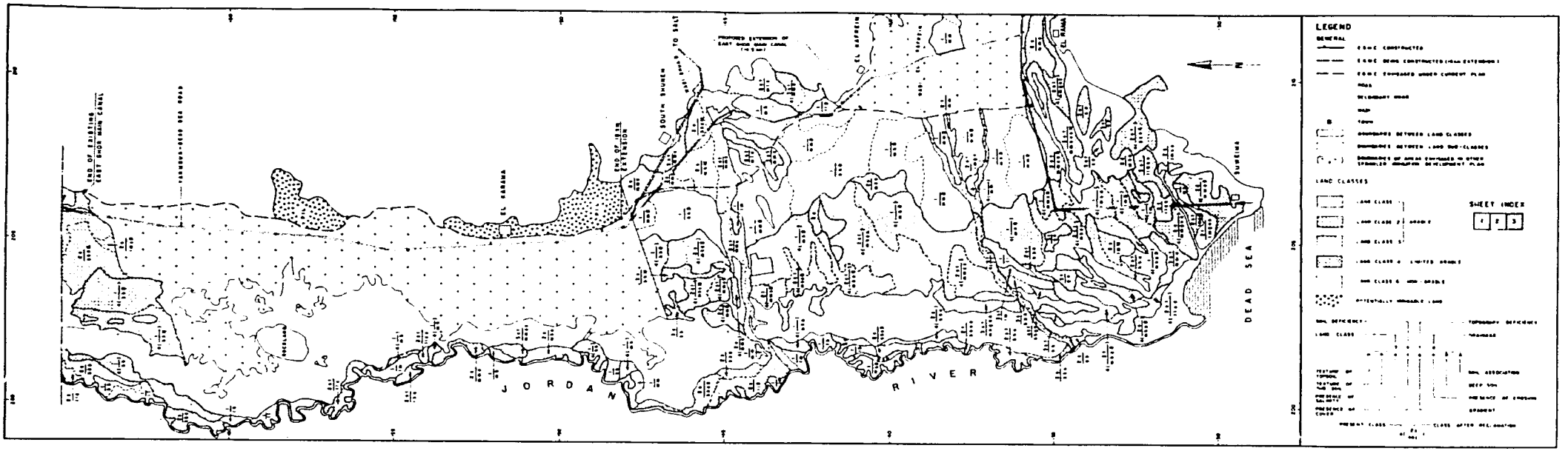
EXHIBIT
SHEET 3 (



DAR AL-HANDASAH CONSULTANTS (SHAIR & PARTNERS) - JANUARY 1978

LAND CLASSIFICATI(
JORDAN VALLEY IRRIGATION PROJ
'STAGE

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EXHIBIT 18

LEGEND

- ▲ Stream Gaging Station
- ● Meteorological Station
- 1. Yarmouk River at Maqarin
- 2. Kufr Saum
- 3. Kharja
- 4. Irbid School
- 5. Irbid Nursery
- 6. Kufr Yuba
- 7. Hawara
- 8. Husn
- 9. En-Nueiylma
- 10. Ramtha
- 11. Khanasira
- 12. Mafraq
- 13. Rihab
- 14. Ibbin
- 15. Amman Air Port
- 16. Wadi Arab near Shuna North
- 17. Wadi Raqqad near Rafid
- 18. Yarmouk River at Adasiya
- 19. Wadi Ziglab
- 20. Wadi Jurum
- 21. Wadi Yabis
- 22. Wadi Kufrinja
- 23. Wadi Rajib
- 24. Zarqa River at Deir Alla
- 25. Zarqa River at New Jerash Bridge
- 26. Wadi Shueib
- 27. Wadi Kafrein
- 28. Wadi Hisban
- 29. El Jubeiha
- 30. Tel Shehab
- 31. Sweida
- 32. Salt
- International Boundaries
- Drainage Area Boundaries
- Rivers and Wadis

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LOCATION OF HYDROLOGIC AND METEOROLOGICAL STATIONS

JORDAN VALLEY IRRIGATION PROJECT

STAGE II

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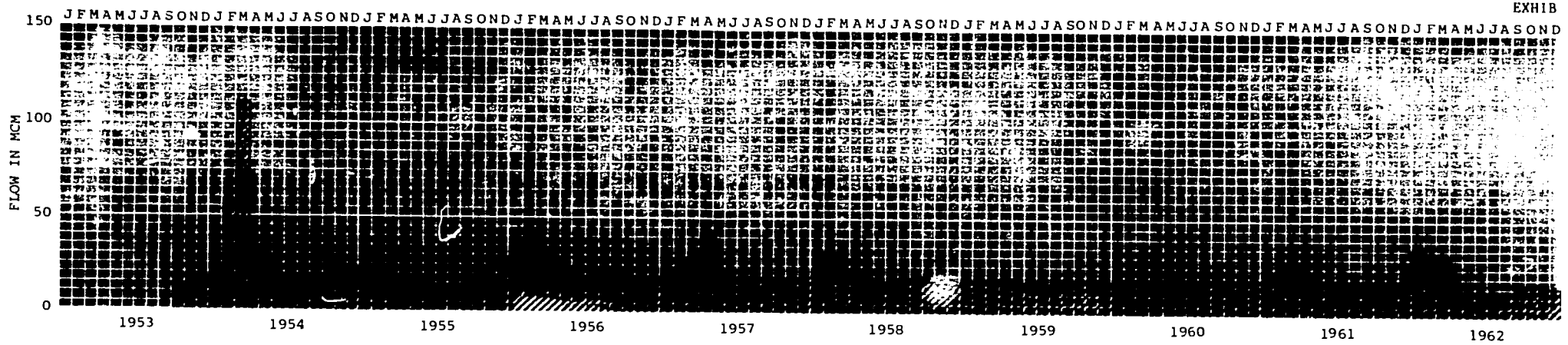
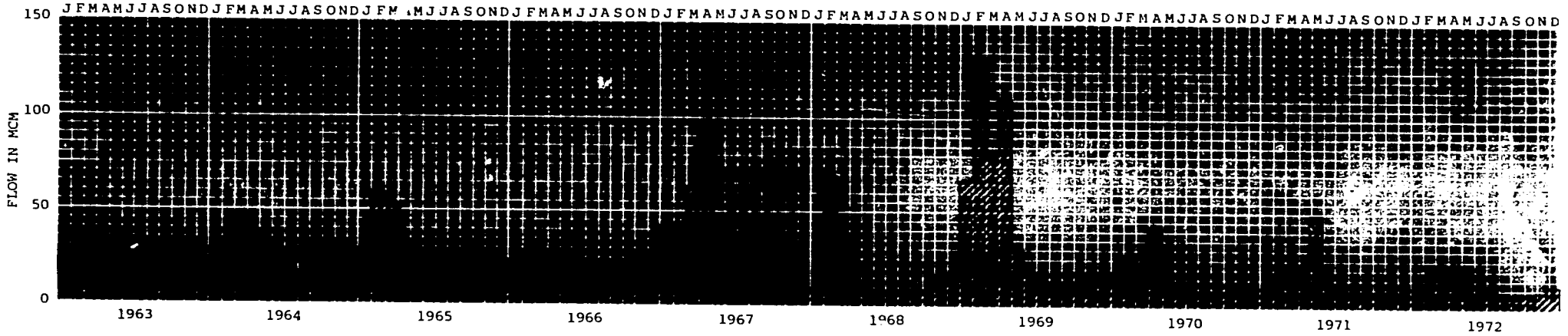
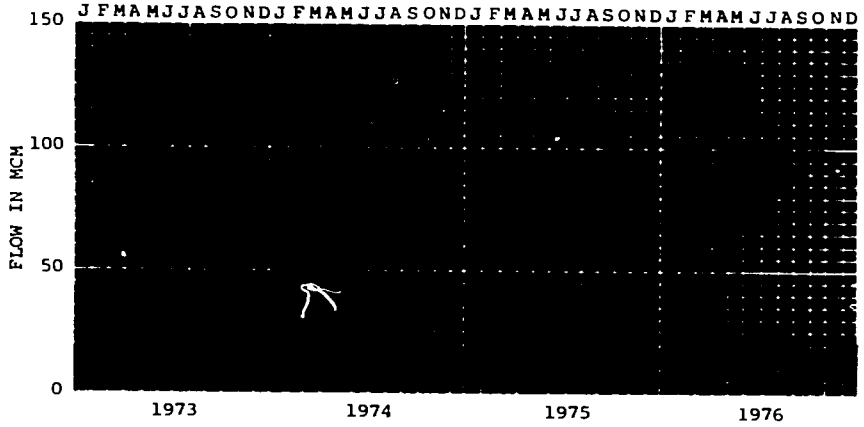
EXHIB







