PN-AAM-292

ENVIRONMENTAL ASSESSMENT

JORDAN VALLEY IRRIGATION PROJECT STAGE II

VOLUME I

United States International
Development Cooperation Agency

Agency for International Development

November 1980

FINAL REPORT

ENVIRONMENTAL ASSESSMENT FOR THE PROPOSED JORDAN VALLEY IRRIGATION PROJECT, STAGE II

VOLUME I

Prepared by

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in conjunction with

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and

The Institute for Conservation Archaeology
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for

United States International Development Cooperation Agency
Agency for International Development

Contract No. AID/NE-C-1591

C-82912

November 1980

PREFACE

This report was prepared for the United States International Development Cooperation Agency, Agency for International Development (AID), by Arthur D. Little, Inc., under Contract No. AID/NE-C-1591, dated 31 January 1979. Subcontractor assistance was furnished by Harvard University, Institute for Conservation Archaeology and Geotechnical Engineers Inc. Technical monitoring was provided by Mr. Robert Fedel and Mr. James Watson, AID Regional Operations Division-Near East, Washington, D.C. Contractor personnel visited Jordan during March and April 1979 and worked under the guidance of AID staff at the U.S. Embassy, Amman and with the full cooperation and substantial assistance of the Jordan Valley Authority.

The contractor wishes to acknowledge the cooperation and assistance given to team members by many agencies and individuals, both governmental and private, in the United States and Jordan. Special thanks go to the Jordan Valley Authority (JVA) and Harza Overseas Engineering Company for their assistance to staff members conducting site inspections.

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Jordanian government officials and technical experts contributed significantly to this study. Although JVA officials had not seen the study's scope of work before the Arthur D. Little, Inc., advanceman arrived in Amman in February 1979, they were consulted thereafter concerning almost every aspect of our field investigations. Headquarters of the Arthur D. Little, Inc., team were in JVA's Planning and Program Unit; its Director, Dr. Ahmed Abu-Sheikha, advised daily on persons to interview in JVA, in government agencies, and in the University. He and his assistants accompanied team members on a number of interviews and field trips. JVA's Vice President for Administration, Dr. Mohammed Adwan, was consulted almost daily on approaches to topics within the study, especially in his own fields of competence, the social sciences. JVA arranged almost all interviews with senior officials of other agencies and the University, providing also a written description of the purpose and scope of the Environmental Assessment which was a new kind of study for Jordanians. Officials and scholars alike received Arthur D. Little, Inc., team members graciously and were uniformly generous with their time, information, and judgments. Midway through the field work, the whole Arthur D. Little, Inc., team met with JVA's President, Senior Vice President, and other senior officials for a lengthy review and discussion of work-in-progress; JVA's top managers answered important questions not covered in documents or by other interviewees. Again at the end of the field work, the team met JVA's leaders to report tentative findings and seek interpretations of critical points.

The Draft Final Report was reviewed and commented on in detail by officials from JVA, AID Washington and Amman, and the World Bank. Modifications were also made to reflect changes in the project scope and water allocations that occurred after the submission of the Draft Final Report.

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1.0 INTRODUCTION

1.1 PURPOSE

This Environmental Assessment (EA) has been prepared to provide the information required by AID Regulation 16 (22 CFR 216). Executive Order No. 12114 (44 Federal Register 1957, January 9, 1979) was issued after negotiation of this EA's scope of work. This EA assesses Stage II of the Jordan Valley Irrigation Project (often abbreviated to "Stage II" in this report), involving works on the Yarmouk River and the East Bank of the Jordan River Valley in the Hashemite Kingdom of Jordan.

This EA is intended not just for U.S. officials and their legal needs. AID's policy requires that an EA "be prepared with the direct participation of recipient country institutions wherever practicable and that it be subject to recipient country review."[1] Moreover, in this case, AID desires to share these EA findings with other donor agencies, including the World Bank, which share in funding parts of the Jordan Valley Irrigation Project and which also have environmental concerns and possibly review requirements. Therefore, this report, although designed according to U.S. requirements and practice, was written also for the eyes and needs of officials in other donor agencies and in Jordan.

Not all reviewers of this report are expected to have personal, recent, or detailed knowledge of Jordan or its development projects. So, this report is designed to be self-contained, to include all data a reader needs to make judgments about environmental impacts.

The proposed Stage II project, part of the Jordan Valley Irrigation Project, will feature the Maqarin Dam and reservoir on the Yarmouk River on the border between Jordan and Syria, a downstream diversion facility to divert Yarmouk River water into the East Ghor Main Canal (EGMC) running south along the East Bank, an extension to the canal, several

[1] Regulation 16, Section I-C-4.

other small facilities to utilize water from side valleys or wadis, the construction of hydroelectric power facilities at Maqarin Dam and King Talal Dam, the extension of irrigation to presently non-irrigated land, the conversion to sprinkler or drip irrigation of lands presently irrigated by gravity ditches and the use of sprinkler or drip irrigation on new lands, and the supply of water for municipal and industrial (M&I) use to upland cities including Amman and Irbid.

In addition to these direct activities, Stage II includes related activities collectively labelled "Village Development Program." The activities include the allocation and farming of land, construction of housing and municipal buildings for East Jordan Valley (hereafter called Valley)[1] inhabitants, and related structural and institutional features required to effectively develop Valley water resources.

1.2 SCOPE OF ASSESSMENT

Environmental Assessments are intended to provide information needed by policy makers, project planners, and designers. The logical time to prepare the EA is after preliminary studies needed to define the proposed action, but before selecting the final design. This timing offers the best way to incorporate into the design any recommendations that might emerge from the environmental analyses. However, this also means that the project design may still be flexible as refinements and changes are added. Thus, the environmental analyses must be sufficiently broad to accommodate any design modifications. Such has been the case for this study.

The facilities and operations as originally planned are described in a report for the Jordan Valley Authority (JVA)[1] prepared by Harza Overseas Engineering Company (Harza) in association with Dar Al-Handasah Consultants (Shair & Partners) entitled Jordan Valley Irrigation Project, Stage II, Feasibility Study, January 1978. This report, in six volumes,

[1]Definitions, abbreviations, and units used in this report can be found in Appendix A.

describes a project for irrigating 36,000 hectares (ha)[1] of land (including some lands presently under irrigation). The project would supply 30 million cubic meters per year (MCM/yr) of water for M&I use: 12 MCM/yr from Maqarin Reservoir for the city of Irbid, 8 MCM/yr for the Valley, and 10 MCM/yr, in effect, from King Talal Reservoir for Amman.

Since Harza's January 1978 study, other studies by Jordan's government agencies led to upward revisions in the estimates of population growth for Amman, Irbid, and Zarqa, and of their demands for M&I water. As a result, Jordan asked Harza to modify its project design. The modified project is described in "Civil Design Memorandum C-1," prepared by Harza and dated August 14, 1979. The plan, which will be referred to in this report as the "C-1" design, provides for the construction of Maqarin Dam to elevation 178 meters above sea level, an allocation of 126 MCM/yr of water for M&I use in the areas of Amman and Irbid, and the irrigation of 21,750 ha of land. This area, together with 10,647 ha that are irrigated under Stage I projects, would provide a total of 32,397 ha of irrigated land.

The proposed "C-1" project was subsequently reviewed by an appraisal team for the donor group, headed by the World Bank. Their report on findings and recommendations has not been released, but some data used in their analyses are available. In general, their studies recognize an increasing need for water for M&I use in the Amman-Zarqa-Irbid area that would range from 74 MCM/yr in the year 1990 to 244 MCM/yr in the year 2010. Their studies also examined an option of withdrawing some of the M&I water from the King Talal Reservoir, and their assumptions about Yarmouk River inflows to the Maqarin Reservoir are somewhat less than those under the "C-1" project. The appraisal studies also indicate the optimum economic height of Maqarin Dam to be to elevation 158 meters, rather than the 178 meters in the "C-1" plan.

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[1] Definitions, abbreviations, and units used in this report can be found in Appendix A.

The Stage II project has thus been described in three studies: (1) the original Feasibility Study of January 1978; (2) the modified "C-1" project of August 1979; and (3) an appraisal team study that has not been finalized but which has provided new data and concepts.

The "review final" EA report, which was completed in July 1979, was written on the basis of the project described in the Feasibility Report, but with awareness that a modified project design was nearing completion. After the memorandum of the "C-1" project was issued, AID directed that the EA report be modified to reflect the changes in project operation shown in the "C-1" plan, and to incorporate other information available from the World Bank. It was not intended that the review final report be entirely rewritten, but rather that changes be made to reflect the new plans.

In preparing this final report, we have modified sections dealing with the proposed project operations to reflect the proposal shown in the "C-1" plan. However, other parts of the report, such as those dealing with irrigation methods and village development, were generally not modified because of the lack of a final project definition. Where appropriate, notes have been added to indicate the project design to which data apply. Because it is not known exactly which lands would be involved in the final project, the entire development area described in the January 1978 report (i.e., 36,000 ha) has been reviewed in the environmental analysis.

AID originally directed that this EA concentrate on impacts to the Yarmouk River valley and the East Jordan River valley. Because Harza's original plan allocated a relatively small amount of M&I water for the upland cities, the Arthur D. Little, Inc., team planned no detailed investigation of the potential impacts to the upland plateau by pipes and pumping stations to divert project water to Amman, Irbid, and Zarqa. Harza's modified design was completed only after Arthur D. Little, Inc., completed its field work in Jordan; thus, the upland impacts described in this EA are only of a general nature.

Data for this report were assembled from published books and articles; many unpublished documents provided by AID, Jordanian government agencies and private institutions, and United Nations agencies; interviews with many persons in the United States and Jordan; and observations during field trips in Jordan by 13 project team members in March and April 1979. Although the time allowed for original field work was not generous, the team exerted its best efforts to corroborate, update, and synthesize the reports of many earlier analysts and consultants.

Despite the uncertainties in the final project design and operation, it is believed that this EA provides a comprehensive analysis of the range of designs from which the final selection is likely.

1.3 ORGANIZATION OF REPORT

This EA discusses all of the subjects required by AID's Regulation 16, (22 CFR 216.5). However, because of the size and complexity of the Stage II projects, the normal EA format has been modified somewhat in order to present the material more effectively. The remaining chapters contain the following information:

Chapter 2, Executive Summary

Addresses and is oriented towards the decision-maker, and is not intended as a detailed summary of the report.

Chapter 3, The General Environment of Jordan

Generally describes the country for the reader not already familiar with Jordan. Site-specific descriptions are presented in Chapter 6. For example, the general geology of Jordan is presented in Chapter 3, while the site-specific geology at the Maqarin site is given in Chapter 6.

Chapter 4, Description of Proposed Actions

Emphasizes constructed facilities directly related to the water supply system, for example, the Maqarin Dam, the diversion dam, the EGMC extension, the hydroelectric plants, and the irrigation pumping and pipeline

facilities. The indirect activities, those associated with the Village Development Program, are only summarized in Chapter 4, since they are detailed in Chapter 6.

Chapter 5, Relationship of Proposed Action to Land Resources, Policies and Controls

Describes how the Stage II projects would fit into Jordan's overall development plans both for the Valley and for the whole country.

Chapter 6, Description of the Environment Affected and Probable Environmental Impacts

Presents the major part of the EA. It combines a description of the site-specific baseline environment, the indirect activities associated with the Village Development Program, and the probable impacts to the environment as a result of both the direct and indirect actions. This format was adopted in order to assemble in one location in the text all the key information that a reader would need to understand each subset impact analysis. This approach seemed particularly appropriate for the Village Development actions.

Chapter 7, Reasonable Alternatives to the Proposed Action

Discusses the "no-project" alternative as well as alternative designs and operations of both direct and indirect actions.

Chapter 8, Adverse Impacts Which Cannot be Avoided and Mitigating Measures

Identifies and gives the reasons for those impacts, described in Chapter 6, that are adverse and unavoidable. It also discusses mitigating actions that could or will be implemented to reduce or eliminate the adverse impacts.

Chapter 9, Relationship Between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity

Examines whether the action will benefit today's generation at the expense of future generations.

Chapter 10, Irreversible and Irretrievable Commitments of Natural or Cultural Resources

Identifies any uses or destructions of resources that are terminal, for example, destruction of archaeological sites.

Chapter 11, Other Policy Interests and Considerations Offsetting Adverse Environmental Impacts

Discusses the extent to which these stated countervailing benefits could be realized by following reasonable alternatives to the proposed action that would avoid some or all of the adverse environmental effects. Cost-benefit analyses are also discussed.

Several appendices include additional technical details on some topics, a glossary, and a bibliography.

2.0 EXECUTIVE SUMMARY

2.1 INTRODUCTION

This chapter provides an overview of the Stage II project and a summary of its significant environmental impacts for the reader whose review time is limited and who is not necessarily familiar with the project and its role in the larger development of Jordan, but who wants a general sense of its beneficial and adverse impacts and the alternatives that could affect the decision-making process.

2.2 PROJECT BACKGROUND

Stage II is but one part of the Jordan Valley Development Plan, which in turn is part of the Five Year Plan for Economic and Social Development (1976-1980), prepared by the National Planning Council.

To understand how these and their prodecessor plans interrelate, one must understand the general geography of Jordan and its limited supply of water resources. The Kingdom is shown in Figure 2-1. The part that lies east of the Jordan River is referred to as the East Bank, as contrasted with the Israeli-occupied West Bank. The portion of the East Bank that receives most of the Kingdom's rainfall and contains most of the population is the northwest corner, located just east of the Jordan River and extending about 100 km from the Dead Sea northward to Syria. The land immediately adjacent to and east of the Jordan River (the "Valley") forms a strip about 2 to 7 km wide, all at elevations below sea level. Beyond this to the east, the land rises abruptly by 1000 m to a broad upland plateau, on which are located the capital of Amman and other major cities.

The East Bank contains about 9,260,000 ha, which can be divided into four climatic regions: [2-1][1]

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[1]Numbers in brackets, e.g. [2-1], refer to references listed in Appendix B.

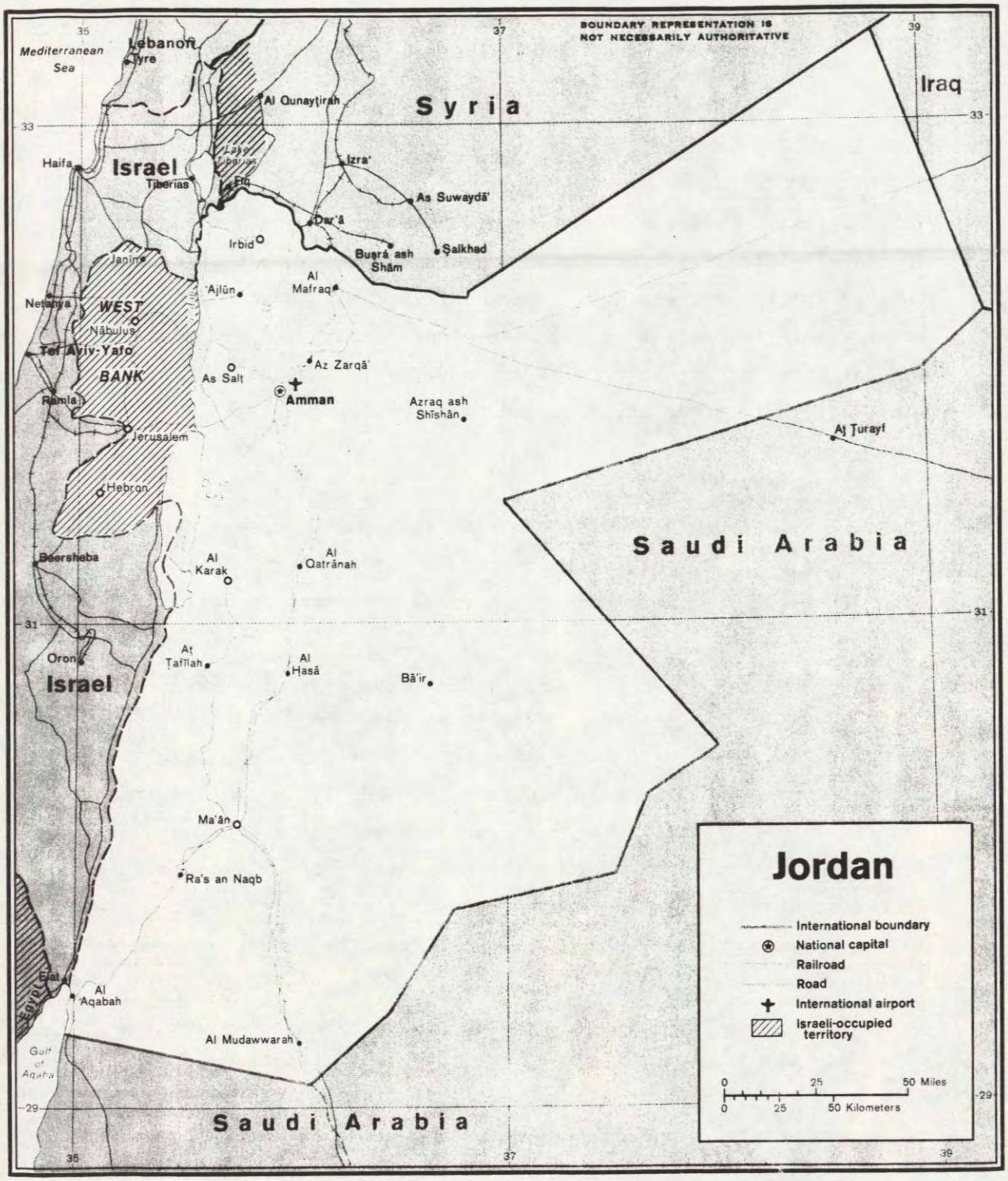


Figure 2-1 Map of Jordan

Source: U.S. Department of State, 1977.

	Region	Annual Rainfall mm	Area ha[1] x 10^5	Area %
1.	Dry (Desert)	Less than 200	84.6	91.4
2.	Marginal	200 - 300	5.3	5.7
3.	Semi-arid	300 - 500	1.7	1.8
4.	Semi-humid	500 - 800	1.0	1.1

Of the total cultivatable area of about 500,000 ha (5.4% of the total area), about 93% are rainfed and 7% (38,600 ha) are completely or partially irrigated. Rainfall areas lie primarily in the uplands; within the Valley itself, irrigation is required. About 640 MCM/yr of surface water are available to irrigate the Valley, primarily from the Yarmouk River (400 MCM/yr) but also with important contributions from the Zarqa River and side wadis flowing down from the uplands. Jordan's total water resources, including surface waters, groundwater and springs, have been estimated to be 1000 MCM/yr. [2-2] The waters of the Jordan River itself are too saline to be used for irrigation.

Water is perhaps Jordan's most valuable resource, not only for M&I use but also for production of crops. The latter is important for decreasing the dependence on food and grain imports and for providing an export commodity (typically fresh fruits and vegetables), both of which contribute to Jordan's balance of payments. The Valley, with its suitable soil and warm sunny climate, can become a major contributor provided irrigation water can be made available.

The first proposal for a scientific development of the Jordan Valley appeared in 1939. [2-3] This was followed by several other plans which, partially due to hostilities with Israel, were never developed. (The hostilities also led to population increases as Palestinians

[1]One hectare (ha) equals 10 dunums, or 2.47 acres.

relocated to the East Bank, thereby increasing the need for food and water supply). The general long-term development concept centered on a dam and reservoir to store and regulate the flows in the Yarmouk River, and an irrigation canal system paralleling the Valley. The reservoir was needed because the heavy flows or "floods" in the Yarmouk occur during the winter, when irrigation needs are lowest. The reservoir would also provide "over-year storage," to supply water during dry years when the flood flows failed to materialize.

Construction of the first irrigation projects commenced in 1958, and by the end of 1971 several facilities had been completed, including 77 km of the EGMC to carry unregulated flows diverted from the Yarmouk River. The canal waters were directed to open ditches to irrigate some 13,700 ha of land in the northern Valley.