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MONTHLY STREAMFI
YARMOUK RIVER AT MAQA
JORDAN VALLEY IRRIGATION PRO
STAG

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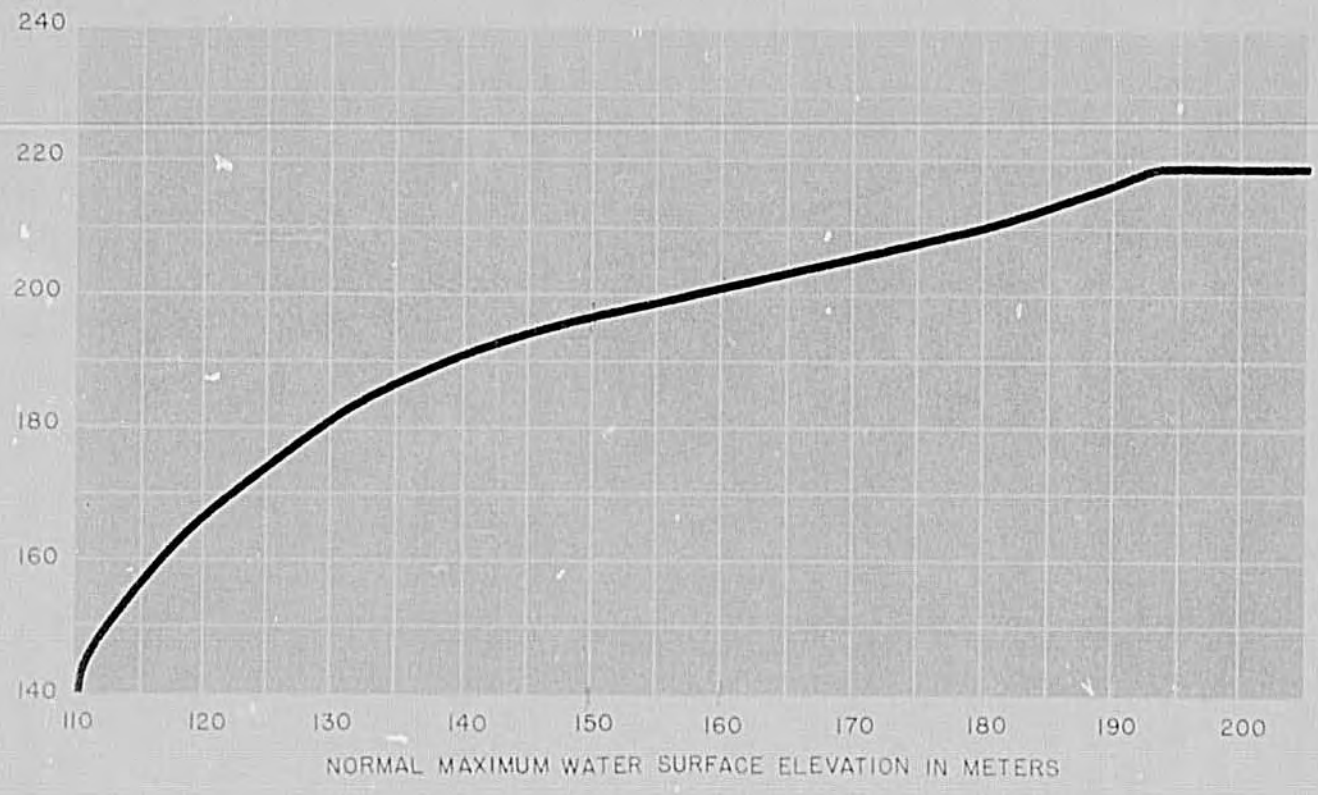
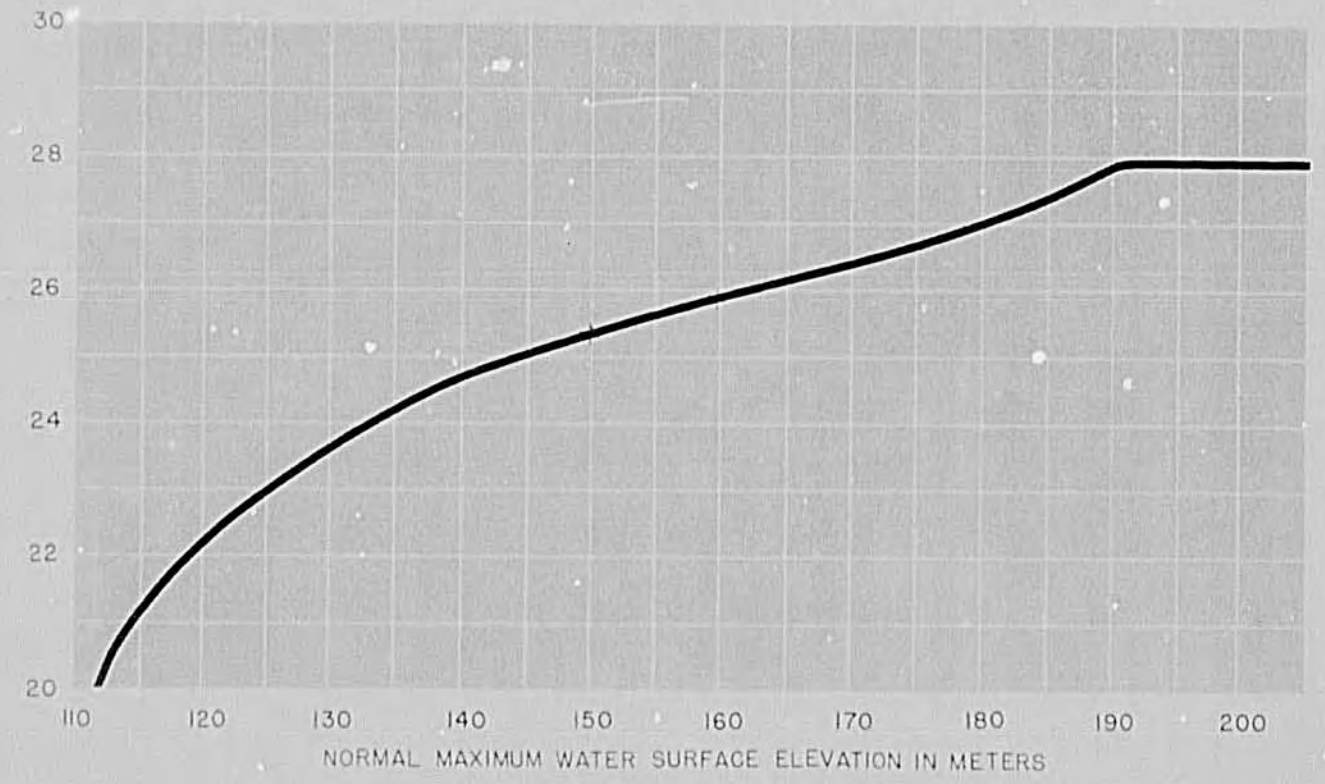