Implementation of Stage I of the Jordan Valley Development Program began in 1972 when work started on the construction of the King Talal Dam on the Zarqa River. [2-4] Other work under Stage I included an 18-km extension of the EGMC, the provision for some sprinkler irrigation, and the development of water supplies from several side wadis. As a result, the total lands irrigated increased to 22,600 ha. In conjunction with the water supply facilities, work was also performed in providing improved roads and utilities for people living in the Valley.

2.3 THE ORIGINAL STAGE II PROJECT

The original Stage II project, as described in Harza's 1978 feasibility report [2-5], represented a continuation of the development of the Valley. It featured a 128-m high earth and rockfill dam on the upper Yarmouk River at Maqarin which, for the first time, would regulate flows in the Yarmouk and, hence, in the EGMC. The Maqarin Reservoir would have a volume of 320 MCM and a drainage area of 5950 km^2, most of which lies in southern Syria. The plan also provided for the future raising of the dam by 42 m, thereby fully developing the water storage potential for the site.

The dam would have a 20 MW hydroelectric plant, the energy from which would be used for irrigation pumping stations in the Valley with the excess added to the national network. Water released from the reservoir (through the powerplant or separately) would flow down the Yarmouk River to Adasiye, where a low-level diversion dam would divert up to 20 m^3/s to the EGMC. In addition, a volume of 25 MCM/yr would be passed on for use in the Yarmouk Triangle, a part of Israel lying north of the Yarmouk River and south of Lake Tiberias.

The original Stage II plan also called for a 14.5-km extension of the EGMC which would extend it to the lower end of the Valley and permit the irrigation of some 11,000 ha of new lands. The total area to be irrigated would then amount to 36,000 ha as shown in Figure 2-2. The plan included provision of 12 MCM/yr of water from Maqarin Reservoir to the city of Irbid for M&I use and 8 MCM/yr from the EGMC for villages in the Valley. The King Talal Dam, constructed under Stage I, would receive a 2 MW hydroelectric powerplant under Stage II. It was expected that water from the King Talal Reservoir would be used for M&I supply for Amman, at a net use rate of 10 MCM/yr. This is because Amman's wastewater would flow down the Zarqa River into the King Talal Reservoir, thus providing a recycle effect.

2.4 THE REVISED STAGE II PROJECT

The revised project, as described in Harza's Civil Design Memorandum C-1 dated August 14, 1979, includes several significant changes from the project described in the Feasibility Report. Under the "C-1" project, Maqarin Dam would be increased in height from El. 158 to 178 m. There would be no provision for raising the height at some future date. Also, Wadi Raqqad, in Syria, would have a canal to divert its flood flows to the Maqarin Reservoir. Without the canal the Wadi Raqqad flood flows would enter the lower Yarmouk River without the benefit of storage regulation, and thus they would tend to be lost for year-round use.

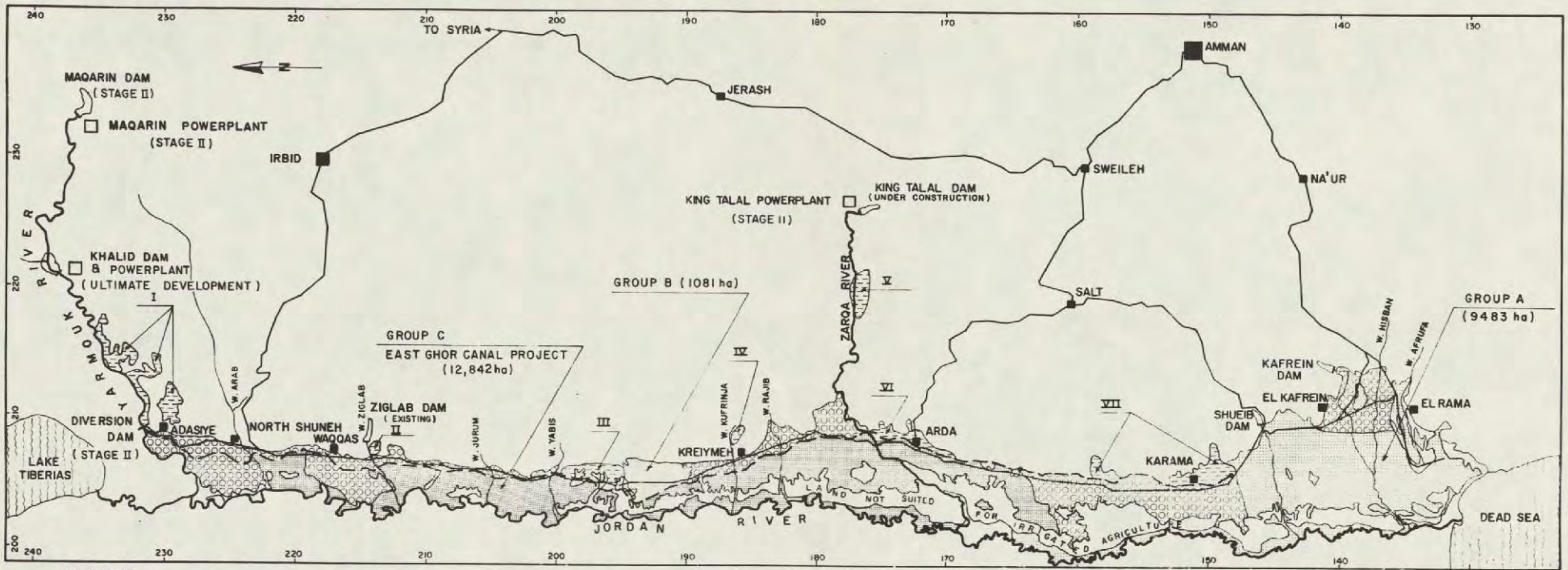
The "C-1" project would provide M&I allocation of 26 MCM/yr to Irbid, to be withdrawn from the Maqarin Reservoir, and 100 MCM/yr to Amman, to be withdrawn from the EGMC. Of the 26 MCM/yr allocated to Irbid, 12.5 MCM/yr is expected to reappear as return flow to Wadi Arab and then be available for irrigation supply in the Valley. Of the 100 MCM/yr allocated to Amman, 47.5 MCM/yr is expected to return to the Zarqa River and eventually be available for irrigation use in the Valley after having passed through the King Talal Reservoir.

Because of the significantly increased M&I withdrawals, there will be less water for irrigation than would otherwise be the case. However, 48% of the M&I allocations are expected to be available in the form of return flows which can be used for irrigation, albeit in different locations than shown in the Feasibility Study. Furthermore, the total water supply was increased in the "C-1" project as a result of increasing the height of Maqarin Dam and diverting Wadi Raqqad excess flows.

The net result is that under the "C-1" design it is expected that 21,750 ha can be irrigated (17,730 ha from Maqarin Reservoir, unregulated flows in the lower Yarmouk River, and return flow from M&I supply to Irbid; and 4,020 ha from return flow from M&I supply to Amman). By contrast, the Feasibility Study attributed 25,350 ha of irrigation to the Stage II project, and thus the "C-1" project reflects a decrease of 3,600 ha in irrigated area.

Water released from the King Talal Dam would flow down the Zarqa River and be used for sprinkler irrigation of the Zarqa Triangle. Stage II also provided for construction of weirs in three wadis to divert their flows to the EGMC.

In order to improve living conditions for farmers already in the Valley and to encourage the immigration of more people to farm the new lands, Stage II provided for expansion of housing, utilities, and municipal services under the "Village Development Program." The allocation of all Valley farmlands was undertaken by the JVA under authority of Temporary Law No. 18 of 1977, gazetted on May 16, 1977.



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	293
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

Figure 2-2 Site Map

Source:

Dar Al - Handasah Consultants (Shair and Partners) January 1978

GENERAL PLAN OF DEVELOPMENT

JORDAN VALLEY IRRIGATION PROJECT

STAGE II

Other aspects of the Feasibility Study are retained in the "C-1" study, including an allocation of 25 MCM/yr to the Yarmouk Triangle, and 5,570 ha that are irrigated from independent sources of water supply.

The original Stage II report discussed briefly a future Stage III effort that would have served to provide for the ultimate irrigation development of the Valley. This would have included the raising of the Maqarin Dam to El 200 m (170 m height), a new 100-m high dam downstream on the Yarmouk River at the Khalid site, increased M&I water supply, and irrigation of some 5000 ha to bring the total lands irrigated to 41,000 ha. Because of the revisions to Stage II plans, it now does not appear that Stage III would be feasible, at least not as presently conceived.

2.5 STAGE II IN PERSPECTIVE

Stage II, even as revised, should not be viewed as a separate and independent project. With respect to irrigation, it will provide the very important feature of a regulated water supply, thereby eliminating the uncertainty associated with uneven natural streamflows. Furthermore, it will permit additional crops to be grown each year, thereby increasing the productivity of both the existing and new agricultural systems.

For the rapidly growing upland cities, water from Stage II will provide M&I supplies without which the increased population could not exist or, at best, would be subject to adverse health effects due to a very limited supply of water of decreasing quality.

When large dams are planned, it is generally economically advantageous to construct them initially to their "full" height. This is because many of their appurtenances, such as diversion tunnels, discharge works and spillways, cost about the same regardless of the dam height. As a result, the full-sized dam provides economy-of-scale. This is the case with Stage II, that is, if any dam is to be constructed, economic considerations will demand that it be large. As such, Stage II represents a major step in the development both of the Valley and of Jordan. Once committed to this action, it also becomes necessary to include all related actions that provide economic return to offset the cost of the dam. Hence, the expansion of agricultural activities and Valley infrastructure must be included to take advantage of the newly provided water resources.

2.6 THE ENVIRONMENTAL COSTS

The adverse environmental impacts associated with the revised Stage II project can be attributed to its construction activities, operations, and socio-economic aspects. The most significant impacts are described briefly below, together with actions that can mitigate their effects.

2.6.1 Construction-Related Impacts

Archaeological sites are Jordan's primary tourist attraction, and tourism is the country's second largest producer of foreign currency revenues. Construction of the Maqarin Dam and the subsequent filling of its reservoir would inundate and destroy 28 sites representing periods from at least 100,000 B.C. to the present. In the southern Valley, extension of the EGMC and the preparation of new lands for farming could damage at least 29 sites, ranging from the Neolithic to Ottoman Periods. Mitigating actions would include the completion of surveys, salvaging of the sites, and realigning the EGMC. Alternately, sites in the southern Valley could be set aside, perhaps using some of the area no longer to be irrigated for this purpose.

As with most construction projects, an increase in erosion and sedimentation can be expected. Lands in the southern Valley which have already been leveled and cleared but which may no longer be irrigated, should be planted with cover to prevent wind erosion. Care should be taken to protect disturbed land from water erosion due to intermittant streamflows and storm runoff.

Construction of the Maqarin Dam will disrupt the Himma Branch of the Hejaz Railroad. A relocated railroad section, or a new access road to the lower Yarmouk Valley, would mitigate this impact.

Construction activities (and reservoir filling) will cause a habitat loss for terrestrial and aquatic biota. Although data are sparse, it is not expected that there will be any significant impacts to rare or endangered species.

2.6.2 Operations-Related Impacts

The filling of the Maqarin Reservoir would require the relocation of the few persons now living there and cause the loss of 20 to 30 ha of cultivatable land.

Operation of the water resource system will mean the end of unregulated flows in the Yarmouk River and its contributions to the flow of the Jordan River and ultimately into the Dead Sea. Flow in the lower Yarmouk (below the EGMC diversion) will essentially be eliminated, although 25 MCM/yr will be diverted to the Yarmouk Triangle. The Dead Sea is expected to drop 3 m in elevation. The flow in the Zarqa River is expected to increase as a result of increased wastewater discharges from the greater Amman area.

The Maqarin Reservoir would trap an estimated 98 MCM of sediments during 100 years of operations. These sediments presently flow down the Yarmouk and Jordan Rivers and are either deposited on floodplains during floods or pass on to the Dead Sea. The result could not be determined; it may be primarily an improvement in the downstream water quality.

The application of irrigation water to farmland can cause waterlogging of the soil where the water table is high and inadequate drainage is provided. It can also cause salt buildup depending on the type and method of irrigation used. And it can carry fertilizer and pesticide residues to groundwater, thereby contaminating it and precluding its beneficial use. These potential impacts are common to most irrigation projects, and they can be mitigated by programs of education, proper land management, and monitoring. JVA reports that it is seeking firms to drill wells to combat waterlogging and facilitate subsurface drainage.

Pesticide application, as a result of Stage II, is expected to increase by 475% from present levels. Total usage would increase 700% as uncultivated lands are placed into production. Some pesticides currently used are highly toxic and have labels printed in English or other non-

Arabic languages. With an illiteracy rate of 65% among farmers, the risk of serious health problems to humans as well as animals is severe. Mitigating actions include programs of education, research, government supervision and regulation of pesticide use, and labeling of containers in Arabic; JVFA is now assigned responsibility for such programs, and is building a department to administer them.

The irrigation operations, with increased water, can create environments favorable to the transmission of disease by vectors, including malaria and schistosomiasis. While the former seems under control, the latter has the potential for introduction of this debilitating disease in Jordan, particularly as foreign workers come from places where schistosomiasis exists.

The increased population in the Valley will increase the need for safe water supplies and wastewater and solid waste treatment and disposal. If these are performed improperly or inadequately, health problems and groundwater contamination could occur with long-term adverse effects. Present planning addresses the issues to some extent, but it needs review for technical and institutional (including enforcement) adequacy and a monitoring program.

2.6.3 Socio-Economic Impacts

This class of impacts would be caused by Stage II indirectly, and thus are difficult to quantify. However, they could have a significant impact on the overall success of the Jordan Valley Development Program.

Land redistribution has been required in order to provide a basis for laying out irrigated farms and to reduce somewhat inequities in land ownership patterns. While the system worked reasonably well when the northern Valley was developed, some inequities may have arisen in connection with land allocations in the south; moreover, not all those seeking land will be able to obtain it. Analysis and review of the land

redistribution program are needed, particularly in view of the reduction in irrigated land under the revised Stage II plan.

The success of the irrigation activities will depend on many management factors, primarily the growing of the type of crops that will provide optimum returns considering water availability, market conditions, and agricultural methods. The need for this type of management has been recognized, but the procedures for carrying it out have not been fully developed and tested.

The Village Development Program has been one of the important components of both Stage I and Stage II programs for Jordan Valley development. The provisions of electricity, domestic water sanitation facilities, new schools, health facilities, and administrative buildings in 34 villages has been underway since 1976 with important, positive results in the improvement in the quality of village life in the Valley. Housing programs have also been included as part of the package--both to improve the stock available to farm families and to attract required professional and public service employees to the Valley. Some of the initial low-cost housing provided by JVA was built on lots which appear to be lacking in sufficient space for many of the activities of farm families, including keeping of animals. While this situation has been corrected in later construction, continuing monitoring of the housing program, particularly to handle design related problems, are needed.

The program to develop domestic water for a number of the villages appears to be lagging behind some of the other components of the Village Development Program. Moving this up in priority and handling the potential problems of wasted water treatment should be important problems to be addressed in the immediate future. With the results of the Village Development Program now about to be realized, a more conscious effort to monitor the experience of villages with new facilities and services should be undertaken both to handle immediate problems and adjust future planning if necessary.

Other agriculturally related enterprises that will be needed to support Valley activities have not been planned; instead, they are expected to develop by themselves. However, the needs for certain activities such as pesticide formulation, fertilizer blending, and food processing plants should be reviewed and sufficient planning encouraged to obtain a balanced and sufficient supply of these enterprises and the trained personnel to operate them. Presently, the JVFA is considering undertaking pesticide application and equipment repair services for the farmers.

Whereas JVA's original plans anticipated a major increase in the population of full-time, resident Jordanians, a smaller increase now appears likely. Reasons include alternative employment opportunities elsewhere in Jordan or abroad, limited amounts of land available for ownership, importing of foreign seasonal workers, attraction of part-time women workers, and agricultural technology favoring mechanization. However, the JVA believes that the Valley's potential attractiveness to Jordanian farmers and entrepreneurs will be realized as projects are completed and land is made cultivable. Moreover, foreign laborers may not prove, over the long term, as dependable and experienced in some tasks as Jordanians. Hence, JVA remains confident that Jordanians will increasingly move into the Valley as full-time resident workers.

Institutional development has so far lagged behind physical facility development, with the notable exception of the Jordan Valley Farmers Association (JVFA). Just as JVA or a successor organization will be needed to maintain and operate the irrigation structures and system, so, too, local governments need to be strengthened to provide or coordinate local public services. At present, the allocation of government functions among JVA, JVFA, some central ministries, and most local municipal and village councils seems unclear and inadequate. Without adequate public institutions and services, the full benefits of Jordan's large investment in physical infrastructure facilities may not

be realized. This danger can be mitigated by explicit and prompt top management attention by the Jordanian Government, as well as by JVA, to policies, plans, training, and staffing for the Valley's future governance.

2.7 THE ALTERNATIVES

Having examined the physical nature of the Stage II development and its role in the development of the Jordan Valley as well as the Kingdom of Jordan, and the significant environmental impacts, the alternatives can be considered.

If Stage II were not undertaken, the irrigated farming of the Valley would continue using the existing Stage I facilities. Agricultural production would suffer from the inefficiencies and risks of an unregulated water supply. The upland cities would face increasing shortages of water, which could lead to serious health problems unless their growth were halted. In short, Jordan must develop its water resources to meet the needs of its increasing population. The Stage II project appears to be the most logical way to do so. In its absence, less desirable alternative supplies would have to be developed.

The delayed-action alternative would permit collection of additional data, particularly on hydrology and water quality, refinement of design studies, and better opportunities to salvage archaeological sites, strengthen institutional capacities, and improve public health facilities. However, it would also create short-term adverse impacts to existing agricultural activities, and aggravate the already critical supply of water to the upland cities.

Other alternatives relate to the height of the Maqarin Dam and the allocation of its water supply. At present, the cost/benefit functions and rates of return on investment are being reviewed by the donor group. The result of their analysis is not available, but it is expected to be instrumental in determining the final dam height. Once the latter is selected and the dam constructed, Jordan will have to live with the system for many years. The assumptions used for the analysis should be reviewed carefully, particularly for how they may be subject to changes in future years and for their sensitivity with respect to project size.

Other design and operational alternatives are less significant and relate more to design choices or mitigating actions, many of which can be incorporated at a later date. They are discussed in Chapter 7.

2.8 CONCLUSION

The revised Stage II project is a reasonable way for Jordan to develop its limited water resources in a way that will benefit its people and enhance its economy. The basic plan differs little in concept from hundreds of other irrigation projects throughout the world: one simply dams a river to store water for regulated release as needed. The Imperial Valley in California is an example. This also applies to the part of the water to be used for M&I purposes.

The environmental impacts can be predicted and to some extent mitigated. There would be a loss of wildlife habitat, revised streamflow regimes, potential loss of archaeological sites, some changes in socio-economic structure, and increased demands on public institutions. Irrigation involves the use of toxic pesticides, for which the farmers are inadequately trained. The population in the Valley will need better housing, utilities, sanitation, public services, and technical assistance. Health problems may arise, both from vector transmitted disease and from contamination due to wastes. Nevertheless, these impacts can be controlled and are more than offset by the potential beneficial impacts of the project.

3.0 THE GENERAL ENVIRONMENT OF JORDAN

3.1 INTRODUCTION

The descriptions in this chapter concern the general environment in Jordan and are intended to provide background information for the reader not familiar with the country. As such, the descriptions are regional rather than site-specific in nature. Moreover, they are limited to existing conditions; trends, plans and projections about future conditions are discussed in Chapters 5 and 6. Site-specific descriptions of the environment appear in Chapter 6.

Because the "environment" encompasses many disciplines, its description can conveniently be presented using the following representative subject categories and sections:

- Physical Environment
  - Terrestrial Regime
  - Atmospheric Regime
  - Hydrologic Regime
- Biotic Environment
  - Natural Biota (flora, fauna, habitats)
  - Disease Vectors
- Human Environment
  - People (numbers, distribution)
  - Their historic and cultural heritage
  - How they live (housing, infrastructure)
  - What they do (economics, land use, recreation)
  - How they are organized (national, regional, local governments)

This general format is followed both in this chapter and in Chapter 6. The sub-categories under "Human Environment" vary somewhat in each chapter to accommodate the particular conditions in Jordan and their relationship to the proposed project.