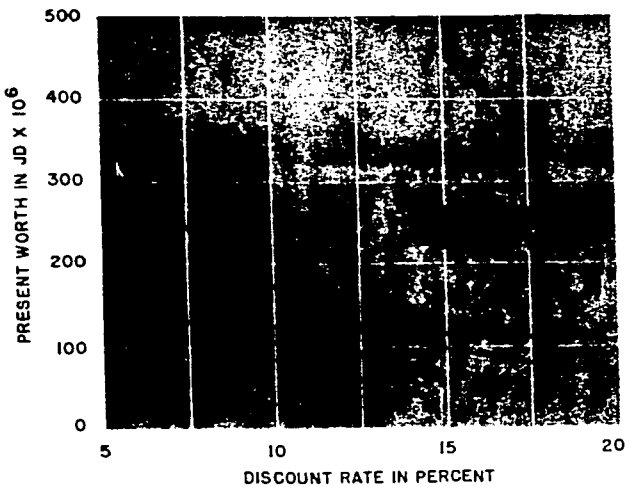
RESERVOIR YIELD VS ELEVATION



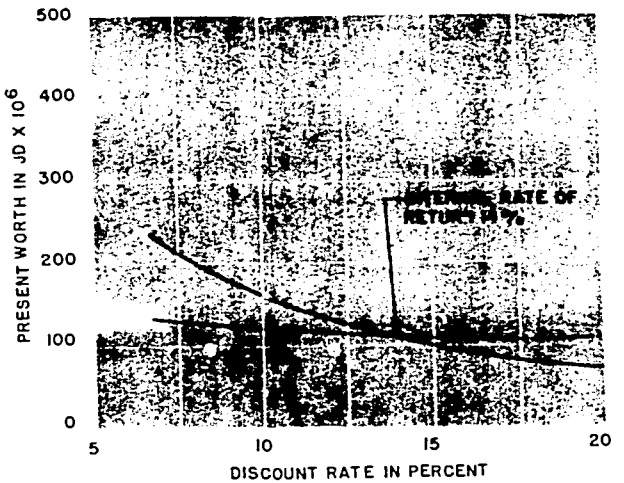
AREA IRRIGATED VS ELEVATION

MAQARIN RESERVOIR YIELD AND IRRIGATED AREA VS ELEVATION

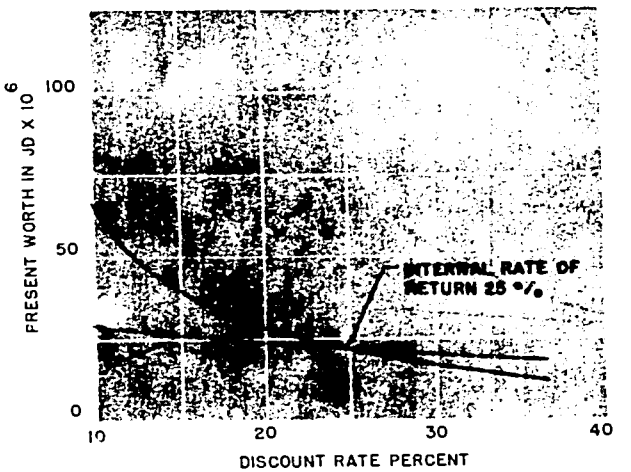
JORDAN VALLEY IRRIGATION PROJECT



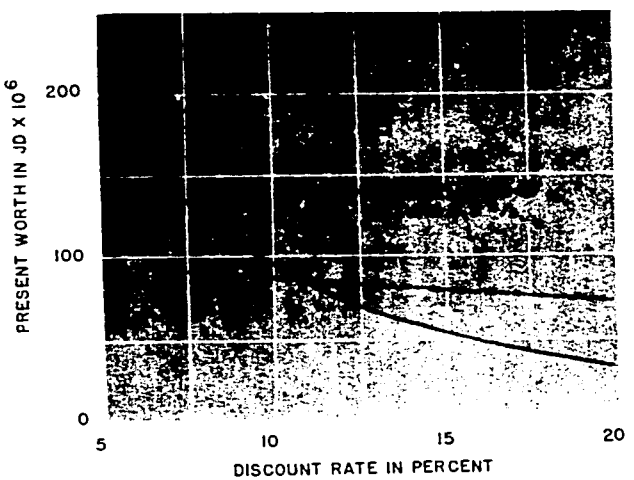
STAGE II DEVELOPMENT



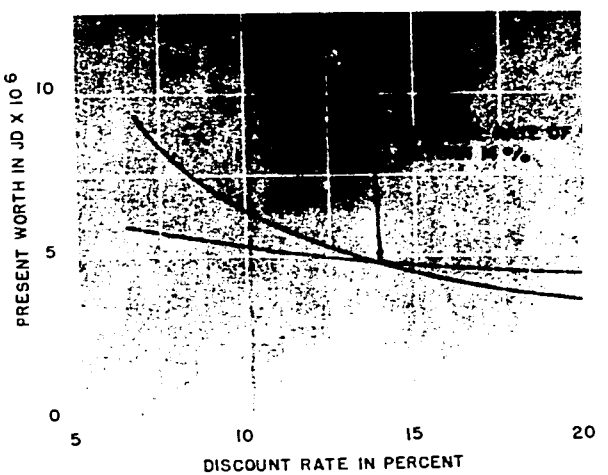
IRRIGATION DEVELOPMENT



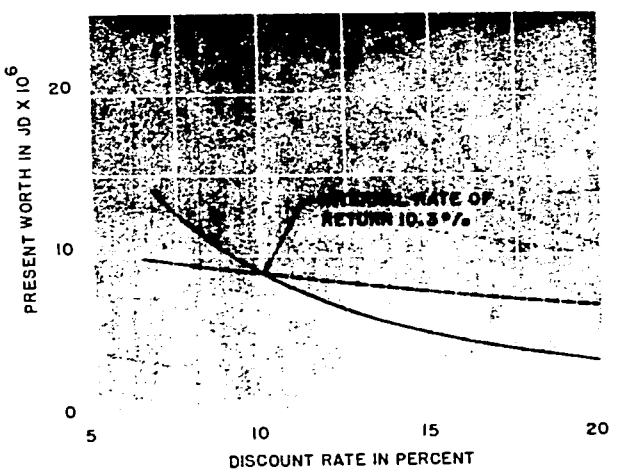
DEVELOPMENT OF CONVERTED AREA



DEVELOPMENT OF NEW-LAND AREA



POWER DEVELOPMENT



MUNICIPAL & INDUSTRAL WATER SUPPLY

LEGEND
——— BENEFITS
– – – – COSTS