3.2 PHYSICAL ENVIRONMENT

3.2.1 Terrestrial Regime

3.2.1.1 Stratigraphy and Geologic History

Bender [3-1][1] indicates that the oldest rocks outcropping in Jordan date back to Pre-Cambrian time (600 million years B.P. (before present)). These limited exposures in the Nubo-Arabian Shield give evidence of early sedimentation followed by igneous intrusion of large granitic dikes producing local metamorphism in a zone believed to be the boundary (geosuture) between two tectonic plates. This suture is presently expressed topographically by the Wadi al Arabah-Jordan Rift physiographic province, illustrated in Figure 3-1.

Erosion of the Pre-Cambrian basement rock was followed by recurrent marine transgressions from the ancient Tethys Sea northwest of Jordan. Fluctuations of sea level began in the Cambrian period (500 million B.P.) and continued into the Eocene (40 million B.P.). The first transgression covered most of Jordan, and only the southeast corner received continental deposition of sandstones and conglomerates. These facies graded to marine sequences of limestone-shale-dolomite towards the northwest. The boundary between these facies retreated to the northwest during successive transgressions, as the Tethys Sea and accompanying marine sedimentation covered smaller portions of Jordan. A final transgression during the early Cenozoic once again covered most of Jordan with a shallow sea, depositing chalky limestones that now outcrop over most of Jordan, except in river valleys and basins south of Jerash where erosion has exposed the underlying continental sandstones. Generally, this lengthy history of sea fluctuation has resulted in deposition of sedimentary sequences dipping southeast, with marine sequences increasing in thickness to the north.

Major rift-forming movements causing faulting and folding in the surrounding country-rock began in the early Cenozoic on the southern

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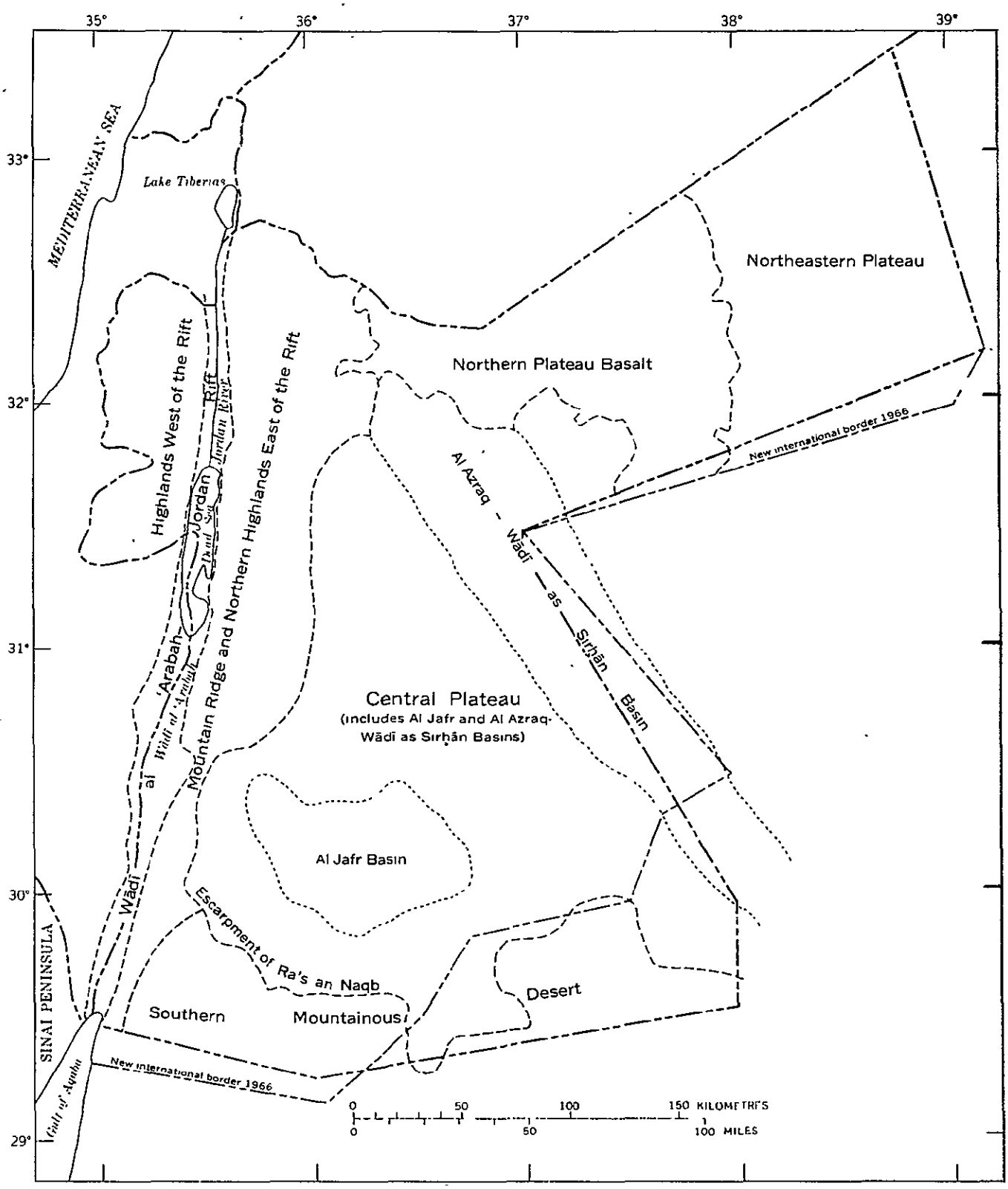
[1]Numbers in brackets, e.g. [3-1] refer to references listed in Appendix B.



Source: F. Bender. "Geology of the Arabian Peninsula--Jordan," Geographical Survey Professional Paper 560-1 U.S. Geological Survey, Washington, D.C.

Figure 3-1 Physiographic-Geologic Provinces of Jordan

end of the rift province marking the tectonic plate boundary. Propagation of the rift northward continued during later disturbances. Rift movements continue today and account for the numerous shallow focus earthquakes that give northern and western Jordan its high seismicity.

Continuing subsidence during the Cenozoic deepened the depression of the fault block structure of the rift valley. Repeated rainfall combined with subsidence formed evaporite deposits up to 4000 meters thick in southern portions of the rift. Folding and regional arching of the plates near the rift produced block faulting in the thick marine sequences in the north. Upthrown blocks formed the faulted and folded highlands near the rift, while downthrown blocks formed deep basins striking northwest.

Relatively recent (2 million years B.P.) vulcanism north of Jordan emitted six basalt flows from fissures produced by rift disturbances. In western Syria these flows extended as far south as the Yarmouk River, but in the east they formed a large plateau covering much of northern Jordan.

3.2.1.2 Physiographic Provinces

Jordan is divided into seven morphologically distinctive physiographic provinces as illustrated in Figure 3-1. [3-2] The Central Plateau in south-central Jordan is the largest province and is characterized by a flat, wind-eroded desert pavement of unconsolidated lake sediments deposited in shallow lakes during rainfall. Isolated, eroded plateaus composed of gently dipping beds of Cenozoic age limestone provide local relief up to 150 meters above the plateau surface, which is about 1000 meters above sea level. South of the Central Plateau in the Southern Mountainous Desert province, granitic basement rocks, from which most continental sediments in Jordan originated, form a steep, mountainous terrain rising to an elevation of 1550 meters near the border with Saudi Arabia.

The province designated as the Mountain Ridge and Northern Uplands east of the rift extends from the Gulf of Aqaba to Lake Tiberias. This province includes most of the Maqarin Project site. The formations in the province vary from meta-sediments in the south to continental sandstones and finally marine limestones in the north. The uplands were uplifted during rift-forming movements in the Cenozoic, and they exhibit very steep slopes near the rift. Subsidence of the base level of drainage in the rift produced deeply incised stream valleys, typified by the Yarmouk Valley. The uplands west of the rift province were uplifted simultaneously with the uplands east of the rift, but the predominant rocks in the former province are limestones deposited during the last marine transgression. Faulting also appears to be more severe in this province than in the uplands east of the rift.

The Wadi al Arabah-Jordan Rift province is a relatively narrow depressed block marking the passage of the great East African-Asia Minor geosuture through Jordan. Subsidence has produced a basin reaching a maximum depth of 753 meters below sea level at the bottom of the Dead Sea. Most of the Jordan Rift is covered with unconsolidated river and lake sediments with occasional thick evaporite deposits.

The East Jordan Valley itself is about 105 km long, and its width varies from 4 to 16 km. If viewed in cross section, the lowest part of the Valley is the U-shaped incision of the River's flood plain--called the Zor. On either side, the terraces of the Ghor, formed of alluvial fans in the north and outwash material in the south, extend in two narrow strips up to the steep sided mountain uplands. The transition zone between them, the Katar, is highly eroded and of "badland" appearance. The Al Azraq Wadi as Sirhan Basin province northeast of the Central Plateau was formed by block faulting during the early Cenozoic. Unlike the rift, this basin is not tectonically active. Collection of drainage from the central wadi system in Jordan and Saudi Arabia has resulted in deposition of lake and evaporite sediments. Limestone and marl also outcrop in the basin.

The Northern Plateau Basalt province was formed in a series of six flows during the early Quaternary. These flows are up to 300 meters thick where they are exposed in the Yarmouk River Valley. Most of these flows are separated by deposits of residual soil weathered from exposed basalt, and much of the basalt is severely jointed and weathered. The surface of the last flow is eroded into a rugged, blocky topography. The Northeast Plateau province is separated from the Central Plateau and the Al Azraq-Wadi as Sirhan Basin by the Northern Plateau Basalt province. The stratigraphy and topography in the Northeast and Central Plateau provinces are essentially identical.

3.2.1.3 Economic Geology

Mineral resources of proven economic value are scarce in Jordan. Limited reserves of copper ore have been found in the mineralized sandstones south of the Dead Sea, but economic extraction is not currently feasible. Test drilling has discovered hematite and limonite deposits in limestone about 35 km northwest of Amman, but their extent is not known. Phosphate and rock salt deposits of economic interest have been found at several locations in Jordan, but commercial mining has been restricted to Ar Rusayfah, 15 km northeast of Amman, and at Hasa. A solar evaporation system is currently being developed to recover 1.2 million metric tons of potash from the Dead Sea. Much of the nodular limestone in south-central Jordan can be used in the production of cement, and several other limestone formations have been quarried for building stone.

Recently, geophysical exploration has discovered possible structural and stratigraphic traps for oil and gas in the Yarmouk River Basin and the Al Azraq-Wadi as Sirhan Basin. [3-2] Exploratory drilling to search for potential petroleum reserves is continuing.

3.2.2 Atmospheric Regime

Jordan lies within a transition zone between Mediterranean and arid climates, receiving much of its weather from the west; with seasonal variations in wind direction. [3-3] In the winter, northeast winds

bring continental polar air from Asia and create temperatures cooler than would be expected for this latitude. The southwesterly shifts of the wind which also occur in winter bring rain. In the springtime, frontal depressions from the North African coast cause increases in temperature and surface winds. These conditions create unstable air masses at higher altitudes which often develop into thunderstorms and occasional hail. In the summer, low pressure troughs over the Arab Gulf, Iraq, Syria and Cyprus result in westerly winds from the Mediterranean. Only occasionally during the summer do the dry air masses from the deserts east of Jordan affect its weather. After the summer the low pressure front moves southeast, allowing continental air fronts and warmer moist air from the Mediterranean to enter the country; this causes temperature drops and the beginning of the rains. Violent storms and hurricanes are uncommon in Jordan.

Temperatures throughout the year are highest in the Jordan River Valley, lowest in the uplands and in-between in the desert. July and August are the hottest months of the year, December and January the coldest. Extreme temperatures of 45°C (113°F) have been recorded in the Jordan Valley. The southern end of the rift valley and the mountains are slightly warmer than the northern end. Mean monthly temperatures and precipitation in these three regions are presented in Table 3-1.

Precipitation, caused by the moist air moving northeast from the Mediterranean, falls most heavily on the northern uplands of Jordan. This region receives an average of 300-600 millimeters per year (mm/yr), with maximum precipitation of 600-700 mm falling near Jerash/Ajlun and west of Amman. The Jordan Valley is in the rain shadow of the West Bank Mountains paralleling the rift valley. The northern Jordan Valley receives between 200-300 mm/yr; and proceeding south down the rift valley, the rainfall diminishes to less than 3 mm/yr at Aqaba. The Jordanian rainy season is from November through February. January has the most

Table 3-1

Mean Monthly Temperature and Precipitation Ranges

Month	RIFT VALLEY		UPLANDS		EASTERN DESERTS	
	Temperature (°C)	Precipitation (mm)	Temperature (°C)	Precipitation (mm)	Temperature (°C)	Precipitation (mm)
January	14	0-75	4-8	25-150	10	0-25
February	14-16	0-75	4-8	25-100	10-12	0-25
March	16-2	0-50	8-10	10-100	12-14	0-25
April	20-24	0-10	12-14	10-25	16-18	0-10
May	26-28	<10	14-20	<10	20-26	<10
June	28-32	0/trace	18-22	0/trace	22-28	0/trace
July	30-32	0/trace	20-24	0/trace	26-30	0/trace
August	30-32	0/trace	20-24	0/trace	26-30	0/trace
September	28-30	0-3	24-28	0-3	18-22	0-3
October	26	0-10	16-20	0-10	20-22	0-5
November	20-22	0-50	12-14	10-50	16-18	0-25
December	14-16	0-75	6-10	25-100	10-12	0-25

Source: "Climatic Atlas of Jordan," Meterological Department, Ministry of Transport, 1971.

precipitation, with some regions receiving as much as 15 mm. Between June and September, there is virtually no rain and only small amounts fall during May and October. Essentially all of the precipitation in Jordan occurs as rain, although snow sometimes falls in the mountains and has been seen briefly in Amman. Frost is a rare occurrence in the Jordan Valley.

Humidity follows the patterns of temperature and precipitation: the uplands, which receive the most rain and is the coolest region, are the most humid, often attaining over 70% humidity; the extreme humidity measured was 84% in the winter. The mean monthly humidity range is 35% to 76% for the country. The Valley and the desert are less humid, having less water to lose through evaporation.

The geometry of the rift valley fosters the generation of haze which lessens the number of hours of direct sunshine received. Because of the country's location, however, this obstruction is negligible--the Valley's annual mean hours of sun per day is 9.5 compared to 10 hours in the uplands and 10.5 in the desert.

The country's prevailing winds are westerly, with an occasional southwest wind. The rare east winds (Khamsin) are cold and dry in the winter and hot, dusty, and scorching in the spring. In Amman, the winds are westerly one-third of the time and occasionally attain speeds of over 34 knots. The daily afternoon winds in Amman reach at least 10 and usually 15 knots. Low wind velocities and dry, clear conditions at night subject the city to daily temperature inversions. These inversions reach to the rim of the hills and usually last about six hours until the sun has sufficiently warmed the air layers above.

3.2.3 Hydrologic Regime

3.2.3.1 General

Several studies have been made concerning the water resources of Jordan, but because of inadequate data and poor information coordination, it is

not clear exactly how much water is available. Depending on the sources and assumptions, one could conclude either that there is no basic problem with regard to water supply through the year 2000 or that Jordan is already experiencing a water shortage which is not likely to be remedied in any satisfactory way. Some overall indicative magnitudes are available, however, from two recent studies, namely, the 1977 National Water Master Plan of Jordan [3-4] and the 1978 North Jordan Water Use Strategy. [3-5] A discussion of their results and of other recent surveys follows.

3.2.3.2 Water Quantity

Under average rainfall conditions, the East Bank catchments of Jordan, including the Syrian area of the Yarmouk River Basin, receive a rainfall volume of about 8065 MCM/yr. Of this, about 75% or 6000 MCM/yr falls over Jordanian territory. However, the known available water supplies in Jordan [3-4] as measured by replenishable[1] surface and groundwater are only about 1100 MCM/yr (880 MCM/yr streamflow including all Yarmouk River flows and 220 MCM/yr groundwater). The total known available water supplies of North Jordan (a region north of Amman which encompasses less than 30% of the country's surface area but contains 97% of the population) are [3-5] about 625 MCM/yr (548 MCM/yr streamflow; 77 MCM/yr groundwater).

3.2.3.3 Surface Water

Of Jordan's 880 MCM/yr annual streamflow, 400 MCM/yr occur in the Yarmouk River at Adasiye. [3-4] The Yarmouk flows originate primarily from catchments in Syria. Only some 480 MCM/yr are attributable to streams having their entire catchment areas within Jordan. Analyses [3-4] indicate that considerable parts of the flows result from groundwater discharge (baseflow) rather than from direct rainfall runoff during the annual rainy season, i.e., between November and May. The

[1]Replenishable water resources are those that are renewed by annual precipitation. They exclude groundwater which, if pumped, would cause a permanent lowering of the groundwater table.

above estimates do not include the flows of the Jordan River, of which 77% originate in Syria and 23% in Lebanon, Jordan and Israel, and Israeli-occupied territory. Table 3-2 shows the average annual estimates of river flows in Jordan. The availability of water (number of rivers, average annual flows) decreases as one moves from the north to the south of the country.

3.2.3.4 Groundwater

The volume of groundwater in Jordan is estimated to be about 12,000 MCM. Annual recharge is about 580 MCM, and annual withdrawal is about 220 MCM. The difference, 360 MCM, either appears as baseflow in streams or is lost to evaporation. Water retained in depths greater than 150 meters below ground may prove to be exploitable for specific purposes in order to increase the present groundwater availability.

3.2.3.5 Other Storage Areas

Eleven reservoirs serve the present water supply system of Jordan. Their names, location, and storage capacity are listed in Table 3-3. Four of the reservoirs are included in the Jordan Valley Irrigation Plan. These are the King Talal Dam which started storing the Zarqa River flows in March 1977, the Kafrein Reservoir, the Ziglab Reservoir, and the Shueib Reservoir.

The Dead Sea, which has no outflow, has a drainage area of 40,650 km^2, a water surface area of 1105 km^2, and a total water volume of 80 MCM. Its present surface elevation is -392.9 meters. The Dead Sea waters are the saltiest in the world and cannot be used as a water resource except for recreation and mineral extraction.

3.2.3.6 Water Quality

The water quality of the surface resources varies in Jordan. The Yarmouk River and the wadis do not contain significant pollution; however, the Zarqa River is heavily polluted from chemicals (heavy content of trace elements), mainly during periods of low flows. The water of

Table 3-2

Surface Water Resources in Jordan

River	Designation[1]	Average Annual Flows[2] (MCM/yr) Harza Estimates[3]	National Master Plan Estimates[4]
Streamflows Within the Stage II Study Area			
Jordan River	King Hussein Bridge	1013.5	1013.5
Wadi Raqqad	(near Rafid, Syria)	73.3	
Yarmouk River	at Maqarin site	240.3	285.0
Yarmouk River	at Adasiye	393.3	387.0
Wadi Arab	AE	28.8	29.7
Wadi Ziglab	AF	9.5	10.2
Wadi Jurum	AG	11.2	11.0
Wadi Yabis	AH	3.3	3.1
Wadi Kufrinja	AJ	6.1	6.0
Wadi Rajib	AK	7.1	4.3
Zarqa River	AL11 (Deir Alla)	67.3	71.0
Wadi Shueib	AM	7.9	8.2
Wadi Kafrein	AN	14.3	13.4
Wadi Hisban	AP1	5.0	3.6
River Basins in Jordan			
Eastern Jordan Valley	A	-	607.0
Dead Sea Basin	C	-	191.0
Wadi Araba Basin	D	-	31.0
Desert Basins	-	-	49.3

[1]Designation shown in the National Water Master Plan of Jordan.

[2]Adjusted to represent estimated 1978 flows after upstream withdrawals.

[3]Harza Stage II Feasibility Study, 1978.

[4]National Water Master Plan of Jordan, 1977.

Table 3-3

Existing Reservoirs in Jordan (1976)

Name of Reservoir	Location/ Region	Source of Water Supply	Storage Capacity (MCM)	Uses[1]	Remarks
Sama Sudud	Mafraq	Local Wadis	1.7	I; D	Effective Yields unconfirmed
Ghadeer Abyad	Mafraq	Local Wadis	0.7	I	Effective Yields unconfirmed
Um Jimal	Mafraq	Local Wadis	1.8	I; D	Effective Yields unconfirmed
Bowayda	Mafraq	Local Wadis	0.7	I	Effective Yields unconfirmed
Al-Lakafi	Dhuleil Area	Local Wadis	0.7	I; G	Effective Yields unconfirmed
Qatrana	Qatrana Area	Local Wadis	4.2	G; D; I	Effective Yields unconfirmed
Sultana	Sultana Area	Local Wadis	1.2	G; D; I	Effective Yields unconfirmed
Ziglab	Wadi Ziglab	Wadi Ziglab	4.3	I	Jordan Valley Plan
Shueib	Wadi Shueib	Wadi Shueib	2.3	I	Excessive Seepage; Limited Storage Effect
Kafrein	Wadi Kafrein	Wadi Kafrein	4.8	I	Jordan Valley Plan
King Talal	Zarqa River	Zarqa River	48.0	I	Jordan Valley Plan

[1]Key to Uses: I = Irrigation; D = Domestic Supply; G = Groundwater Recharge.

Source: National Water Master Plan of Jordan, Volume II, Annex III A-6.1

the Jordan River is saline because of the return flows from the irrigated areas and is not considered an exploitable water resource. This also applies to the Dead Sea.

Jordan possesses significant groundwater resources of good quality. In general, because of the mechanism of the water circuit (water pathways), groundwater resources having a high rate of annual replenishment are of good quality (in terms of natural salinity also). By contrast, groundwater stored in deep aquifers which flow slowly and have low recharge rates are generally unsuitable for use. Regions of good water quality, in terms of salinity, are: (1) Syrian Jebel Druze, southwards to the Azraq and Wadi Dhuheil regions (extreme north); (2) Ajlun-Amman (north); (3) Karak-Ras En Naqb (south); and (4) northwards from the Um Salim mountains (extreme south). Regions of poor groundwater quality are: (1) the central axis of the East Jordan Valley (and the Wadi Araba in the west); (2) the whole eastern region except the extreme north and south; and (3) a connection between these regions, extending from the Dead Sea to the east. However, within these regions, local sources of acceptable water quality exist, but at present it is not known how far the fresh water in the deep sandstone aquifer systems extends. The deterioration of the groundwater quality in Jordan is mainly due to: (1) recycled irrigation water; (2) pumping of saline water from deeper aquifers; and (3) wastewater from human settlements and industry.

3.2.3.7 Water Use

The total 1978 water use in Jordan is estimated to be about 450 MCM/yr. This includes some water being "mined" or extracted above its replenishment rate and, to this extent, is a high estimate of sustainable yield. Of the 450 MCM/yr, about 400 MCM/yr, or 80% is used for agricultural irrigation, and most of that is allocated to the East Jordan Valley. Of the remaining 50 MCM/yr, about 40 MCM/yr is used for domestic water, both rural and urban, and more than half of this is used in the Amman/Zarqa "conurbation." The per capita domestic water consumption in this area varies significantly, with a maximum rate of about 40 liters/capita/

day which is very low. A minimum of 100 liters/capita/day is considered desirable. The industrial water consumption of 10 MCM/yr corresponds to less than 3% of total water use in Jordan and represents a very small demand, although the trend has been toward relatively fast growth.

The National Water Master Plan of Jordan estimates that the water use in the year 2000 will be just about equal to supply and comprised of 300 MCM/yr for M&I use and 800 MCM/yr for agricultural (irrigation) use. The North Jordan Water Use Strategy estimates the use in the year 2000 in North Jordan alone to be 920 MCM/yr, of which M&I would be 290 MCM/yr and agriculture 630 MCM/yr.

3.3 BIOTIC ENVIRONMENT

3.3.1 Existing Biological Systems

The biota of Jordan are the result of centuries of human influence in this very small area. Given the regionally severe climatic conditions, human populations have concentrated in the higher rainfall areas, resulting in changes in land use and water use patterns. Thus, present aquatic and terrestrial systems largely represent a combination of introduced or remnant biotic associations that can survive with increasing urbanization and agricultural land use rather than the natural succession or climax ecosystems that might otherwise exist in this climatic regime.

3.3.1.1 Terrestrial Biota

3.3.1.1.1 Plantgeographical Regions

Jordan is composed of three distinct plantgeographical regions. These have been described as Mediterranean, Irano-Turanian, and Saharo-Sindian. [3-6]. Table 3-4 lists some general characteristics of the regions as they are found in Jordan. The general geographical distribution of each region is illustrated in Figure 3-2.[1] It is important to note that rainfall (and, to a lesser extent, soils) has traditionally limited agriculture to the narrow Mediterranean region and, to a lesser degree, the Irano-Turanian area. [3-7]. Thus, human populations are concentrated here. Grazing by domesticated stock, primarily sheep and goats, is also concentrated in these two regions.

These generalized delineations of terrestrial ecotypes listed above can be somewhat misleading as wide variation in topography and microclimate affects variation in species composition within regions. Furthermore, the boundaries between regions are not precise and encroachment of species from one region to another is common:

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[1]Two species lists are presented in Appendix C.

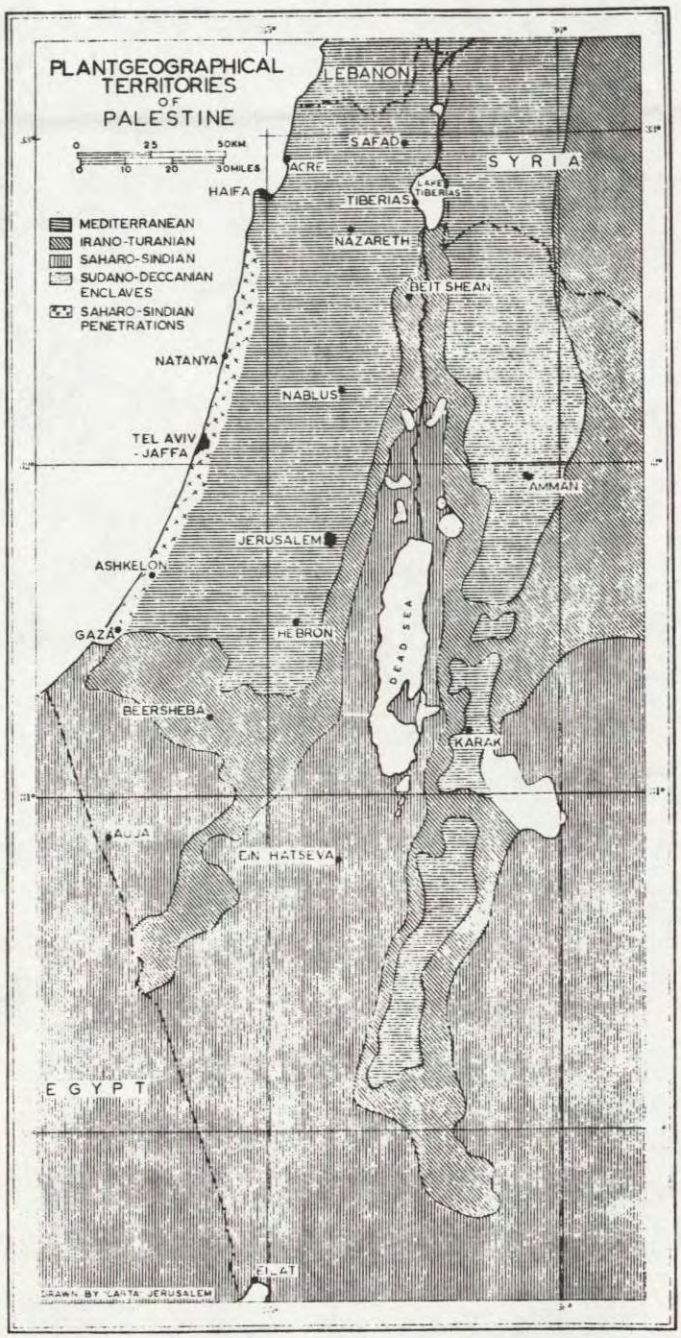
Table 3-4

Jordan's Major Plantgeographical Regions

Region	Soil	Rainfall (mm/yr)	Type of Vegetation	Representative Genus	Examples of Phase II Impact Areas
Mediterranean	Terra rossa, rendzina, basalt and sandy soils	350-600	Forest, maquis,[1] and shrub	Ononidetum, Salvia-Ballota Association, Echinops-Carlina Association	Maqarin Dam site, Amman
Irano-Turanian	Gray steppe soil and loess	200-350	Dwarf shrubs and herbaceous species	Zizyphetum-Loti Association (Zizyphus, Ballota, Salvia, Echinops, etc.)	Northern Jordan River Valley
Saharo-Sindian	Hammada, saline soil, sandy soil	25-200	Dwarf shrubs and herbaceous species	Salsoletum, Suaedetum, Arthrocnemum-Tamaris Association	Southern Jordan River Valley

[1]Woodland composed of low trees and shrubs up to 4 meters tall.

Source: Adapted from M. Zohary, Plant Life of Palestine, 1962.



Source: M. Zohary, Plant Life in Palestine, 1962.

Figure 3-2 Vegetation Regions of Palestine and Transjordan

- Many arid region species, adapted to marginal conditions, can be found in disturbed areas in the Mediterranean region;
- Mediterranean tree species may be found in wadis or other areas with access to water within the generally treeless Saharo-Sindian or Irano-Turanian regions. [3-6]

Centuries of human habitation have resulted in marked alterations to the terrestrial environment. Indigenous vegetation has been largely replaced or reduced in diversity due to clearing for agriculture, deforestation for lumber and fuel, grazing by domesticated animals, and fire. New or previously secondary species have displaced the former floral dominants resulting in new or altered plant associations over large portions of Jordan. [3-6]

Thus, existing plantgeographical regions, especially the historically Mediterranean and Irano-Turanian regions, are better described as remnant populations. In large part, indigeneous communities have been replaced by agricultural crops and their associated weeds (where rainfall or irrigation have permitted); by species that have survived the selective pressure of grazing; and by species adapted to introduced conditions (e.g., reduced soil water holding capacity). Areas denuded of almost all vegetation exist, and extensive soil losses due to erosion have occurred, especially in regions with more severe topography. [3-7] Clearing of natural vegetation in a region with climatic conditions sufficiently severe to retard or restrict regenerative growth has undoubtedly contributed to this situation. In some cases, such changes may be irreversible. [3-8]

3.3.1.1.2 Faunal Communities

Considering the fact that plant systems largely define animal populations, habitat losses described above along with competition with domestic species and excessive hunting by man have contributed to significant changes in indigenous, faunal communities. [3-9] At least ten large

mammalian species have become, or are becoming, locally extinct in the twentieth century.[1] Other less obvious mammalian and avian species have also been greatly reduced in type and number.[1] [3-10] No recent definitive systematic survey of Jordan's fauna has been conducted. Information (other than isolated, incidentially collected accounts) is largely unavailable on Jordan's indigenous reptile, amphibian, insect, and other invertebrate populations. One could assume, however, that there has been an increase in agricultural pests and species better adapted to co-exist with increased human populations.

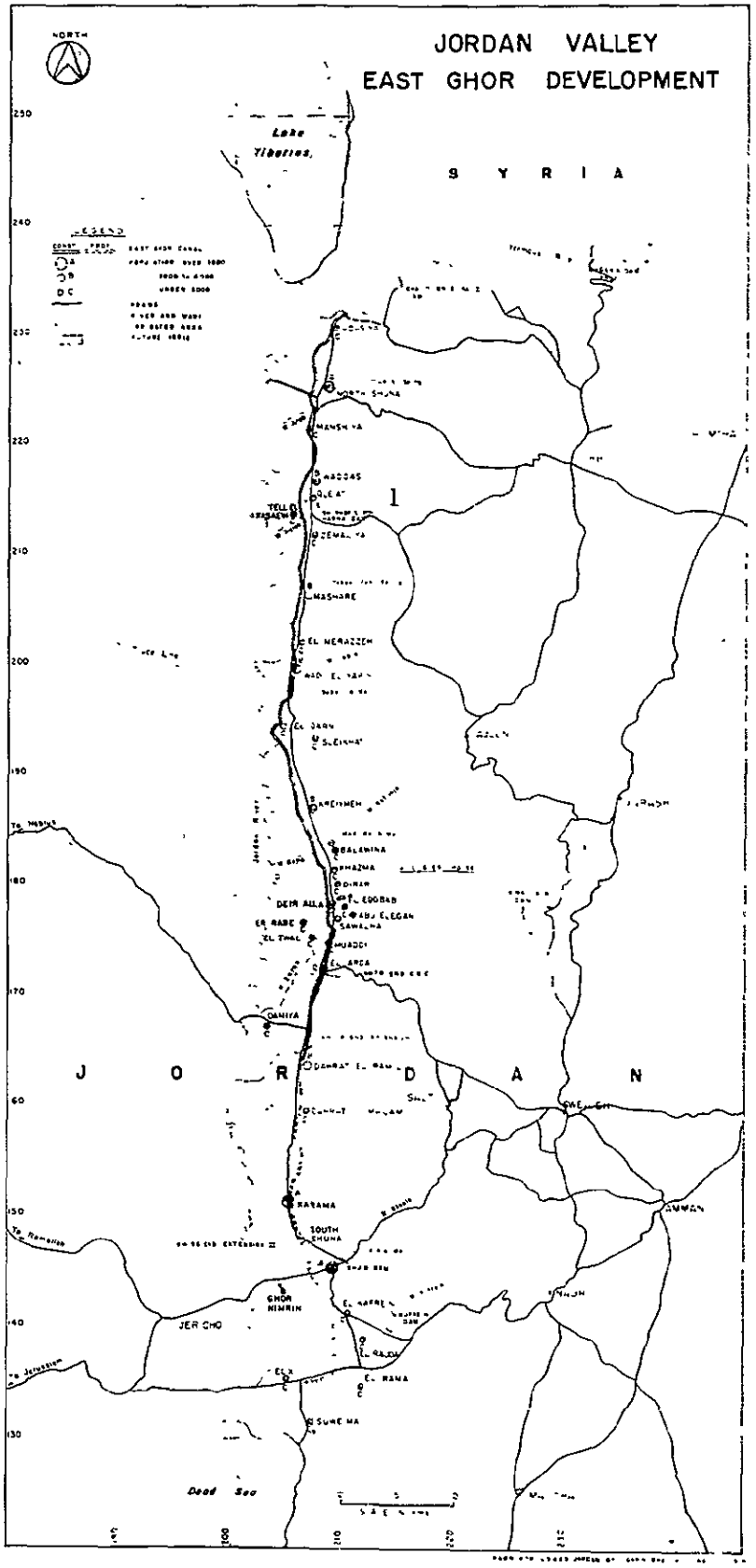
3.3.1.2 Aquatic Biota

Three distinct topographic/climatic regimes essentially define the surface water resources of Jordan. From west to east, these include: the eastern half of the Jordan rift valley, the uplands, and the desert. In northwestern Jordan (the focus of this report), the Jordan River is a meandering, increasingly saline riverine system as it flows southward in the Jordan rift valley. (See Figure 3-3.)

The steep escarpments that form the eastern border of the lower Jordan Valley (Ghor) and become the uplands, intercept significant rainfall. Hence, the uplands have been frequently and deeply dissected by torrent drainage. [3-7] In most cases, only portions of these streams (wadis) contain perennial flow near their entrance to the Ghor. In some instances, flow is maintained only by additions of water from springs. The two most significant streams are the Yarmouk and Zarqa Rivers.

Major changes have occurred in the types of available aquatic habitat, most during this century. These are associated with the construction of dams on many of the more significant wadis in order to provide reliable sources of water for irrigation and M&I use. A number of these are illustrated in Figure 3-3, with the most recent being the King Talal Reservoir on the Zarqa River. Few records of aquatic species exist

[1]These are listed in Appendix C.



[1]Ziglab Reservoir

Source: U.S. AID, Jordan, 1974.

Figure 3-3 Surface Water Resources

for the area, and documentation of changes in aquatic organisms due to alterations in aquatic habitat are not available. It is, however, expected that those indigenous riverine species that could also survive and continue to reproduce in impoundments, are likely to represent existing aquatic flora and fauna. The general lack of available data limits descriptions of existing systems to species incidentally observed and, hence, may not represent community structure.

3.3.1.2.1 Phytoplankton

Where they are available, reports of phytoplankton populations are largely very general. Brief field surveys made during several recent investigations report periphytic algae growths (possibly cladophora) in stretches of the Zarqa River and slower flowing irrigation canals. [3-8, 3-11] A 1978 spring survey of the filling King Talal Reservoir reported a dominance of green algae with diatom species being of lesser importance. The nutrient loading of this reservoir and Jordan's climatic conditions create a potential for high algae productivity. The degree to which blue-green algae species (especially problematic in a drinking water source) may predominate seasonally is dependent upon as yet undefined nutrient budgets and reservoir stratification patterns. [3-8]

The extent to which similar conditions exist in the series of small reservoirs located on wadis entering the Ghor is also dependent on watershed nutrient inputs and stratification patterns. Conditions in these reservoirs are largely undocumented, although increasing eutrophication would appear likely considering their size, the climate, and land use patterns. During a visit to the Kufrein Dam impoundment in March 1979, large dense floating mats of aquatic vegetation were observed along its periphery. This presented a sharp contrast to the Ziglab Reservoir; no

visual evidence of floating/rooted vegetation or periphytic algae was noted in March 1979. This observation reinforced a similarly reported lack of aquatic vegetation made in a 1978 survey.[1] [3-11]

3.3.1.2.2 Aquatic Invertebrates

As with aquatic vegetation, little information is available on aquatic invertebrates. Turn-of-the-century surveys of the Jordan River system exist [3-12], but considering the degree of environmental change in the area, present use of such surveys without field verification is questionable. In a recent brief look at a portion of the Zarqa River, the diversity of benthic fauna, specifically aquatic insects, was described as low. [3-8] Since portions of this stream are known to have degraded water quality, such observations may not apply to the whole stream or other streams in Jordan.

Information pertaining to specific disease vector invertebrates is somewhat of an exception. A number of species of Anopheline mosquitoes that are carriers of malaria were responsible for a relatively high incidence of this disease early in this century. [3-7] Preferred breeding sites for the various species found ranged from seasonally rain-fed pools and house cisterns to slow-moving streams. While malaria is presently controlled, increases in irrigation canals and water storage areas supporting dense vegetation will increase breeding habitat for a number of species of this genus. [3-13]

Slow-moving water, especially that associated with periphytic algae or aquatic weeds, and impounded water, where floating or submerged vegetation becomes established, represent ideal habitat for snail species that carry schistosomiasis (i.e., Bulinus and Biomphalaria). [3-13, 3-14] Recent snail surveys of Jordan's surface waters have reported

[1]The lack of visable vegetation in Ziglab Reservoir may (or may not) be related to an as yet undocumented water quality problem.

Physa and Lymnea species throughout the country. These species are commonly associated with Bulinus. [3-15] Melanopsis and Neritina species were also recorded. [3-11] In fact, large snail populations were generally apparent in most surface waters. The exception was the Ziglab Reservoir.[1] Nonetheless, only very few, small populations of potential schistosomiasis-carrying snails have been located in Jordan. Section 3.3.2 further describes disease problems associated with such organisms.

3.3.1.2.3 Fish

Surveys of fish populations, where they exist, are also very old. [3-12] Information does exist for commercial catches from the Jordan and Yarmouk Rivers. While not likely to represent all species present or species abundance,[2] such information does indicate that these two rivers support 100 tonnes per year production of Tilapia spp. (locally called Muscht) and Carp (Cyprinus Carpio), Nile catfish (Clarius Lazeia), and Barbus spp. (locally, Kersin and others). Tilapia represent two-thirds of the harvest, although the latter species is also far more marketable, a situation which may be reflected in the numbers reported. Several efforts have been made to farm fish commercially, including stocking of the Wadi Ziglab and King Talal Reservoir. [3-16] To date, the approaches used have not proved commercially successful. (See Section 6.4.1.4.5.)