INTERNAL RATE OF RETU
JORDAN VALLEY IRRIGATION PRO
STAG

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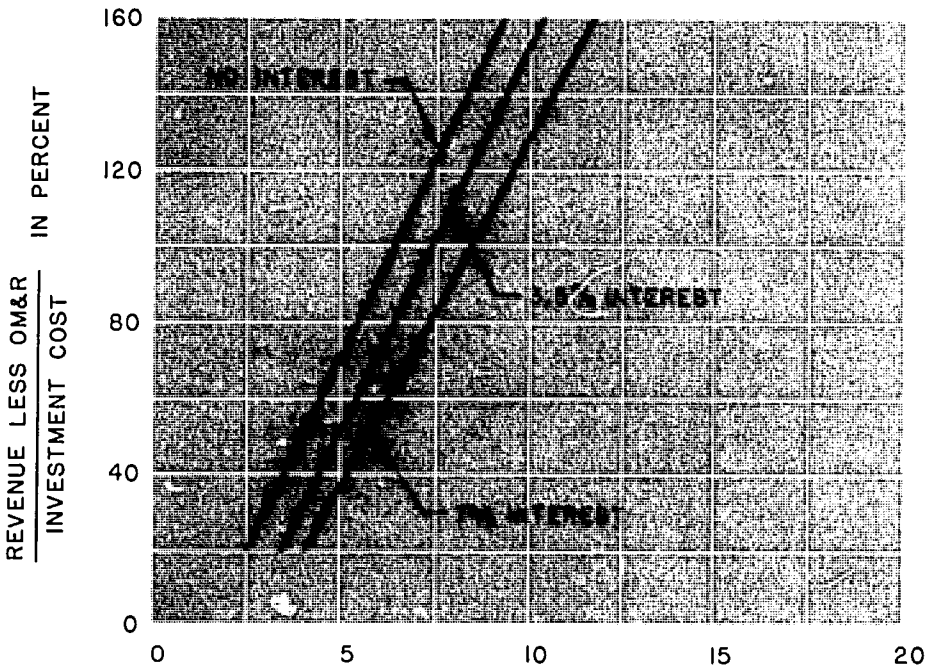
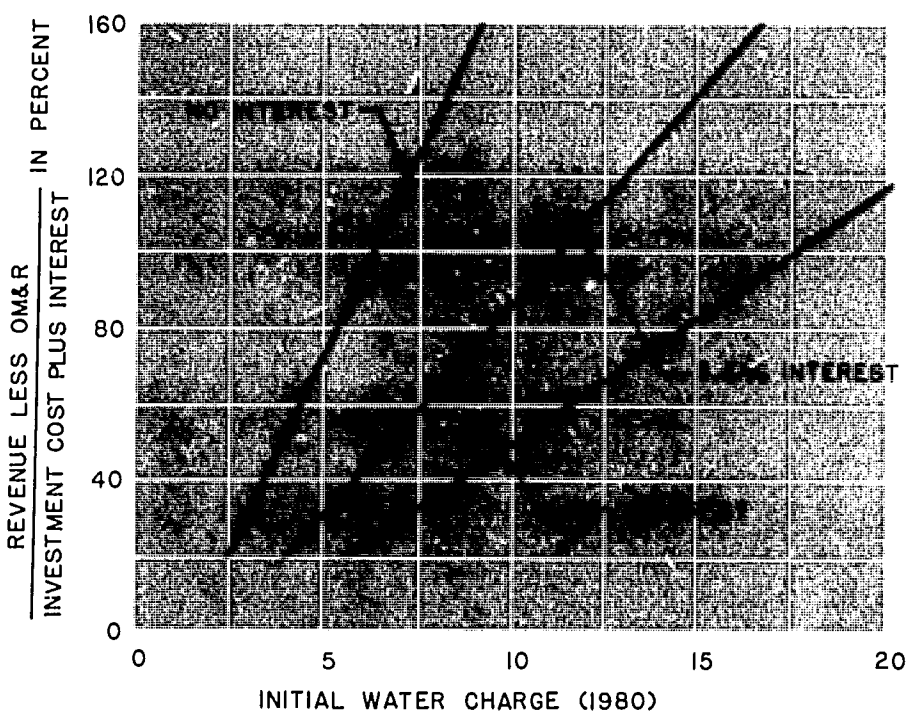
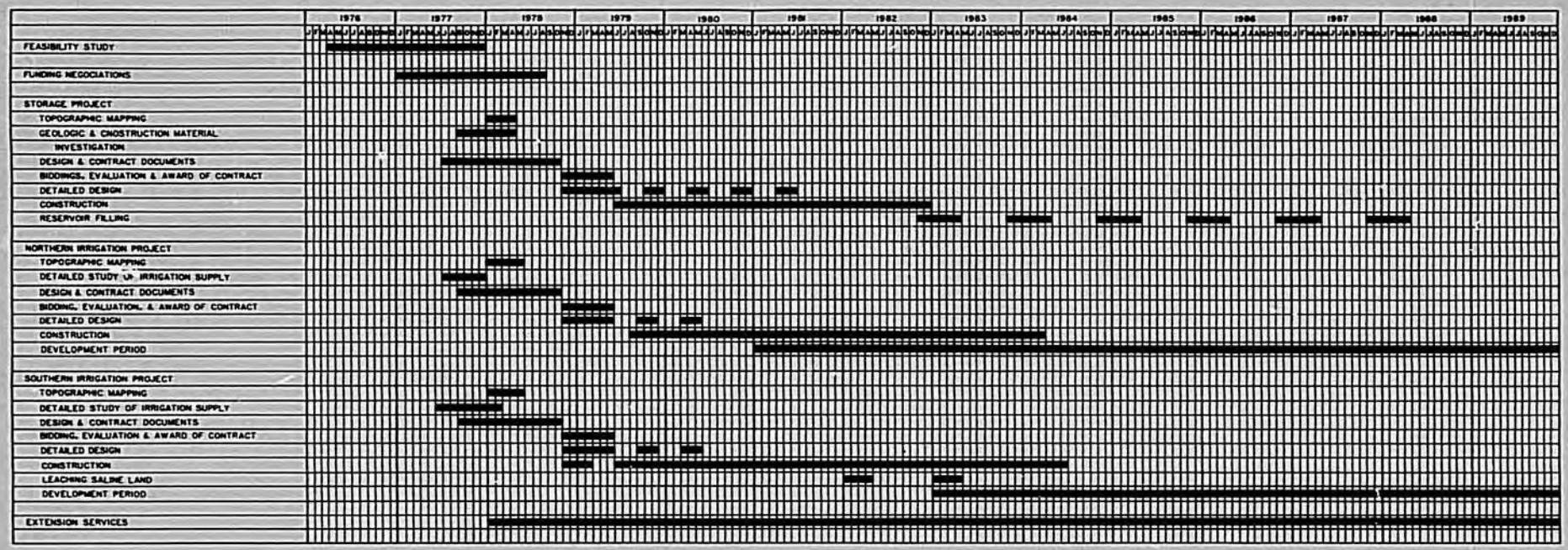




PERCENT REPAYMENT
VS
INITIAL WATER CHARGE

JORDAN VALLEY IRRIGATION PROJECT
STAGE II

EXHIBI



IMPLEMENTATION SCHED

JORDAN VALLEY IRRIGATION PR(

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HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

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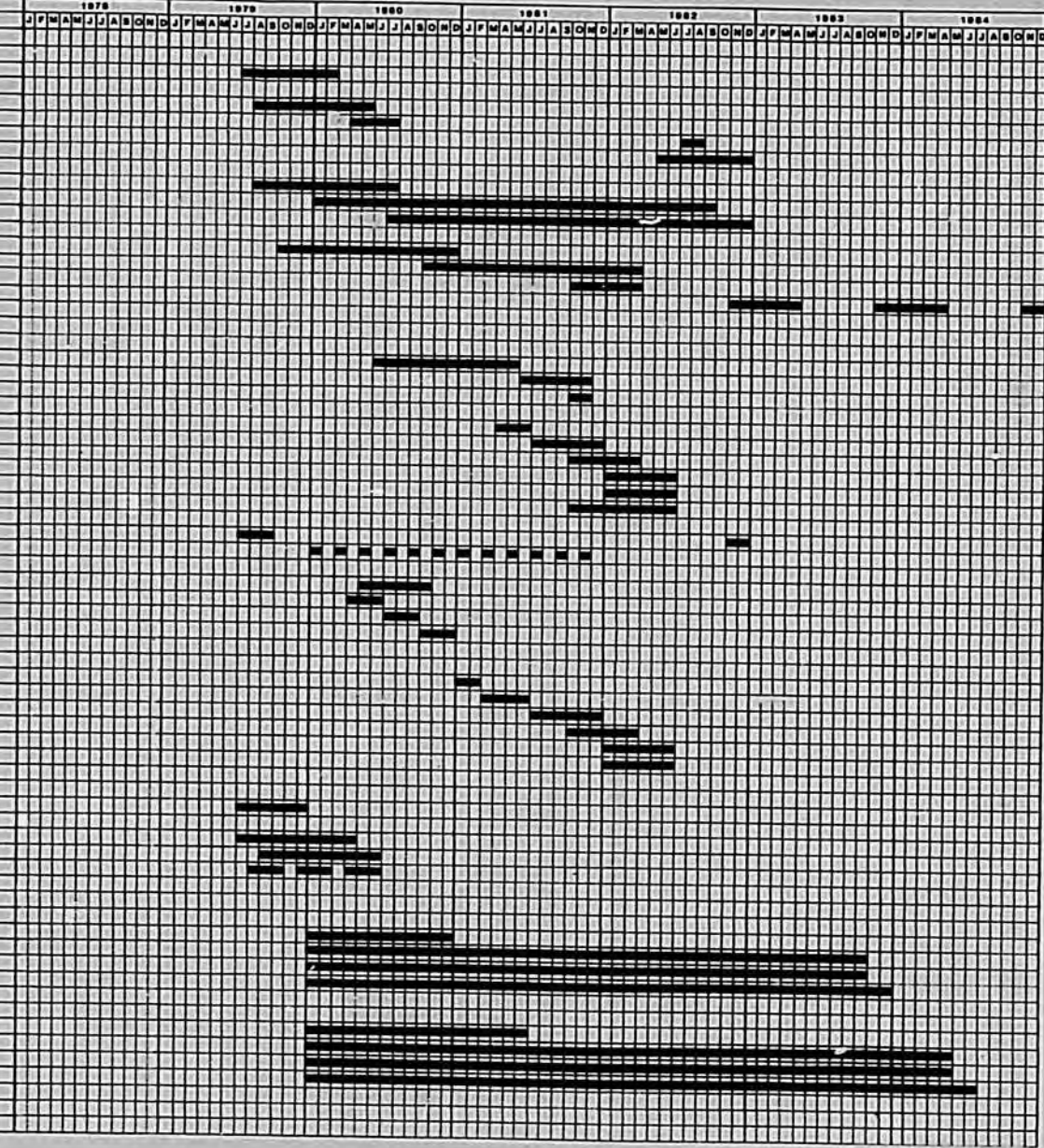
EXHIBI

	QUANTITY
CONSTRUCTION SCHEDULE	
MAQARIN DAM	
MOBILIZATION	
RIVER DIVERSION	
TUNNEL	900 M
COFFERDAMS	305,400 M^3
CLOSURE	
LOW LEVEL OUTLET	
MAIN DAM	
EXCAVATION	3,154,000 M^3
GROUTING AND DRAINAGE	
FILL	14,320,000 M^3
SPILLWAY	
EXCAVATION	6,040,100 M^3
CONCRETE	216,880 M^3
GATES AND HOISTS	3-12M X 18M
RESERVOIR FILLING	
MAQARIN POWER PLANT	
WATER CONDUCTOR	
EXCAVATION	21,700
CONCRETE	8,880 M^3
GATES	
POWERHOUSE	
EXCAVATION	4,040 M^3
CONCRETE	3,700 M^3
MECHANICAL EQUIPMENT	
ELECTRICAL EQUIPMENT	
SUBSTATIONS	
TRANSMISSION LINE	31 KM
OPERATORS VILLAGE	
RELOCATIONS	
DIVERSION DAM NEAR ADASIYE	
DIVERSION DAM-WADI YABIS	
DIVERSION DAM-WADI KUFRINJA	
DIVERSION DAM-WADI RAJIB	
KING TALAL POWERPLANT	
MOBILIZATION	
WATER CONDUCTOR	
POWERHOUSE	
MECHANICAL EQUIPMENT	
ELECTRICAL EQUIPMENT	
TRANSMISSION LINE AND SUBSTATION	10 KM
IRRIGATION SYSTEM	
REPAIR EGMC	
EXTEND EGMC	14.5 KM
EXCAVATION	170,000 M^3
CONCRETE	M^3
SIPHONS	1,400M
CONVERTED LAND	
PUMP STATIONS	9
PIPE NETWORK	870,800 M
FARM SYSTEM	
DRAINAGE SYSTEM	
NEW LANDS	
PUMP STATIONS	16
PIPE NETWORK	416,000 M
FARM SYSTEM	
DRAINAGE SYSTEM	



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CONSTRUCTION SCHEDU
JORDAN VALLEY IRRIGATION PROJ
STAGE

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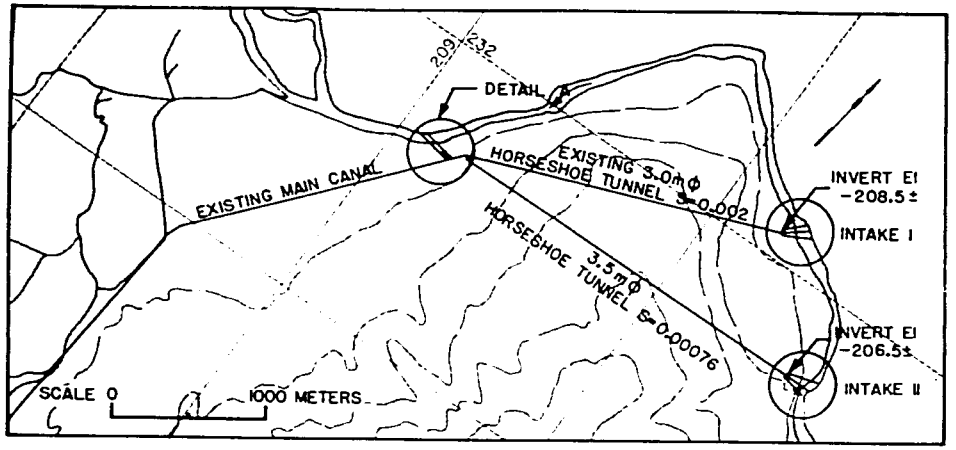
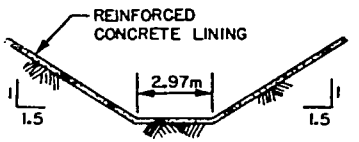
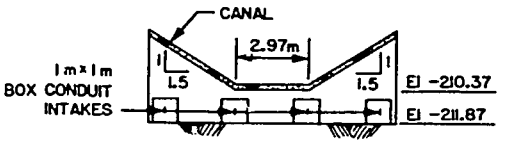
EXH1
SHEET