3.3.2 Health and Disease

Two recent studies [3-17, 3-18] provide a useful description of health and disease in Jordan. Infectious diseases, particularly gastroenteric and respiratory infections, continue to be major causes of illness while the newly developed and developing health care systems tend

[1] The Arthur D. Little, Inc., team in 1979 and Schinski in 1978 [3-11] both observed this lack of marginal fauna.

[2] Commercial statistics represent selective sampling and may represent selective reporting of economically significant species.

to focus on chronic diseases. Crude indicators of health status in Jordan are comparable with neighboring countries. They suggest considerably better conditions than are found in central Asia or sub-Saharan Africa but worse conditions than those in the industrialized Western countries. The mortality rate for the period 1970-1975 averaged 14.7/1000 population (USA = 9.4/1000; Nigeria = 22.7/1000). The infant mortality rate in 1975 was 99/1000 live births (USA = 18/1000; Nigeria = 180/1000). The average life expectancy at birth for the period 1970-1975 was 53 (USA = 71; Nigeria = 41). Unfortunately, any discussion of health status in Jordan is compromised by the lack of accurate medical statistics. Published data emphasize chronic diseases and ignore the many infectious diseases which are not reported and thus do not receive official recognition. This is especially true among the poorer segments of the population who have the least contact with the medical system and who also suffer most from infectious diseases.

Several categories of disease, which have particular relevance to this study are discussed below. The reader is also referred to Section 3.4.7.2 which discusses health institutions and services.

3.3.2.1 Malaria

Malaria is currently considered to be eradicated in Jordan; however, a considerable effort is required to maintain this status. Some of the factors which contribute to this problem are the immigration of foreign laborers carrying malaria infections; the presence of several vector species of Anopheline mosquitoes including *A. sergenti*, *A. superpictus*, *A. sacharovi*, and others; military conditions which inhibit control operations; and an increasingly mobile indigenous population. The control activities of the Malaria Service of the Ministry of Health [3-19, 3-20] include (1) residual house spraying with DDT, (2) larviciding with Abate, (3) drainage, (4) entomological investigations, (5) case detection and treatment, and (6) control of ports of entry. These efforts have apparently halted the indigenous transmission of malaria in Jordan; however, 400 imported cases were detected during 1978.

3.3.2.2 Schistosomiasis (Bilharziasis)

All of the factors which are necessary for the transmission of schistosomiasis are present in Jordan except for the presence of established colonies of vector snails (temporary colonies have been reported). [3-15, 3-21] In recent years, Jordan has not had a problem with indigenous transmission of schistosomiasis; however, a survey of 17,000 foreign workers in 1977 found that at least 8% of them had urinary schistosomiasis. Although no stool samples were taken, it is suspected that there was also a high prevalence of intestinal schistosomiasis. [3-22] The potential for the establishment of schistosomiasis is recognized by officials of the Ministry of Health and by members of the Jordanian medical and scientific communities. On the other hand, there is significant disagreement on the severity of the threat and on the necessary procedures for preventing indigenous transmission. In essence, the Ministry of Health has taken the approach of destroying temporary colonies as they are identified. The academic community proposes to survey the country to identify potential habitats and to establish surveillance procedures to identify vector snail colonies and to test them for schistosomal infection.

3.3.2.3 Other Parasitic Diseases

Because of incomplete reporting, it is difficult to assess the current status of some of the major parasitic diseases. For example, while the Ministry of Health reports only one recent case of Cutaneous Leishmaniasis (also known as Oriental Sore or Jericho Boil), a recent study identified about 524 cases over the past five years, 259 of which were from the East Jordan Valley. [3-23] In fact, studies in the region near Jericho and the Jordan River report that the disease has been hyperendemic for decades. [3-24] Another major parasitic disease, which is associated with severe chronic morbidity, is hydatid disease (Unilocular Echinococcosis). The parasite, E. granulosus, is frequently transmitted in endemic areas between dogs and sheep. The Ministry of Health claims to have little evidence of a problem while personal communications suggest that Jordanian surgeons frequently

encounter this disease when calcified cysts develop in vital organs. [3-25] A recent survey of livestock claims a prevalence of hydatid infection ranging from 2% to 5%. [3-26]

3.3.2.4 Water-Borne Bacterial and Viral Diseases

Gastroenteric infections are significant causes of illness and death especially among young children. A recent study of Jordanian children found that environmental factors such as contaminated drinking water and lack of proper sewage disposal were significantly associated with malnutrition as a result of gastrointestinal infection, malabsorption of nutrients and dehydration. [3-27] Closed potable water systems and adequate sewage treatment and disposal are planned. At present, however, sporadic and intense epidemics result where antiquated systems and a lack of sufficient water pressure lead to cross-contamination of drinking water supplies. For example, in 1976 a severe outbreak of gastroenteritis, including infectious hepatitis and typhoid, was associated with municipal water contamination. [3-28] Contaminated agricultural water supplies also leads to disease. Personal observation in the East Jordan Valley confirmed the use of the EGMC and secondary irrigation ditches as sources of domestic water. The lack of sufficient quantities of water for maintaining a high level of personal hygiene is also a problem which is exemplified by the large number of reported cases of trachoma. [3-29]

3.3.2.5 Acute and Chronic Exposure to Toxic Substances

Two major areas of concern are the health effects of exposure to agricultural pesticides and exposure to toxic industrial wastes. No official data were found relating to this subject; however, suggestions made off-the-record confirm the suspicion that the current lack of control and increasing use of toxic substances is leading to acute illness and perhaps even death.

3.3.2.6 Control of Motor Vehicle and Occupational Injury

Attempts to collect information on motor vehicle fatality rates were unsuccessful. Nevertheless, it was frequently observed that highway

safety is a problem in Jordan. A lack of police control as well as inherent design problems make the highways of Jordan a significant hazard. It appears, from the lack of any identifiable effort to the contrary, that industrial safety is also an area for concern.

3.4 HUMAN ENVIRONMENT

3.4.1 Archaeological and Historic Sites

Any general description of Jordan's archaeological sites must recognize the changes wrought by recent political developments. The Arab-Israeli war of 1967 caused a serious loss to Jordanian archaeology. Many important sites are now in Israeli-Occupied Territory. The Qumran caves, where the Dead Sea scrolls were discovered in 1948, and the Neolithic/Bronze Age site of Jericho are but two examples of major archaeological sites that passed into Israeli hands. In addition, Jordan's national archaeological museum in East Jerusalem, together with most of its archaeological materials was lost, which accounts for the relatively meager size of the present national archaeological museum in Amman.

On the East Bank are more than 800 known archaeological sites, most of them concentrated in its northwestern quadrant. The East Jordan Valley alone contains 224. Fewer sites exist in the desert regions of eastern and southern Jordan. Only under the Nabataeans, with their sophisticated irrigation systems, and during the Paleolithic Period, with its Pleistocene lakes and higher rainfall averages, did these deserts support significant populations.

A brief summary follows of Jordan's periods of prehistory and history. Each period's most important or most representative sites are shown in Figure 3-4 and listed in Table 3-5. It should be emphasized that the archaeological data base is still very small; fewer than 5% of the known sites have undergone major excavations, and many parts of Jordan are still largely unexplored archaeologically.

The earliest human occupation goes back at least to 100,000 B.C.--the Paleolithic Period. Exact dating of this earliest period has

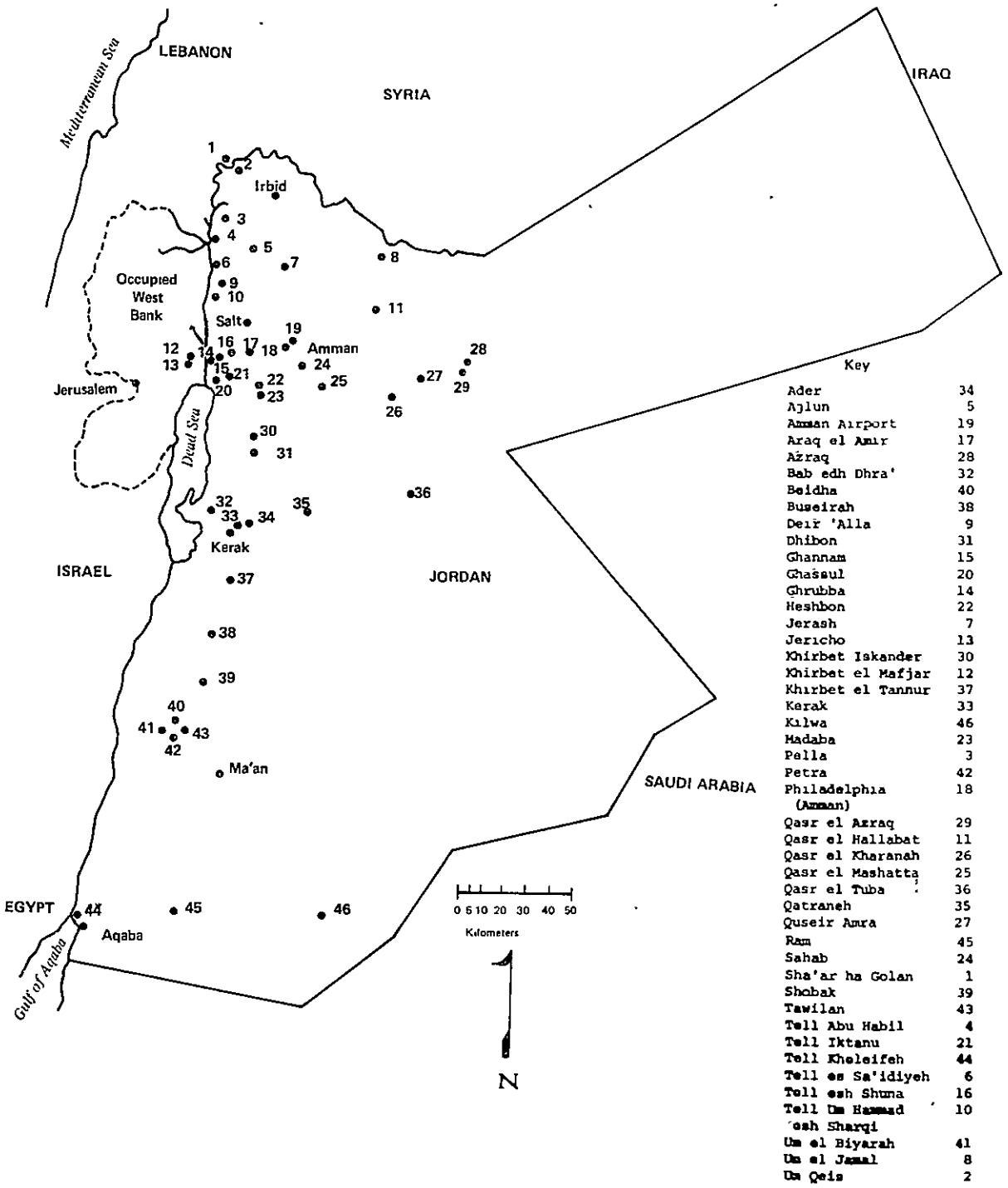


Figure 3-4 Major Archaeological Sites in Jordan

Table 3-5

Chronology of Jordanian Prehistory and History, with Major Archaeological Sites

Period	Major Sites	Years
Paleolithic		100,000+ - 14,000 B.C.
	Azraq	
	Kilwa	
	Ram	
Mesolithic		14,000 - 8000 B.C.
	Beidha	
	Jericho	
Neolithic		8000 - 4500 B.C.
	Beidha	Sha'ar ha Golan
	Ghannam	Tell Abu Habil
	Ghrubba	Tell esh Shuna
	Jericho	
Chalcolithic		4500 - 3300 B.C.
	Ghassul	
	Sahab	
Bronze Age		3300 - 1200 B.C.
Early Bronze Age		3300 - 2100 B.C.
Early Bronze Age IV - Middle Bronze Age I		2300 - 1950 B.C.
Middle Bronze Age II		1950 - 1550 B.C.
Late Bronze Age		1550 - 1200 B.C.
	Ader	Khirbet Iskander
	Amman airport	Tell esh Shuna
	Bab edh Dhra'	Tell Iktanu
	Deir 'Alla	Tell Um Hammad esh Sharqi
Iron Age		1200 - 539 B.C.
	Buseirah	Tell es Sa'idiyeh
	Deir 'Alla	Tell Kheleifeh
	Dhibon	Tell Siran
	Heshbon	Um el Biyarah
	Tawilan	

Table 3-5 (Continued)

Persian			539	- 332 B.C.
Hellenistic Age			332	- 63 B.C.
	Araq el Amir Jerash			
Nabataean			350 B.C.	- 106 A.D.
	Khirbet el Tannur Petra			
Roman			63 B.C.	- 324 A.D.
	Jerash Pella Philadelphia Um Qeis			
Byzantine			324	- 624 A.D.
	Madaba Um el Jamal			
Early Islamic			624	-1099 A.D.
	Khirbet el Mafjar Qasr el Araq Qasr el Hallabat Qasr el Hir esh Sharqi	Qasr el Kharanah Qasr el Mashatta Qasr el Tuba Quseir Amra		
Crusader			1091	-1291 A.D.
	Ajlun Kerak Shobak	Castles		
Maluk			1291	-1516 A.D.
Ottoman Turks			1516	-1918 A.D.
	Qatraneh	Castle		

been difficult because of a lack of excavated, stratified sites. Most of the Paleolithic sites consist of surface scatters of stone tools such as flint scrapers, chopping tools, and hand-axes. Sites are especially common in the southeast and northeast. These earliest inhabitants were nomadic hunter/gatherers whose camps are most frequently found beside permanent springs or on the edges of now-dried-up Pleistocene lakes. The best assemblage of excavated Paleolithic artifacts for the region comes from the Ubeidiya, a site in Israeli-Occupied Territory of the Jordan Valley and just south of the Sea of Galilee.

The Mesolithic Period (14,000-8000 B. C.), known also as the Kebaran and Natufian Periods, is represented by sites throughout Jordan, but again little is known because few sites have been excavated. Only in the lowest levels at Beidha has a good assemblage of Mesolithic artifacts been excavated. Evidence from Beidha and other excavated sites in the region, such as Jericho, indicates that a number of important cultural changes were taking place during this time span. The larger stone tools of the Paleolithic were replaced in the Mesolithic by microliths: tiny flints bladelets and points hafted or set into wooden shafts to make composite tools such as sickles and spears. Accompanying these technological innovations was a shift to a more diversified diet including such varied meat sources as fallow deer, gazelle, onager, pig, ibex, and ostrich. Toward the end of the Mesolithic Period, there is evidence for increased herding of sheep and goats, and of greater preparation of plant foods (the earliest mortars, pestles, and pounders).

The Neolithic (8000-4500 B.C.) marked a major turning point in human evolution. In Jordan, as well as in Palestine and other parts of the Near East, one finds the first evidence of sedentary life and year-round settlements, the first domesticated plants (wheat and

barley) and animals (sheep, goats, cattle, pigs), and the earliest pottery vessels. Beidha is the most extensively excavated Jordanian site from this period, but there have also been small soundings in the East Jordan Valley at Tell esh Shuna, Tell Abu Habil, Ghannam, and Ghrubba, and at Sha-ar ha Golan on the Syrian side of the Yarmouk River. Just across the Jordan River in Israeli-Occupied Territory lies Jericho, the most famous Neolithic site in Palestine.

During the Chalcolithic Period (4500-3300 B.C.) copper metallurgy was introduced into this part of the Near East. Extensive excavations of Chalcolithic remains have been carried out at Ghassul, the largest pre-Bronze Age site in the East Jordan Valley, Brightly painted wall frescoes with varous geometric designs found at Ghassul are currently being restored by a special team of UNESCO consultants. Numerous Chalcolithic sites, some of them in caves, have been in northern Jordan; but only at Sahab, southeast of Amman, have the remains been excavated.

The Bronze Age in Jordan (3300-1200 B.C.) marks the first appearance of urban centers and regular long-distance trade. The different phases of the Bronze Age were each ended by the arrival of new cultural groups such as the Amorites (about 2200 B.C.), the Hyksos (about 1900 B.C.), and the Sea Peoples (about 1200 B.C.). In the Late Bronze Age, Jordan came under the influence and partial control of New Kingdom Egypt. The richest and most important site in Jordan, Bab edh Dhra', has thousands of Bronze Age tombs. Other excavated Bronze Age sites include Tell esh Shuna, Tell Um Hammad esh Sharqi, and Deir 'Alla in the East Jordan Valley; Ader, Khirbet Iskander, and Tell Iktanu in north-central Jordan; and a Late Bronze Age temple at the site of the present Amman airport.

The Iron Age (1200-539 B.C.) saw the rise of three independent kingdoms in Jordan: from north to south they were, Ammon, Moab, and Edom. All were mentioned in the Old Testament and figured directly in the rise of the kingdoms of Israel and Judah in neighboring Palestine. The major excavated sites in Edom(southern Jordan) include Tell Kheleifeh near Aqaba (an important copper-smelting site which probably also was King Solomon's port of Ezion-Geber), Tawilan, Buseirah, and Um el Biyarah. In Moab (central Jordan) excavated sites include Heshbon and Dhibon (the capital of the Moabite king Mesha). Ammonite sites (northern Jordan) include Deir 'Alla, Tell Siran, and Tell es Sa'idiyeh.

Toward the end of the Iron Age, Jordan fell under foreign domination, a status it was to endure, with only a brief respite under the Nabataeans, until the twentieth century A. D. In 733 B.C. the expanding Assyrian Empire under Tiglath-pileser III conquered Ammon. The Assyrian Empire, in turn, fell in 612 B. C. to the Babylonians, who inherited control of most of Jordan. In 539 B.C. Jordan became part of the Persian Empire. Few archaeological remains have been excavated from the periods of Assyrian, Babylonian, and Persian control.

Alexander the Great conquered Palestine and Jordan in 332 B. C. After Alexander's death in 323 B.C., Jordan was incorporated into the Hellenistic kingdom of Seleucia. A major Hellenistic palace is being excavated at Araq el Amir, and extensive remains from a Hellenistic town have been found at Jerash.

The Romans captured Jerusalem in 63 B.C. and went on to control Jordan as a province for the next 400 years. This was a period of pronounced population growth and prosperity, the focus of which became the group of towns and cities in northern Jordan called collectively "the Decapolis." The best-preserved Roman city of the

Decapolis is Jerash, but there have also been excavations at the Decapolis cities of Philadelphia (modern Amman), Um Qeis, and Pella.

In the south, beginning in the fourth century B.C., there evolved an independent kingdom (the Nabataeans) controlling the heavily used trade routes across the Arabian peninsula and down the Red Sea. The spectacular rock-cut Nabataean capital of Petra has been the object of numerous excavations, and a Nabataean temple has been unearthed at Khirbet el Tannur. The Romans did not succeed in conquering the Nabataeans until 106 A.D.

In 324 A. D. Jordan became part of the newly formed Eastern Roman or Byzantine Empire. Remains from the Byzantine Period are most commonly churches, the most completely excavated group being at Madaba, famous for its churches' fine mosaics. The ruins of many Byzantine churches also were found at Um el Jamal.

Fundamental religious and cultural changes took place with the conquest by the Arabs and the arrival of Islam in 624 A.D. The Umayyad kings built many palaces in the eastern Jordanian desert.

The success of the Crusades led to a brief interlude of non-Muslim control between 1099 and 1291 A.D. Crusaders built the great castles at Shobak and Kerak. The Arabs, in turn, built a large fortress at Ajlun in 1184 A.D.

After the Arabs finally expelled the Crusader rulers in 1291 A.D., Jordan came under the sovereignty of the Egyptian Mamluk Dynasty. In 1516 A.D. the expanding Ottoman Empire defeated the Mamluks and ruled until World War I. Qatraneh, an eighteenth-century castle in Jordan's eastern desert, survives as one of several the Ottoman Turks built to protect caravans of pilgrims to Mecca.

3.4.2 History

Until the early twentieth century, Jordan was dominated by outside rulers because of its strategic geographical position straddling major trade routes connecting the Mediterranean with Southern Arabia, Egypt, and Mesopotamia.