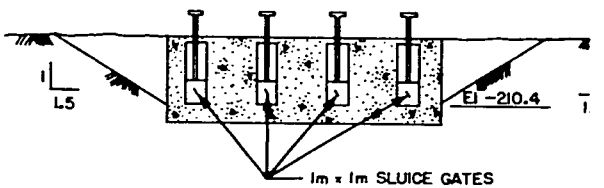
GENERAL PLAN



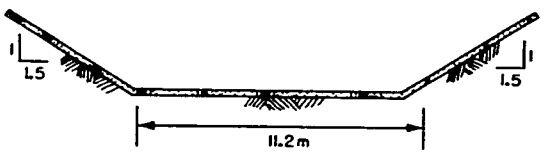
TYPICAL SECTION
EXISTING CANAL



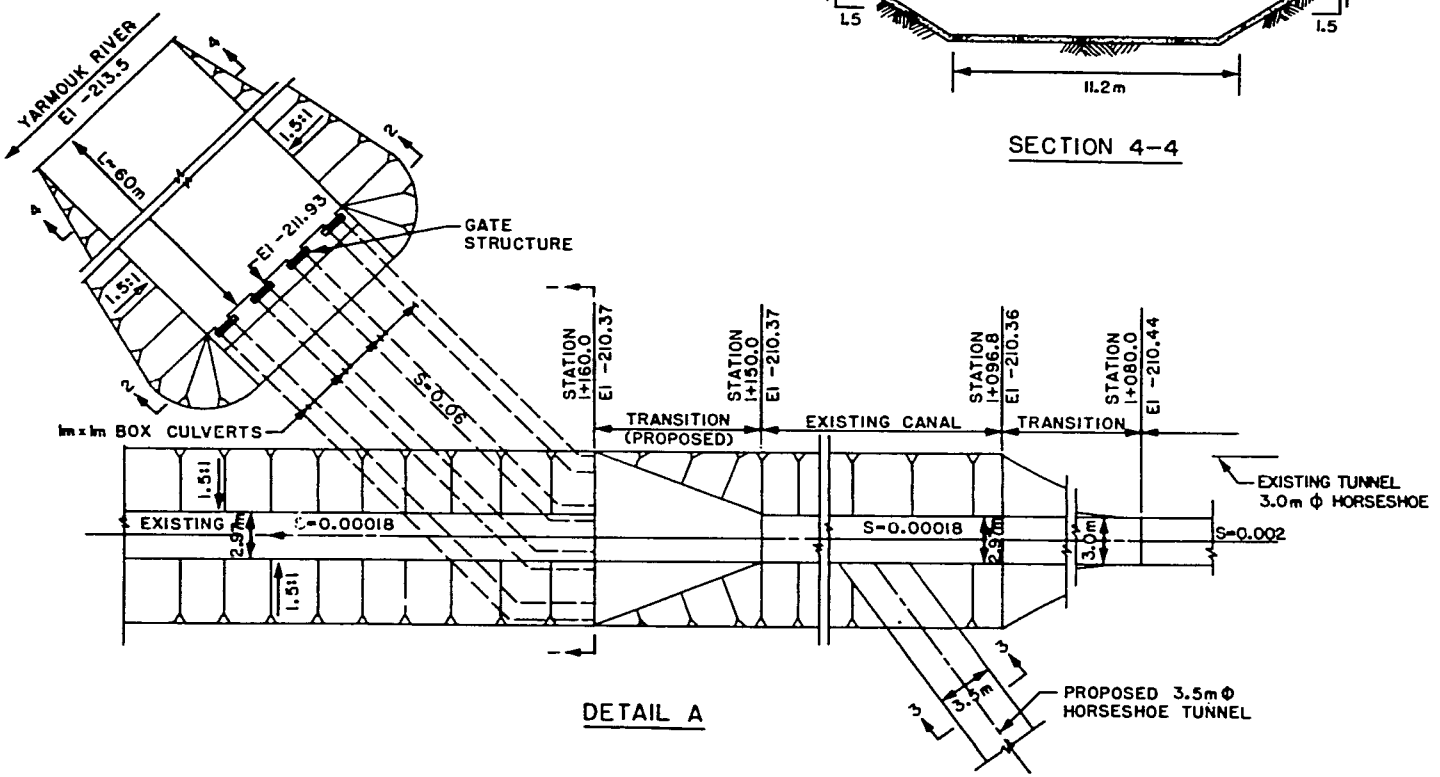
SECTION 1-1



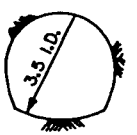
SECTION 2-2
GATE STRUCTURE



SECTION 4-4



DETAIL A



SECTION 3-3
PROPOSED TUNNEL

TYPICAL SECTIO
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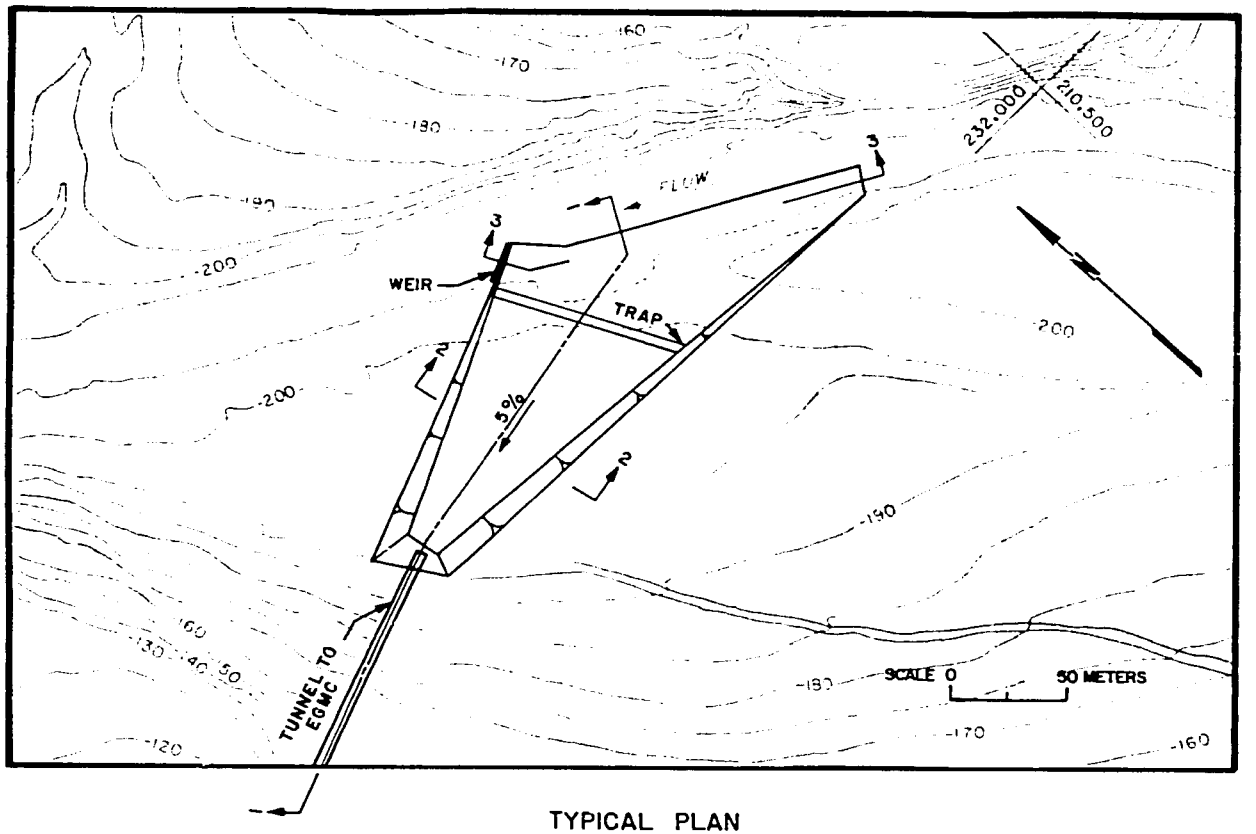
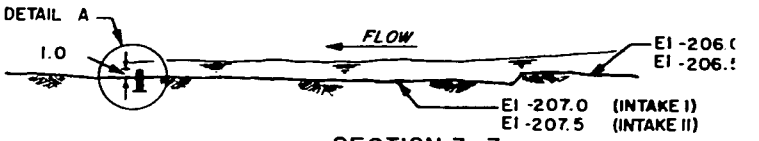


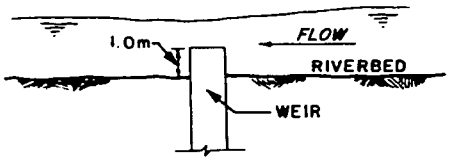
TYPICAL PLAN

SECTION 2-2

(NOT TO SCALE)

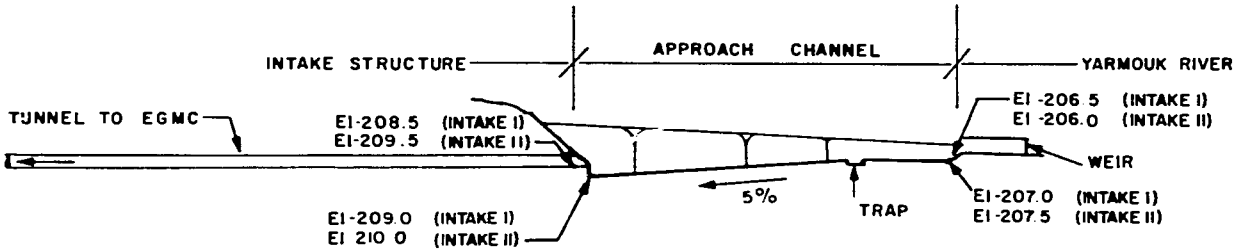


SECTION 3-3



DETAIL A

(NOT TO SCALE)



SECTION I-I

NOTE: LOCATION OF INTAKE STRUCTURE SHOWN ON SHEE

UNCC
DIVERSION S
PLAN AND
JORDAN VALLEY IRRIGA

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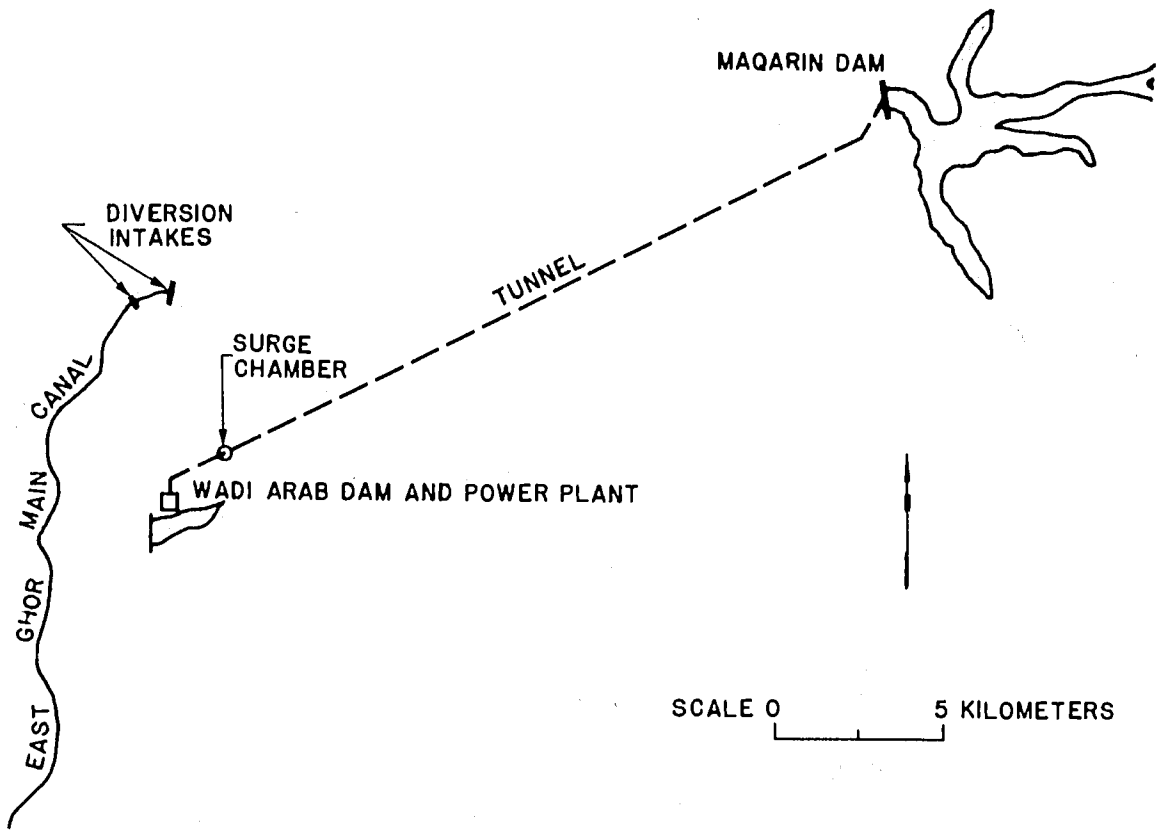
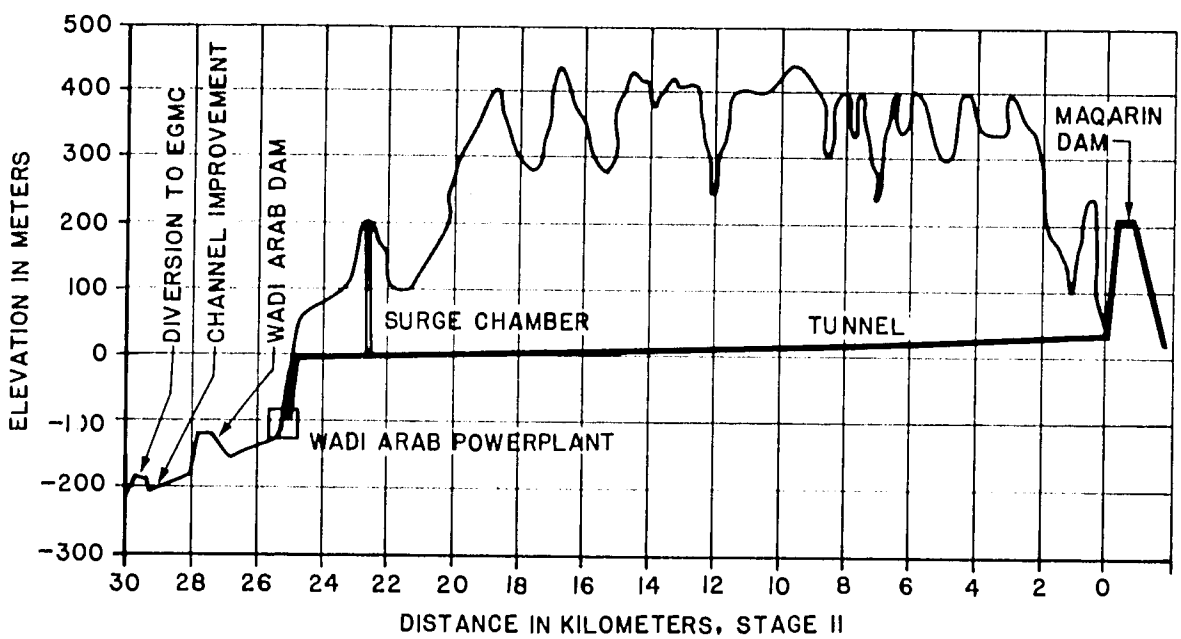


PLAN



PROFILE

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ALTERNATIVE DEVELOPMENT

JORDAN VALLEY IRRIGATION PROJECT

STAGE II

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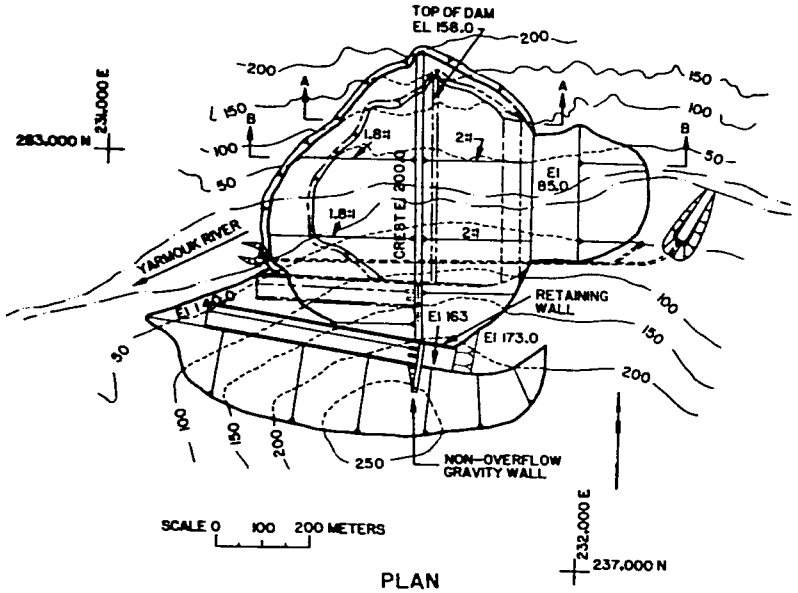
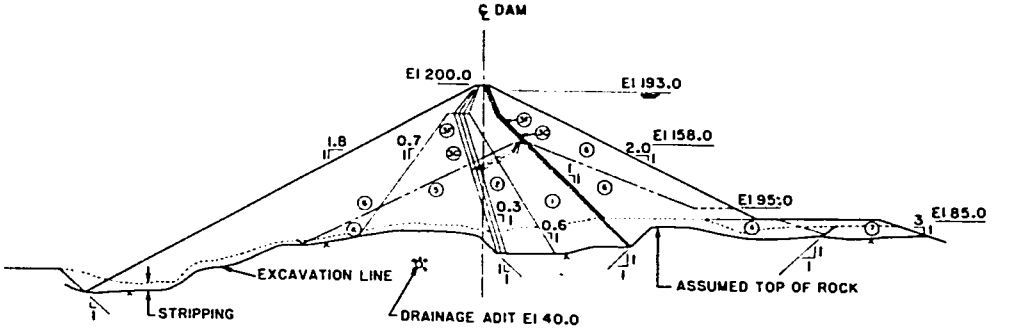
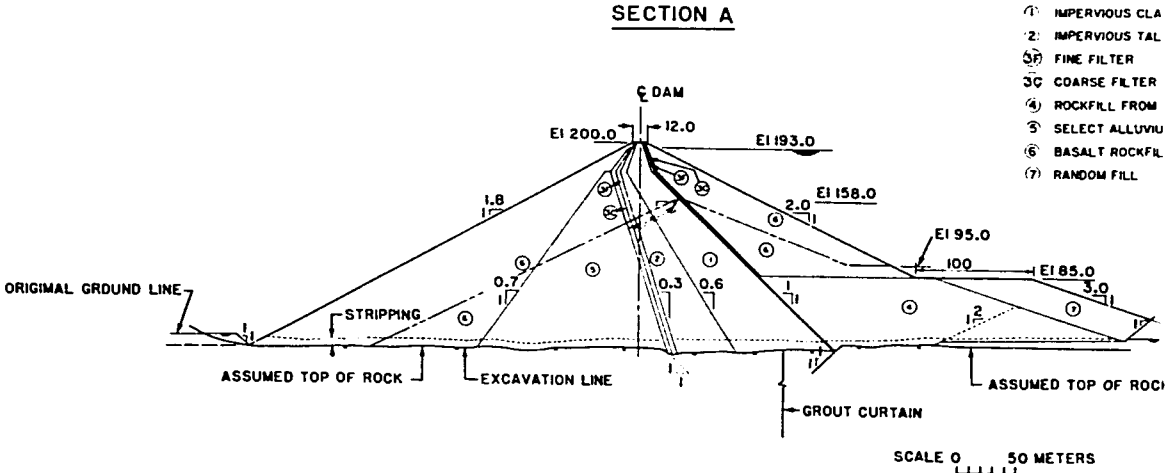