When the Ottoman Empire was dismembered in 1918, both Palestine, west of the Jordan River, and Trans-Jordan, east of the Jordan River, became British mandates. In 1922 the British placed the Hashemite Prince Abdullah, second son of King Hussein of the Hijaz (Mecca), on the newly created throne of Trans-Jordan, part of a plan to create a number of pro-British monarchies. Although the mandate ended in 1946, Jordan was not sufficiently independent to gain international recognition at once; the United States recognized it only in 1949.

In Palestine after World War II, conflicts among Zionists, nationalist Arabs, and the British over establishing a Jewish state became acute. The British, unable to implement a U. N. plan for partitioning Palestine into Arab and Israeli sectors, ended their mandate on May 14, 1948. Establishment of the state of Israel led to immediate warfare with its Arab neighbors. Trans-Jordanian forces, the only well trained Arab troops, took control of the Arab sector of Palestine, on the west bank of the Jordan River, which formally became part of the new Hashemite Kingdom of Jordan in 1950. Thus, Jordan's population was two-thirds Palestinian, including one-half million newcomers. In 1951, King Abdullah was assassinated. His son, Talal, became king, but suffered from illness and within a year had to abdicate in favor of his young son, the present King Hussein.

The 1967 Arab-Israeli conflict resulted in the Israeli occupation of all territory west of the Jordan River, including East Jerusalem, and sent 200,000 more newcomers to the East Bank. Tensions led to a civil war in 1970-1971, in which the Arab Legion drove the dissidents out of Jordan. Jordan did not take part seriously in the 1973 Arab-Israeli war.

3.4.3. People

3.4.3.1 Anthropology

Until 1948, Trans-Jordan had a population of only one-half million. More than half lived in tents. The settled population was centered in Ajlun district, a wheat-growing region in the northwest. Balqa and Amman districts were only half settled, since a large part of their populations were semi-nomads who lived in tents but grew crops as well as raising animals. To the south and east, the desert fringes could support only nomadic Bedouins engaged exclusively in raising livestock.

Thus Trans-Jordan continued its traditional role as the boundary between the agricultural communities ruled from Damascus or Jerusalem and the desert tribes based in Saudi Arabia. The Jordan Valley, not a center for trade or agriculture in its recent history, remained uninhabited and unproductive. As a nation, therefore, Trans-Jordan owed its existence to political expediency, and lacked its own distinct and viable historical, ethnic, or economic base.

Socially, Trans-Jordanians were organized tribally. The vast majority were Arab. Until the twentieth century, the term "Arab" applied only to the desert tribes; in this sense Trans-Jordan, with few towns and no cities, was truly an "Arab" state. Tribal

loyalties were thus vital. Tribes and clans were based on patrilineal descent. Local tribes controlled territory, dispensed justice, and engaged in warfare. Tribal feuds and disputes made it difficult to unite except against a common enemy. Even the settled population was also largely tribal. Until the 1920's, village lands in the northwest had been held in common and redistributed every generation on the basis of inherited rights. Villages were often divided into tribal factions. [3-30] Without cities, Trans-Jordan lacked a sophisticated urban elite which might have leavened the tribal character of the society.

Although largely Arab, Trans-Jordan included several non-Arab communities--Chechens and Circassians, two Caucasian Muslim groups which fled Russian dominance in the nineteenth century to become subjects of the Ottoman Empire; Bahais, a non-Muslim religious group which fled from persecution in Iran in the late nineteenth and early twentieth centuries; and Turkomans, Turkish-speaking Muslim nomads transferred by the Ottomans from northeast Iran. Though small in numbers, they wielded considerable economic and political power which continues today. [3-31]

The transformation of Trans-Jordan which, since 1948, has been termed the "East Bank," began with the annexation of Arab Palestine, now the Israeli-Occupied "West Bank." Suddenly, the new Hashemite Kingdom of Jordan had a Palestinian majority. Moreover, the Palestinians differed in some respects from the tribal Arabs.

In Palestine the social organization was based on village affiliation and extensive networks of family relations. Land was privately owned, and the population was largely urban and well educated. [3-32] While struggling against Zionists, the Palestinians had become sensitive to economic and political relationships.

The skills, land holdings, and overseas earnings of the newcomers helped to make Jordan economically viable; large infusions of foreign aid and commitment of Jordanian leaders to development made major contributions. Some differences of attitudes and aspirations existed between the former Trans-Jordanians and the newcomers who shared none of the tribal loyalties on which the monarchy was based. The monarchy, therefore, developed its army around the Arab Legion of loyal Bedouins and limited the access of newcomers to important positions in government.

With the occupation of the West Bank in 1967, Jordan was reduced to its original territory and much poorer economic base. But by this time, the population of newcomers to the East Bank had risen to 40% of the country as a whole and to a majority in urban centers. [3-33]

The influx of newcomers transformed the East Bank from its rural orientation and created a large urban population. Today, about 30% of Jordan's population lives in Amman [3-33], and urbanization is continuing strongly around Irbid and other centers. In the East Jordan Valley, many of these newcomers have also helped to provide a cheap, but skilled, pool of farmers needed to develop new agricultural areas.

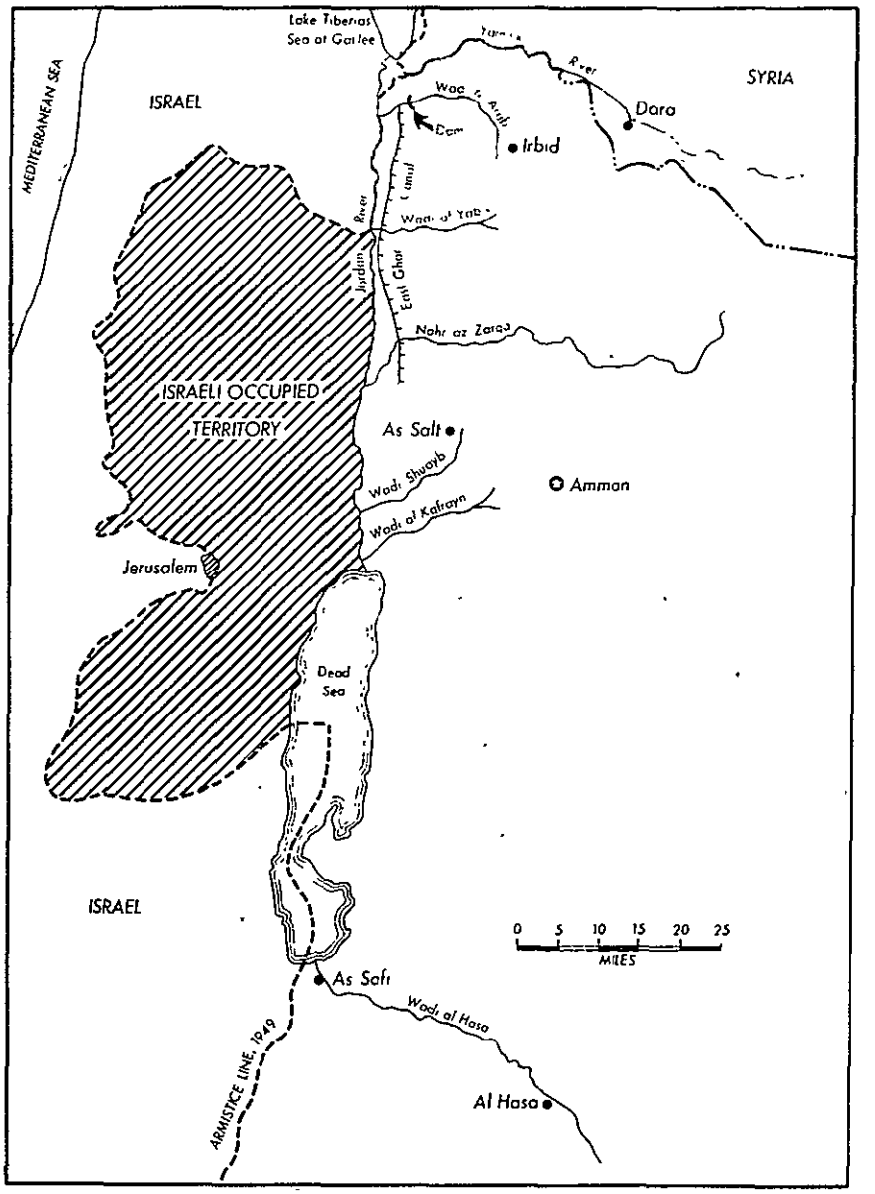
Jordanians working in other countries and remitting their earnings provide much of the resource base for Jordan's current growth. This helps to create a social system in which many males are absent for long periods.

3.4.3.2 Population Patterns

3.4.3.2.1 Population Growth and Distribution

Population growth and distribution in Jordan have always been strongly influenced by water availability. Historically, the land supported a small population which herded camels, sheep, and goats in the desert and semi-arid regions of the country and occasionally settled in areas with more water supplied by the Jordan River system, streams, and underground springs. Although unreliable during dry years, the streams and springs enabled a limited number of agriculturalists to grow grains and some vegetables and to maintain small numbers of domestic animals. Living closely together, for social and defense needs, agriculturalists established small villages of several hundred persons (Figure 3-5). This settlement pattern characterized Jordan's demography until the early 1960's when, with the introduction of more sophisticated technology, water suppies were increased to support a substantially larger and more urbanized population.

This population is highly concentrated in the northwestern corner near the Jordan River and its tributaries. The East Bank population was estimated at 2.1 million in 1977. Many newcomers found refuge after the 1948 and 1968 conflicts in villages and urban centers in Jordan's northwest. Palestinian Arabs now constitute roughly one-half of the East Bank's population; with the native Jordanians, they comprise a predominantly Arab society. The minorities, such as Circassians, Armenians and Kurds, reside in towns and possess economic power disproportionate to their numbers; combined, they made up about 10% of Jordan's population in 1965 and are probably considerably less today given the more rapid increase in Arab peoples.



Source: Area Handbook for the Hashemite Kingdom of Jordan, Foreign Area Studies, American University, 1974.

Figure 3-5 Principal Water Resources of Jordan

The vast majority (80%) of the East Bank's present population is concentrated in the north as is shown in Figure 3-6 which presents the estimated 1977 population for the five administrative districts, or governorates. The governorate of Amman with a population of 1,219,108 contains over half of the East Bank's population. In contrast the combined population of the Karak and Ma'an governorates largely uninhabitable desert due to water scarcity, contain only 8%.

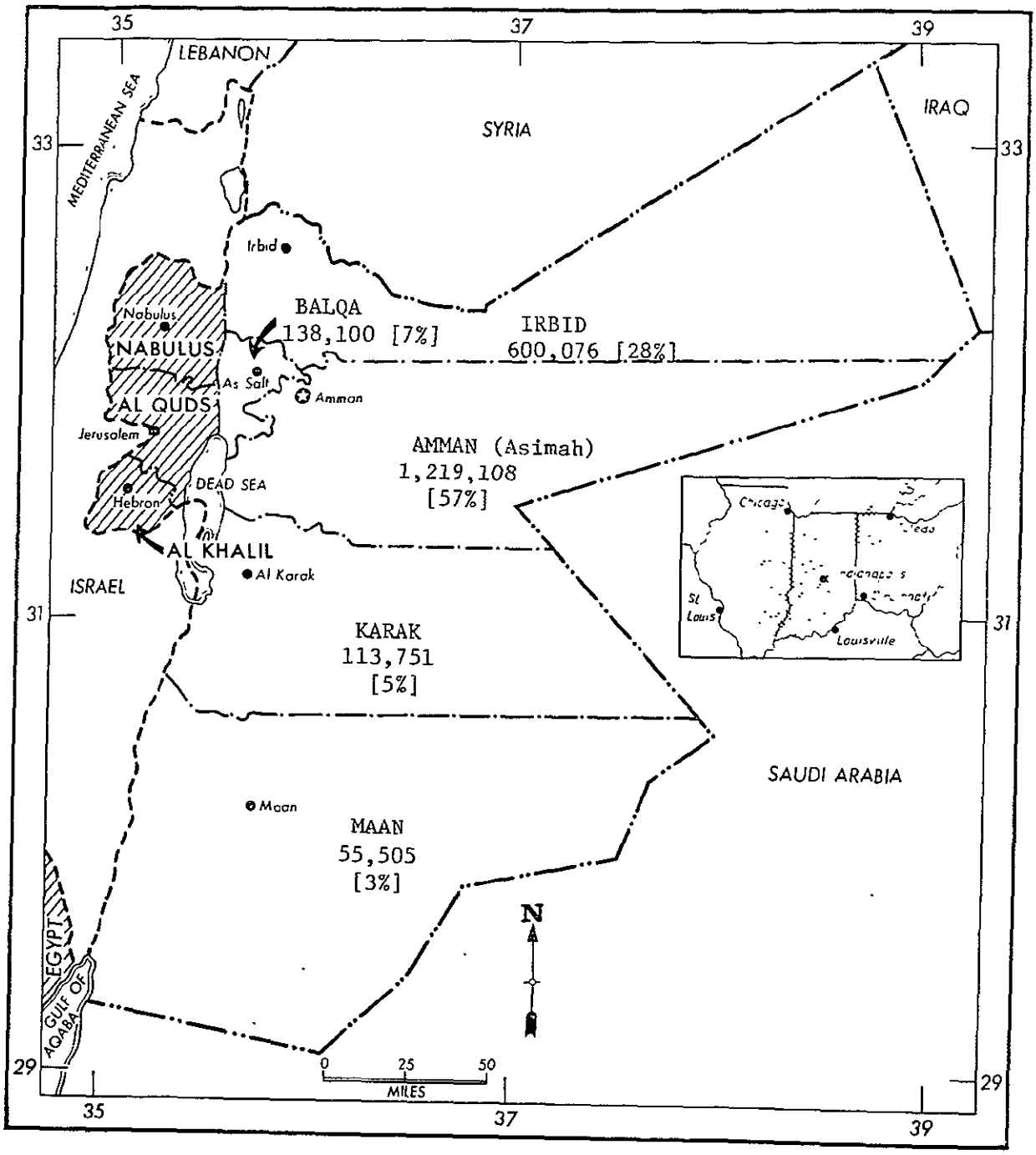
As the result of the in-migration of Palestinian Arabs and high rates of natural increase, the East Bank's population doubled between 1961 and 1977. Table 3-6 compares the East Bank's 1961 and 1977 population by governorate. Population increases were particularly high in Amman and Irbid. Because of its strategic position on the Jordan River, population increases in Balqa have been constrained by defense programs. But population growth in Karak and particularly Ma'an has been modest.

3.4.3.2.2 The Effect of Demography on Jordan's Development

3.4.3.2.2.1 High Rate of Natural Increase

Current demographic trends in Jordan have serious implications for its ability to achieve planned social and economic development. At the current rate of population increase, approximately 3.5% per year, the population will double every 20 years. By 2000 the population which is now 2.1 million will be 4.5 million, and by 2025 it will reach 10 million. This very rapid rate of natural increase has characterized Jordan's demography since the 1950's when child and infant mortality began to drop.

Jordan's annual population growth rate is high not only in comparison with industrialized countries, but also with other middle income and middle eastern countries. Moreover, the birth rate is increasing. From 1970 to 1975, the average annual population growth rate was 3.2%. By 1978 it had reached 3.5%, and by some estimates as high as



[ ] Percent of 1977 East Bank Population.

Source: Area Handbook for the Hashemite Kingdom of Jordan, Foreign Area Studies, American University, 1974.

Figure 3-6 East Bank Population by Governorates

Table 3-6

Population Growth of Jordan's East Bank by Governorate

(1961-1977)

	1961	1977	Increase (%)
Amman (Asimah)	433,618	1,219,108	181.1
Balqa	79,057	138,100	74.7
Irbid	273,976	600,076	119.0
Karak	67,211	113,751	69.2
Ma'an	45,914	55,505	18.3
TOTAL	900,776	2,126,540	136.1

Source: 1977 Statistical Yearbook, Kingdom of Jordan, 1977 population is estimated.

4.2%. Table 3-7 compares average annual growth rates for selected countries and country groupings for the period 1970-1975.

High urbanization rates have not resulted in lowered fertility rates. The number of children born to women living in Jordan's urban areas is somewhat higher than that of rural women; however, the difference is not statistically significant. In turn, fertility rates are higher in rural Jordan than in rural Egypt. [3-34]

The very high rate of natural increase has resulted in a skewed population pyramid as illustrated in Figure 3-7. Over 50% of the East Bank's population is under age 15.

The very rapid rate of natural increase is and will continue to strain existing social service and infrastructure programs to an even greater degree if present birth rates are maintained. Over time, an increasing percentage of gross national product will be required to provide imported foodstuffs, schools, housing, water for domestic and other uses, and services which the current population now enjoys. Unless the birth rate is curtailed, it is unlikely that future generations will enjoy the standard of living maintained by the present generation.

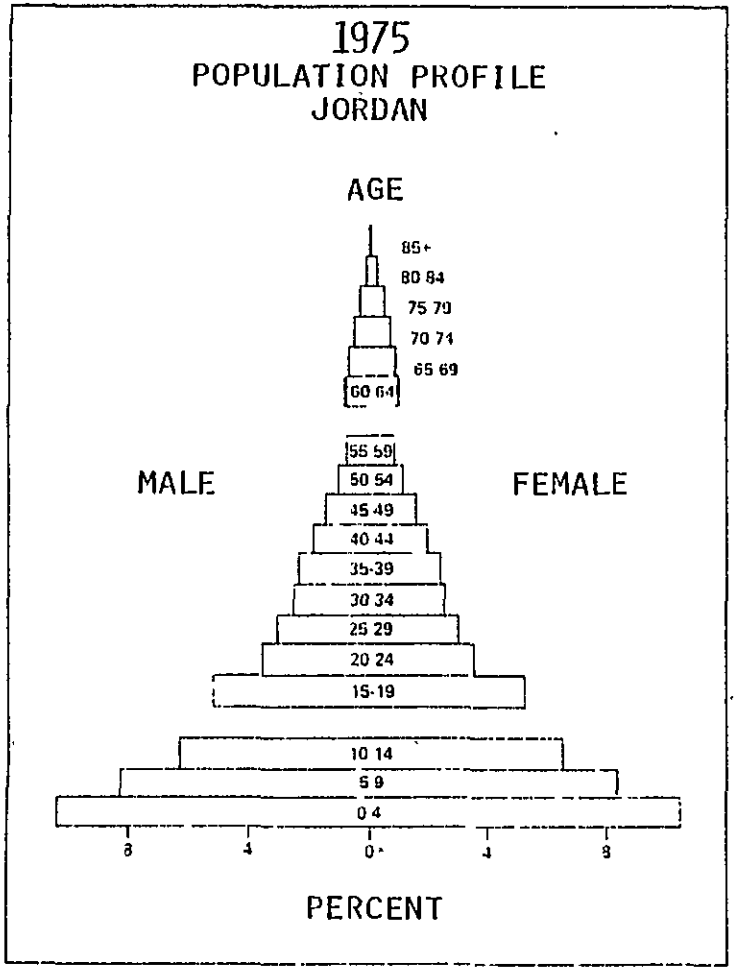
While not undertaking an official population control program, the government is encouraging female education and participation in the labor force, the result of which would be a lower birth rate. According to a 1976 survey an average of 6.5 children are born to an illiterate woman, 3.7 to a primary or preparatory school graduate and, 2.7 to a secondary graduate. [3-34] While statistics on fertility rates by participation in the labor force are not available, statistics do show that the older a woman is when she marries, the fewer children she will have. [3-34] Delayed marriage is usually associated with entry into the labor force.

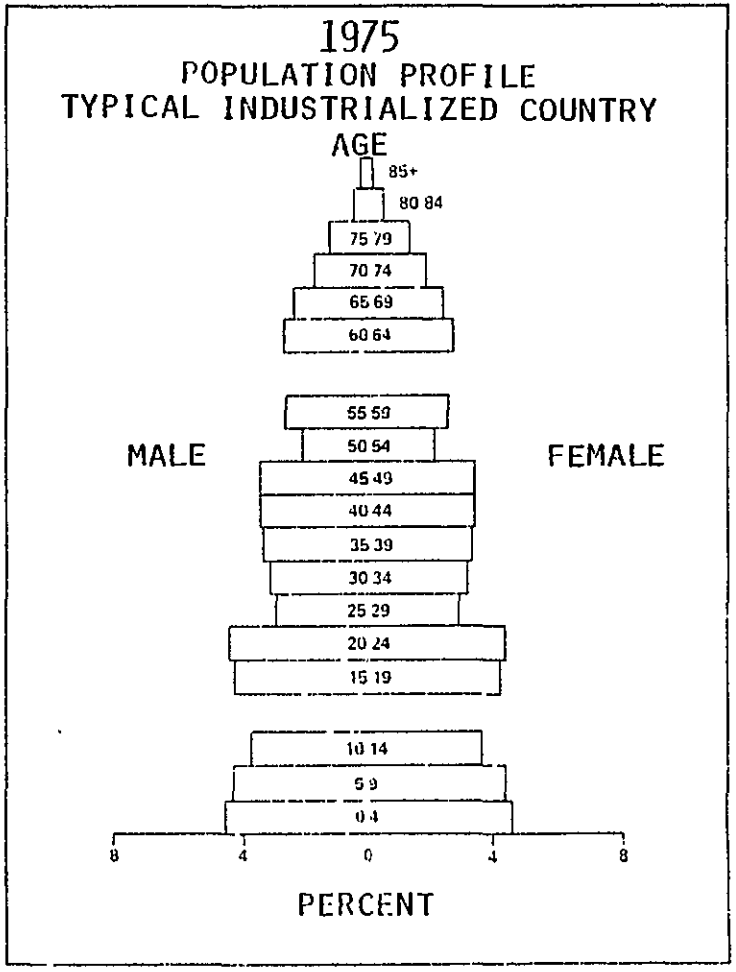
Table 3-7

Average Annual Growth Rates for Selected Countries and Country Groupings--1970-1975

Country	Average Annual Growth Rates (%)
Jordan	3.2
Egypt	2.2
Saudi Arabia	2.4
Iran	2.8
Yemen (Arab Republic)	1.9
United States	0.8
Low Income Countries	2.4
Middle Income Countries	2.7
Industrialized Countries	0.8

Source: World Development Report, 1978, World Bank, August 1978.





Source: Jordan: The Interrelation of Population Factors and Development, Futures Group, Washington, D.C., 1979.

Figure 3-7 Population Profile of Jordan

3.4.3.2.2.2 Urbanization

Although Jordan is already highly urbanized by Third World standards, its rate of urbanization is rapidly increasing. In 1975 over two-thirds of the country's population was considered urban. This was a sharp increase over 1961, when less than half of the country was classified as urban. The combined populations of three northwestern cities Amman (750,000), Zarqa (244,700) and Irbid (150,000) constitute slightly over one-half of the East Bank's population. The City of Amman alone comprises 33.4% of the country's total population. [3-35] The remaining urban population is scattered among 80 to 90 smaller towns with a minimum size of 2500; the largest are Salt near Amman and Ramtha near Irbid with 30,000 to 40,000 people each.

Rapid urbanization is a relatively new phenomenon. One cause was the influx of newcomers in 1967 and 1973. The other is a powerful rural-to urban migration, particularly among younger people. Both have strained urban infrastructure systems, housing, and local economies.

While annual population growth rates of Jordan as a whole have averaged between 3% and 4% per year over the past two decades, growth rates of its major cities have been much higher. Amman, for example, has grown at a rate of about 6% since the late 1960's, down only slightly from the rate of the 1950's. This continuing pressure has caused the government, aided by private and international interests, to begin long-range planning for both the Amman and Irbid regions.

The non-urban population is classified into two groups. About 29% of the population are classified as rural and 6% as nomadic and semi-nomadic. Rural residents live in some 200 small villages, most having fewer than 1000 persons. Most are in Irbid governorate where water for domestic and agricultural use has been available from wells,

supplemented in recent years by improved surface irrigation systems fed by the Yarmouk River and smaller streams. The Nomads and semi-Nomads move with their herds among agricultural settlements and rocky hillsides, and, when rainfall increases vegetation temporarily, eastward toward the desert.

Finally, a significant proportion of the people still live in newcomer camps. These consist of row upon row of handmade "temporary" houses of cinderblock and other materials comparabe to houses elsewhere in Jordan. The camps are built in the countryside but not far from the major cities and their job opportunities. At present, ten such camps house close to 300,000 people.

3.4.3.2.3 Labor Force Participation

Given the broad base pyramidal structure of Jordan's population and a nine-year compulsory education policy, labor force participation is low. According to the Labor Force Census of 1975, labor force participation was 20% of the total population. Almost two-thirds (63%) of the total labor supply of 385,000 is engaged in service industries. The remaining workers are almost evenly split between agriculture and manufacturing.

Available labor supply is diluted by the large number of young Jordanian men who work in neighboring Arab states and Europe. Data on emigration are fragmentary. Estimates drawn from various statistical reports indicate that approximately 100,000 Jordanians or 30% of the labor force is working in neighboring states. Ministry of Labor officials say that two-thirds of the male labor force is working outside of the country.[1]

[1]Interview with Islen Ajluni, Minister of Labor, March 31, 1979.

These men are considered to fall into the 20-39 age group and to possess medium-to-high-level skilled and technical workers. Interviews with the National Planning Council indicate that this type of migration is expected to be relatively short term for the following reasons:

- The wage differential between Jordan and other Arab states is narrowing as Jordanian wage levels increase.
- Other Arab states have and are training indigenous personnel to replace foreign labor. This has been particularly true in teaching.
- Jordanians, after a certain age, will return in order to be close to their families and to place their children in Jordanian schools.

The Jordanian labor supply has been supplemented by in-migration of Egyptians and Asian nationals such as Pakistanis and Koreans. These workers are drawn to Jordan by the high wages and economic opportunity vis-à-vis their own countries. They tend to be employed in agriculture and construction industries. In interviews with the Ministry of Labor, one-third of the labor force is cited as foreign.

The exodus of Jordanian males has also resulted in a increased female participation rate. Although the female participation rate was only 4% according to the 1975 Labor Supply census, officials estimate that it has risen to 12% in 1979. The government is actively encouraging female labor force participation by providing not only conventional education but also special training programs. Women also comprise a substantial percentage (32%) of the agricultural work force. In an effort to integrate women into the country's development, a Department of Women's Affairs has been established within the Ministry of Labor. A plan to achieve effective integration is now being drafted and will be incorporated into the next five-year plan. It will address the present status, needs, and future aspirations of women.

3.4.3.3 Social Factors Favoring Modernization

3.4.3.3.1 Socio-Economic Indices

By Third World standards, Jordan's level of modernization is already impressive. Jordan's per capita income places it well above that of low-income countries. With a per capita income of $610, Jordan is considered by the World Bank to be a middle income country. Jordan falls midway in the ranking of the Arab states as shown in Table 3-8. Jordan's lack of natural resources, including oil, has placed it far behind oil-rich states such as Saudi Arabia, Kuwait, and Iraq. However, Jordan's adult literacy rate is 62%, much higher than many other Arab-speaking countries, as shown in Table 3-8.

Jordan's labor force is well-educated. Almost one-fourth hold secondary and/or post secondary degrees. [3-36] These individuals could provide the managerial and technical leadership required by modern complex organizations. Jordan's future development must capitalize upon its labor force which, in comparison with surrounding states, is highly educated and highly skilled. As indicated in Section 3.4.3.2.3, a high percentage of Jordan's skilled labor force is not contributing to the country's development program within Jordan, but is working abroad in neighboring states and Europe. Their remittances of salaries to families in Jordan does, of course, represent a contribution.

3.4.3.3.2 Rural Development

Jordan's level of modernization is perhaps most impressive in rural areas.[1] Even in small villages many adults are literate. Compulsory education for both boys and girls is widely embraced. In several days of interviewing men and women in the Valley, we observed that

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[1] Compared to many developing countries, in which 70% to 80% of the labor force is engaged in agricultural activity characterized by low levels of mechanization and productivity, only 18% of Jordans's labor force falls within the agricultural sector.

Table 3-8

Per Capita Incomes and Literacy Rates of Selected Arab Countries

	Per Capita Income (1976) (U. S. Dollars)	Adult Literacy Rate (%) (1974)
Egypt	280	40
Syria	780	53
Jordan	610	62
Iraq	1,390	26
Iran	1,930	50
Saudi Arabia	4,480	15
Kuwait	15,480	55

Source: World Development Report, 1978, World Bank, August 1978.

no school-age children were present during school hours in either crop fields or homes, and parents reported that their children were in school.[1] In response to survey questions concerning future expectations for their children, parents responded that they wished additional education for both sons and daughters. Future hopes for daughters included becoming teachers and nurses. Only one respondent out of fifty wanted only marriage for his daughter.

The survey also revealed that Jordan's rural people are highly mobile and have been exposed to a variety of people and events. Although this stems partly from the exodus of Palestinians from the West Bank, survey results indicated that rural residents regularly go up to Salt, Irbid, and Amman to shop and visit relatives. Good roads and a regular bus service foster such urban-rural linkages. Through the military service and employment in other Arab states and Europe, Jordanians, including rural residents, have lived and worked in non-Jordanian environments and are more receptive to adopting new technologies.

Although electricity is unavailable in most rural villages, nearly all survey respondents indicated that they listen to the radio daily to hear news, music, and the Koran. Battery-run televisions were also found in some villages.

Adoption of new agricultural practices is widely apparent particularly in the Valley, where farmers have begun to grow vegetables under plastic greenhouses to conserve moisture.

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[1]A survey was conducted by Arthur D. Little, Inc., staff members in the Jordan Valley to ascertain current socio-economic environment and to obtain rural residents' impressions of the effect of the proposed project.

Nearly all Valley farmers interviewed use tractors and other types of mechanized equipment. Fertilizer and pesticides are used widely, although not always wisely.

The mobility and positive attitudes toward adapting to modernity of rural Jordanians is in sharp contrast to the isolationism and rigidity which typifies thousands of interior villages of India and sub-Sahara African countries.

3.4.3.3.3 Egalitarianism

Village life is strongly influenced by the Islamic precept of egalitarianism. Desert life did not permit great differences in material possessions among Bedouin tribesmen, and this tradition has been retained in village life. Although villagers' occupations and incomes may vary substantially, especially given current opportunities of men to work outside while maintaining their families within the village, this economic differentiation has apparently not yet produced distinct social groupings. Money earned outside the village is often used to purchase land, an automobile, or a tractor. Owners often rent out their tractors to other farmers.

Jordanians living in urban areas are also disinclined to conspicuous consumption.

Increasingly, agricultural lands within the village are owned and operated by small farmers. Except in the southern Valley and in Wadi Araba, south of the Dead Sea, large absentee landlords are not as prevalent as in many countries. These small farmers who own 10 to 40 dunums (2½ to 10 acres) are assisted during harvest season by occasional paid laborers, and in some instances by sharecroppers and their families as well. During our field survey, we observed relations among landowners, sharecroppers, and daily wage laborers to be friendly and informal. Moreover, owners and sharecroppers showed supportive and paternalistic

attitudes toward female laborers, particularly the many widows of the 1948 and 1967 wars.

In summary, Jordan's present society possesses many characteristics considered prerequisites to modernization. These include: a predispostion to changes resulting from dislocations, adoption of modern agricultural technology, strong urban-rural linkages, literate populace, and equality despite differences in income and material possessions. These characteristics are not limited to a small percentage of the population. They are found in all societal segments, creating a fertile environment in which modernization can occur.

3.4.4 Public Institutions and Services

3.4.4.1 Public Sector Organizations and General Services

Jordan's constitution, promulgated in 1952, authorizes three branches of government--legislative, executive, and judicial; but it vests predominant powers in the monarch. The King commands the armed forces; appoints the prime minister, the cabinet, judges, and governors; calls general elections (last held in 1967); convenes, adjourns, and dissolves the Assembly (dissolved in 1974, and reconvened for three days in 1976 to approve indefinite postponement of the pending election); and approves and promulgates laws. Indeed, the formalities of a modern state, constitution, and government are relatively new compared to the lineage of Jordan's leading families and tribes. Hence, government institutions are overshadowed by the personalities of leaders--nationally by the King, and locally by governors and sheikhs.

Jordan's major development efforts are conceived, guided, financed, or executed mainly by public sector agencies. These are of two types: purely government agencies, such as ministries; and independent agencies, such as the Natural Resources Authority, which are legally separate yet still derive their status (and often their financial resources) from government. Figure 3-8 shows the government framework, ministries, major independent agencies, and their relationships to the King.

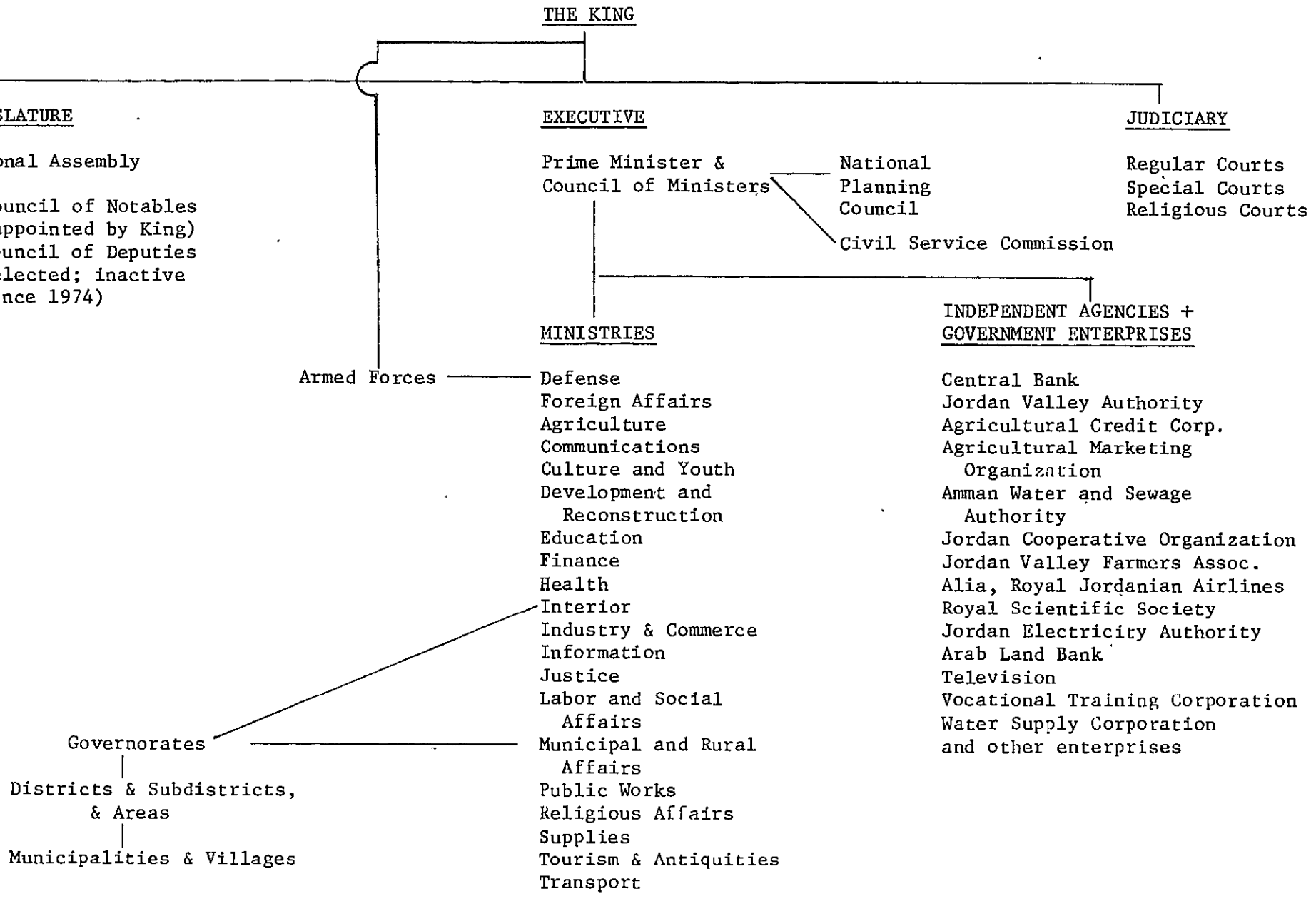

Figure 3-8 Major Public Sector Organizations of Jordan, 1979

Central ministries, staffed by professional civil servants, set policy and standards for the nation. Planning, a key government contribution to development, began with the World Bank's advice during the 1950's and worked well during the 1960's and also, despite the loss of the vigorous West Bank economy, the 1970's. The National Planning Council sets national goals, develops projects, coordinates agencies programs, manages foreign fund resources, and monitors progress. Present population growth is causing planners to broaden their focus beyond towns and cities; regional planning is well underway for the Irbid and Amman metropolitan areas, and is expected for Aqaba.

Public services may usefully be categorized by level of government and by topic or sector. Some general and national services are provided by central government ministries and agencies; examples are defense, foreign affairs, planning, police, air transportation, finance, and scientific research. Other services are provided mainly by or through governorates and municipal and village councils, within the framework of central plans and policies. Governors and district officers are responsible for coordination within their jurisdictions of planning, public safety, development projects, and common services such as education. Municipal and village councils are supposed to provide local functions such as street cleaning, water supply, sewage disposal, supervising public markets and amenities, fire prevention, collecting minor taxes, animal control, and building licenses. However, not all towns and villages have councils, either because they are too small to qualify or because factionalism or maladministration have caused district officers to suspend them; indeed, some Jordanian observers report that local government is none too vigorous or successful.

Administratively, national policies and plans are executed through the five East Bank provinces or governorates. Their boundaries are shown in Figure 3-6. Each governor is assisted by an executive council which includes a representative of each central ministry and is thus an important regional coordinating tool. Moreover, each governor has a

consultant's council of about 50 prominent community and village leaders who advise the executive council.

Each governorate is further divided into districts, subdistricts, and areas; all are headed by appointed central government administrators. Local governments may be formed in municipalities and villages, with councils elected by citizens. However, the elections of councillors and mayors must be approved by the governors, who may (and often do) replace them at will by civil administrators. Moreover, local administration and finances are supervised closely by district officers and the Ministry of Municipal and Rural Affairs.

Independent authorities as instruments for development seem to be growing in number and significance, in Jordan as elsewhere. These public enterprises enjoy, ideally, both access to government resources and autonomy to manage themselves in response to market opportunities. For example, the Jordan Valley Authority is remarkable among government agencies in both Jordan and other Arab countries for its energy and effectiveness.

Some services were provided by local councils. But changes in technology have increased financial and engineering requirements beyond the capacities of local councils. Water and electricity, especially in the densely populated northwestern districts, are becoming largely the responsibility of central government enterprises, such as the Natural Resources Authority and Jordan Electricity Authority. Similarly, other functions such as sewage disposal may in time be moved from local to central government.

Of the various service sectors in Jordan's development plan, education and health are nationwide in scope and are discussed in the following sections.

3.4.4.2 Education

Elementary, secondary, junior colleges, and vocational education are the responsibility of the Ministry of Education. The country is divided into 13 directorates for administrative purposes. While the budget is centrally prepared, it is divided among the directorates on the basis of the population, teacher availability, and the special needs of the area.

Because of the relatively fluid nature of Jordanian public administration, there are no rigid channels through which the Ministry works with local governments to profile educational services. Initiative for provision or upgrading of educational programs can be taken at the local, directorate, or ministerial level. The approach taken depends upon the relationships of the Undersecretary, others within the central Ministry, the directoral staff to the villages, and also the governor of the governorate in which the village is located. Villagers are usually expected to contribute either land or a portion of the cost of constructing a school within their village.

As the result of the very high proportion of the population which is of school age and a national policy of compulsory universal education until age 16 or the completion of nine years of school, educational resources within the country are strained. Teachers are responsible for 30 to 40 students. While this pupil-teacher ratio contains a much higher number of students per teacher than that generally found in developed countries, it is a practical standard, given available educational personnel. Because of the insufficient number of teachers throughout the country, teachers are assigned extra loads to ensure that education is provided to all children. The burden of educational resources is heaviest in the urban areas where most population growth has occurred. In these areas, many children attend schools in rented buildings which were not designed to provide educational services.