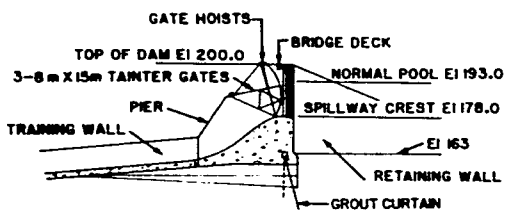
PLAN



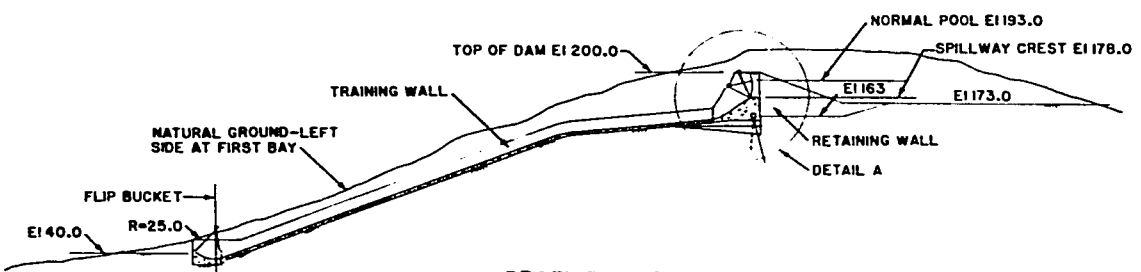
SECTION A



SECTION B



DETAIL A



PROFILE OF SPILLWAY

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JORDAN VALLEY IRRIGA

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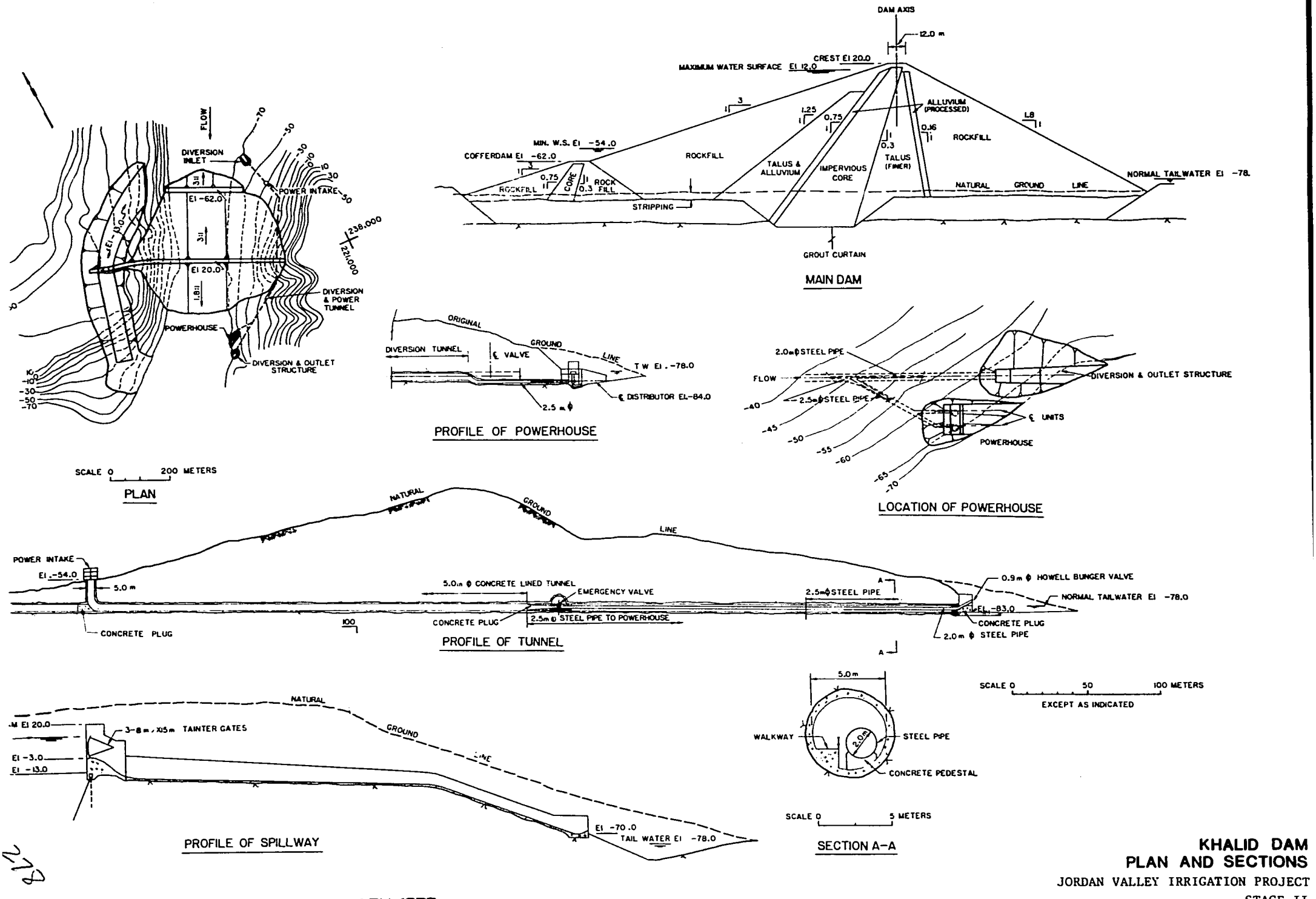
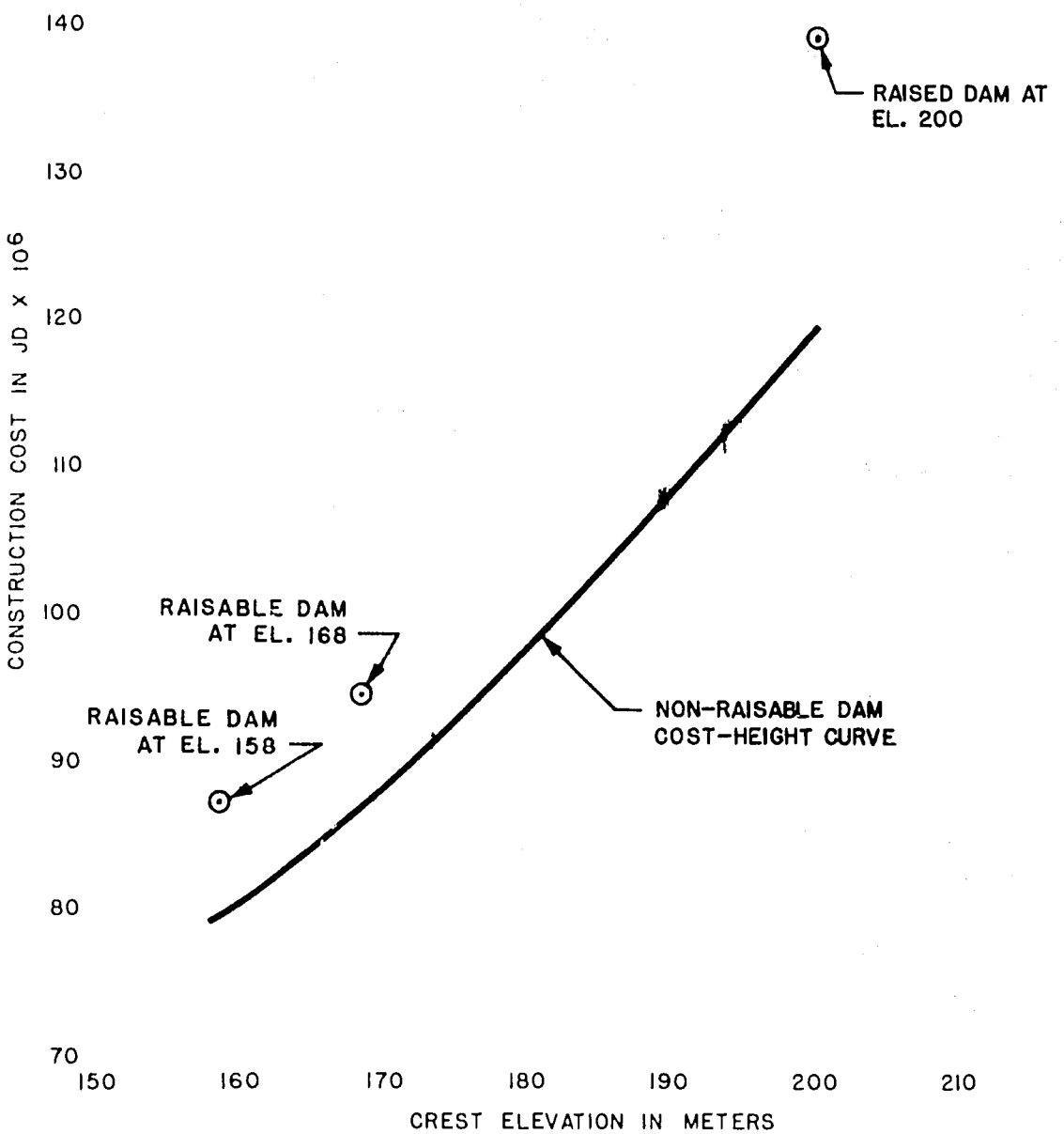
EXHIBIT 28



KHALID DAM
PLAN AND SECTIONS
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

SEAS ENGINEERING COMPANY JANUARY 1978



NOTE:

CONSTRUCTION COST BASED ON JANUARY 1977 PRICE LEVELS

COSTS EXCLUDE IRRIGATION FACILITIES

SINGLE STAGE MAQARIN PROJECT CONSTRUCTION COSTS

JORDAN VALLEY IRRIGATION PROJECT

STAGE II

HARZA OVERSEAS ENGINEERING COMPANY JANUARY 1978