3.4.4.3 Health

The Jordanians receive health care from many sources, the primary being the Ministry of Health. Other health-related institutions include the Royal Medical Service (military), private-practice physicians, the United Nations Relief and Works Agency of Palestine Refugees, the University of Jordan Medical Faculty, the Ministries of Education and Religious Affairs and the traditional private system of operating midwives (dayahs). This diversity in health care sources, and often the lack of coordination among them, are the outstanding characteristics of Jordan's health care sector.

Recognizing the lack of a comprehensive health information system and of central policy direction, a consensus of professional opinion throughout the health community recognizes both the need for a stronger coordinating effort and the fact that the Ministry of Health is the appropriate organization for the task. Under 1971 and 1976 legislation, the Ministry was assigned broad authority to provide preventive, curative, and pharmaceutical services; to develop health education and training; to supervise the private sector health services; and to formulate a national health policy.

Significant improvements in the quantity and quality of health services have been achieved, although not wholly due to government stimulation. The health sector received a low level of investment in the Five-Year Plan for Economic and Social Development 1976-1980, receiving only about 1.2% of the total national investment. Over half of these funds were designated for hospital construction and over a third for new clinics. Eighty-two percent of this funding was to come from Jordan's general budget, 11% from Jordan's own private sector, and the remaining 7% from foreign sources. [3-17, 3-18]

3.4.5 The Economy

3.4.5.1 General Setting and Structure

The predominant characteristics of Jordan's economic setting are (a) its small but rapidly expanding population, (b) its limited physical and mineral resources, (c) a weak agricultural base, (d) a trade and service-oriented economy, and (e) a development process which depends heavily both on foreign aid and on remittances from Jordanians working abroad.

Despite the serious problems which have confronted Jordan, its progress since 1948 has been notable. In its earliest years, Jordan's infrastructure was woefully inadequate even in relation to other Arab states, particularly with respect to transportation, electricity and water supply, and educational and health facilities.

Between 1954 and 1966, the rate of growth of the economy was rapid. In 1966, Jordan's per capita GNP ranked in the Middle East behind only those of the three richest oil states and Lebanon. The 1967-1971 period was distorted by the aftermath of the Six-Day War and the domestic turbulence of 1970-1971. Only after this period was the country able to turn its attention to longer-term economic development. During the 1973-1975 period, the gross domestic product (GDP) grew about 5% per year, and the industrial sector (mining, manufacturing, and construction) rose from 18% to 21% of GNP. As a result, Jordan's GNP has risen from about $140 million (U.S.) in 1954 to about $1.4 billion (U.S.) in 1975. Per capita GNP was about $250 (U.S.) in 1967 but had risen to $610 (U.S.) by 1976.

Jordan has no petroleum[1] and few metallic minerals in commercially developable quantities.[2] It is rich in high quality phosphates, but in the past, these were not available in sufficient quantities and at low enough prices to justify substantial industrial development; however, they can now be exported via Aqaba and contribute to the balance of payments. Recent developments may improve this situation further.[3] Few other minerals are available. So, compared with the mineral riches of its neighbors, Jordan appears poor indeed.

Its principal natural resource has long been its 400,000 to 600,000 ha of cultivatable land.[4] One rich area is the broad fields around upland Irbid, suitable for grains. The other is the 60,000 ha of the East Jordan Valley where, with warm winter temperatures and water from irrigation, high-value fruits and vegetables can be raised for Jordan's cities and for export, mainly to the Persian Gulf. Nonetheless, agriculture's contribution to Jordan's GDP dropped during the 1970's, as did agricultural employment.

A major problem for the Jordanian economy has been its difficulty in absorbing its labor force, in part because of the increases in working age population as well as the influx of Palestinian refugees. Conversely, one of Jordan's principal resources is its educated and skilled manpower, due partly to immigration of young, urban Palestinians and partly to the British-created tradition of training soldiers. As a result, Jordanian

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[1]Petroleum exploration is continuing in the Dead Sea-Jordan Valley area and in the northern highlands with no major results as yet.

[2]Copper explorations are going on in the Farnan area along with prospecting for iron ore, lead sulfide, marble, tin, pyrite and gypsum in other parts of the country.

[3]The phosphate exploration program resulted in revised estimates of deposits from 300 million tons in 1972 to 1200 million tons in 1975, Subsequently, sales have increased along with the potential for more development in this sector, including phosphate fertilizers.

[4]Estimates for cultivable land range as high as 1.5 million ha if water could be made available.

military personnel serve in the armed forces of other Arab states--particularly in the Persian Gulf. This is a major source of revenue for many families with younger males. Indeed, skilled manpower is a key export, particularly to the oil-rich but manpower-poor economies of the other Arab states. It has been estimated that 20% to 50% of Jordan's labor force works abroad and sends paychecks home to their families.

These trends in the agriculture and service sectors are reflected in Tables 3-9 and 3-10.

Jordan registered high real growth rates of 12% in 1976 and about 8% in 1977. These resulted partly from booms in mining, as donor-assisted investments came on-stream, and in construction, fueled both by foreign aid for infrastructure projects and by private remittances from abroad for building houses. Growth rates for 1979-1980 are expected to be about 6% to 8% per year.

The following subsections discuss several sectors of Jordan's economy.

3.4.5.2 Agriculture

In 1977, Jordan had approximately 200,000 ha under cultivation in field crops; 20,000 in vegetables; and 40,000 in fruit crops. Wheat is by far the principal crop with respect to area farmed, comprising nearly 50% of all cultivated land. Tomatoes are the principal vegetable crop followed by eggplants, melons, and cucumbers. Over 80% of the land in tree crops is olives. However, in terms of tonnage produced, citrus and grapes are more important. In addition to the above major crop categories, 3000 to 4000 ha of tobacco are planted annually. Within the livestock sector, sheep and goats are of primary importance with the national flock size being approximately 850,000 and 350,000 head, respectively, in 1977. Beef cattle are of minimal importance. The national dairy herd is approximately 13,000 head (1975), and there are approximately 800,000 birds in the national poultry flock.

Table 3-9

Employment By Economic Sector--1961-1973 (%)

	1961	1970	1973
Agriculture[1]	33	33	18
Manufacturing-Mining	10	7	9
Construction	10	2	9
Electricity-Water Supply	1	1	1
Transport-Communications	4	3	7
Wholesale-Retail Trade[2]	8	7	14
Banking-Finance	-	1	2
Public Administration-Government Services[3]	14	23	36
Services	13	10	-
Ownership of Dwellings	NA	NA	NA
Other	7[4]	14[4]	5
TOTAL	100%	100%	100%

[1]Includes crops, forestry and livestock production.

[2]Includes hotels and other tourism facilities.

[3]Includes armed services.

[4]Includes unemployed labor force.

[5]Total employment 400,000 to 450,000 in the late 1970's.

Source: Five-Year Plan for Economic and Social Development, 1976-1980, National Planning Council.

Table 3-10

Relative Share of Main Sectors in Gross Domestic Product

(%)

Period	Agriculture	Industry	Services
1954-1961	22	13	65
1962-1966	21	16	63
1967-1972	18	17	65
1973-1975	12	24	64

Note: In countries at similar stages of development, the services sector contributes to no more than 40% of the GDP and employs 15% to 25% of the labor force.

Source: Five-Year Plan for Economic and Social Development, 1976-1980, National Planning Council.

Unlike most developing countries, yet typical of many countries in the Middle East today, Jordan does not derive a major share of either its employment or national output from the agricultural sector. Net agricultural income as a portion of GNP has declined from 25% (JD 13 million) in the mid-1950's to approximately 10% (JD 58 million) at present. The International Bank for Reconstruction and Development (IBRD or "World Bank") estimates it as only 7% of GDP in 1978.

In only the six-year period, 1972-1978, that portion of the national labor force engaged in agriculture was estimated to have declined from 33% to 18%. [3-37] The most recent agricultural census (completed in 1975) indicates 125,000 persons employed in the agricultural sector. Of these, slightly less than 60% were permanent workers, with the remainder seasonal or occasional laborers.

The 1967 census of agriculture indicated that over 70% of those persons engaged in agriculture were farm operators and their families, and the remainder were wage earners. Approximately 20% of the total agricultural labor force was women. However, at that time, very few women were engaged in farm employment outside a family-run operation. At present, both the percentage of wage earners and the percentage of women in the agricultural work force has increased. In addition, it is more common now than a decade ago to find women employed for wages on farms other than their own family's. Women appear to be especially important during planting and harvesting.

In 1975, approximately 74% of land farmed in Jordan was owner operated; 12% was rented or sharecropped; and 14% was a mixed arrangement of ownership and rental or sharecropping. In terms of size of holding, the 1975 agricultural census indicated that over 24% of the agricultural holdings were of one ha or less, approximately 56% were from one to 10 ha, and only 20% were greater than 10 ha. This had changed from 35%, 50%, and 15%, respectively, a decade earlier, indicating an increase in size of the average holding.

In 1977, approximately 4700 workers were employed in food or other industries processing agricultural commodities. Approximately, half of these were employed in food manufacturing enterprises such as milling, dairy processing, preserving fruits and vegetables, baking, etc. The remainder were employed by beverage, tobacco, leather (tanning), and weaving/textile operations. Value added by these "agro-industries" was estimated at nearly JD 9 million in 1974.[1] In addition to these industries, agriculturally related transportation, marketing, service, and government enterprises or organizations likely employ several thousand additional persons throughout Jordan.

As would be expected, the vast majority of those engaged in agriculture are found in those parts of Jordan with the greatest amount of water availability. Consequently, except for people involved in land-extensive grazing, most farmers are found in the Jordan Valley and several "semi-humid" areas scattered between Irbid and Amman west of Jordan's vast deserts, and in the vicinity of Karak.

3.4.5.3 Manufacturing - Mining

The mining and industrial sector, despite the limitations of natural resources and absence of large internal markets, has been growing over the past few years. It increased its contribution to the GDP from 11.1% in 1973 to 14.8% in 1975. This is a faster increase than any of the other productive sectors of the economy.

While much of this increase resulted from increased prices for exported phosphates, it also reflected new or increased production in other industrial segments. Table 3-11 shows employment and number of establishments in Jordan's principal industries, which, through extensive efforts of the government and outside investors, have been expanding during the 1970's. Table 3-12 shows trends in production of Jordanian industries over time.

[1] Haddad, Dr. Mohammed K., The Agricultural Sector of Jordan, Royal Scientific Society, July 1976.

Table 3-11

Industrial Establishments Employing Five or More Persons

Economic Activity	No. Of Employees	No. Of Establish-ments	Wages & Salaries (thousand JD)	Value Added (thousand JD)
Mining and Quarrying	2,965	71	2,812	16,432
Food	2,391	126	848	3,411
Beverages	182	4	65	935
Soft Drinks	294	5	174	527
Tobacco & Cigarettes	525	4	451	960
Weaving & Textiles	1,098	59	477	1,321
Clothing	719	52	302	2,052
Leather & Leather Products	239	6	127	2,277
Footwear	322	11	161	873
Wood Products	502	51	249	434
Paper Products	378	8	144	452
Printing and Publishing	404	28	218	664
Chemical Products	468	17	242	2,061
Petroleum Products	1,531	1	1,501	6,026
Rubber Products	194	4	87	28
Plastic Products	296	10	83	948
Non-Metallic Product	2,120	66	1,307	4,775
Metallic Product	1,202	47	588	3,049
Electric Appliances	388	2	132	572
Transport Equipment	77	13	37	205
Miscellaneous	172	13	94	197
Electricity	1,597	3	977	1,847
Total	18,214	601	11,076	49,046

Source: 1977 Statistical Yearbook, Kingdom of Jordan.

Table 3-12

Production of Principal Industries in Jordan, 1967-1971

Product	Unit	1967	1969	1971	1975	1977
Phosphate (dry)	thousand tons	917.8	1,087.3	640.0	1,352.5	1,769.3
Cement	thousand tons	289.2	480.4	418.9	598.2	537.6
Petroleum products	thousand tons	392.6	464.1	556.7	828.2	1,145.5
Tanning:						
Sole leather	tons	329.4	373.7	397.4	531.4	345.5
Upper leather	thousand sq. ft.		1,678.0	1,888.0	2,230.7	2,873.9
Detergents	tons	1,300.0	1,312.0	2,592.0	4,203.0	6,026.7
Liquid batteries	thousand units	45.6	66.9	40.0	44.4	51.3
Cigarettes	tons	1,804.0	1,803.0	1,536.0	1,998.0	2,700.0
Spirits and alcoholic beverages	thousand gal.	505.0	579.0	633.0	1,453.9	1,462.9
Paper	tons	n.a.	2,741.0	2,109.0	4,147.0	5,228.0
Electricity	million kWh	91.1	122.7	133.7	256.7	401.3
Iron	tons	n.a.	26,551.0	9,214.0	31,304.0	77,605.0
Textiles	thousand yards	443.0	512.0	748.0	953.0	869.8
Fodder	tons	19,941.0	21,533.0	34,204.0	41,457.0	63,182.0

n.a. - not available

Source: Adapted from Central Bank of Jordan, Eighth Annual Report: 1971, Amman, 1972, page 12; Fourteenth Annual Report: 1977, Amman, 1978, page 17.

Two characteristics of these emerging industries are important for Jordan's future development. First, only 15 large industrial firms employ 100 or more people. The firms contribute about three times as much production per worker as smaller firms. About 580 firms employ from five to 99 people, and perhaps 6000 establishments employ four or less--mostly in handicraft and other small-scale industries. This indicates that Jordanian industry, although expanding, can now serve only selected local markets. Second, industry is concentrated around Amman and Zarqa to take advantage of their markets and labor. Other areas have yet to feel the impacts and advantages of major industrial growth.

3.4.5.4 Tourism

Tourism has always been important to Jordan's economy. It is the second largest source of foreign currency (the first being remittances from Jordanians working abroad). Tourism earnings exceeded those from all other export commodities combined in 1977. Tourism contributes about 20% of GDP. About two-thirds of the 7.8 million persons entering Jordan in 1976 were tourists; over half of these came from neighboring Arab states. The forests, mineral springs, and stream valleys of upland Jordan have traditionally attracted Arab families from more arid areas; many Syrians come on weekends to spend a day in the Yarmouk Valley which is only an hour's drive from Damascus.

Before the 1967 war, Jordan's economy benefited greatly from visitors to Jerusalem, a holy city to three of the world's great religions. Tourism began to revive in the 1972-1975 period, only to be dampened again by the civil war in Lebanon.

Even without the Israeli-Occupied Territory, the Kingdom is rich in potential attractions. Historic sites from antiquity, particularly Petra and Jerash are unique. Medieval castles, deserts and valleys, and Jordan's coastline on the Gulf of Aqaba have already been developed for tourism.

Development of a large and expanding tourism industry is an important priority in the current five-year plan. The program seeks to:

- Improve important antiquities and archaeological sites, including excavation of such important sites as Um Qeis, overlooking the Yarmouk Valley and Deir 'Alla, in the central East Jordan Valley.
- Construct new visitor centers and rest houses near main attractions.
- Encourage construction of modern hotels both in Amman, which now has the overwhelming number of rooms, and in outlying areas. The object would be to lengthen the average stay, now only 2.6 nights.
- Improve both internal and external transportation networks, including highways (over 80% of the tourists come by road) and local air service (between Amman and Aqaba) and helicopter service (between Amman and Petra and other important sites).
- Promote more tourism, particularly from Europe and North America. Western tourists spend two to three times as much as Arab tourists, but now constitute less than 20% of Jordan's total traffic.
- Cooperate more closely with neighboring states in promoting tourism in the Middle East.
- Prepare master plans for tourism development, including one now nearing completion for JVA for the East Jordan Valley.

The Jordan and Yarmouk Valleys are to play important roles in Jordan's tourism.

3.4.6 Infrastructure

3.4.6.1 Water Supply

Jordanians are served by public water supply systems or water transported by tank trucks from nearby springs, cisterns, or other water sources. A recent survey of 747 communities, including all municipalities and villages except Amman, found that:

- only 1.5% have satisfactory (in quality and quantity) potable water supplies for 80% or more of their residents;
- 18% provide satisfactory supply to 50% to 79% of their residents; and
- 14% provide satisfactory supply to 1% to 50% of their residents.

The remaining entities, which constitute more than 66% of the total, have no potable water supply systems at all. Water consumption figures were given in Section 3.2.3.

At present, Jordan has approximately 20 municipal water supply systems in operation, with a total production of 29 MCM/yr. This includes 15 MCM/yr for Amman. All of these systems pump groundwater either from deep wells or from springs. In most cases water is stored in small tanks or reservoirs near the water source. Raw water is not treated except for chlorination of storage reservoirs. Distribution systems are in poor condition, and losses range from 25% (Amman) to more than 60% (Irbid). Septabe is believed to have infiltrated into the upper aquifer at Amman.

Industries either tap public supplies or operate their own systems. The former are mostly small enterprises with a negligible water consumption; the latter are important industries that include phosphate mines, a cement factory, textiles factories, and a refinery.

3.4.6.2 Wastewaters

Domestic and industrial wastewaters are treated and disposed of primarily in individual, self-contained facilities. Only three central municipal sewage treatment facilities are operational, serving Amman, Salt, and Aqaba. Jordan now faces significant pollution problems for which it is unprepared technically, legally, and economically, because of:

- Rapid growth in urbanization,
- Rising standards of living,

- Extensive but uncoordinated development of land, mineral, and water resources,
- Poor condition of the existing individual and central treatment facilities, and
- Lack of emphasis, until recently, on adequate wastewater treatment and management. [3-38]

In rural areas, human wastes are most commonly disposed in percolation pits serving individual or groups of dwelling units. The pit (also referred to as pit privy or latrine) consists of a manually dug hole, round or rectangular in cross section, with walls either unlined or lined with stones. Such a pit provides little or no biological activity with the result that the untreated liquids percolate into the ground through the walls and the bottom, while the solids accumulate in the pit. When one pit has been filled to capacity, it is normally covered with earth and abandoned, and a new pit is dug.

In most urban areas, household septic tanks or cess-pits are common. Most of these facilities are single-chamber tanks with masonry or concrete walls, which provide varying degrees of anaerobic sludge digestion depending upon factors such as design capacity, existing wastewater load, and cleaning frequency. Effluents are discharged to the ground via outlet drain pipes or openings in the walls or bottoms. Accumulated sludge is occasionally pumped out by special tank trucks for disposal on land, in open dumps, or, less often, in central treatment facilities.

Amman's sewage collection system and activated sludge treatment plant is designed to handle 60,000 m^3/day average flow (78,000 m^3/day peak flow) and to serve 300,000 inhabitants. [3-39] The treatment plant effluent is discharged to Seil Zarqa, while the sludge is anaerobically digested, dewatered in drying beds, and given free of charge to farmers for use as soil conditioner or fertilizer. The plant has had operational problems resulting in only 80% efficiency of the effluent process. [3-39] Salt is served by sewers, and a sewage treatment plant is nearing

completion. [3-40] Aqaba's primary treatment plant serves part of the newer urban areas.

Industrial wastewaters are normally discharged either to nearby streams or ponds with little or no treatement or into septic tanks. No regulations exist yet for treatment of industrial wastewaters.

As indicated in the discussion of potable water supply (Section 3.4.6.1), present data on per capita water consumption are inconclusive. Even less complete are the data on per capita wastewater production. [3-40] Estimated consumptive use factors are presented in Table 3-13; it shows that with a rural per capita water consumption of 50 to 60 liters/day, the wastewater flow would be 20 to 24 liters/capita/day, assuming a use factor of 0.6.

Data on wastewater quality are available for Amman only. Raw sewage entering Amman's treatment plant has been sampled extensively. [3-39] Data in Table 3-14 indicate that Amman's sewage is characterized by levels of BOD and solids higher than typical U.S. averages, even for strong sewage. This is to be expected because of:

- Lower per capita water consumption in Jordan than in the United States (50 to 60 liters/capita/day in Jordan vs. 200 to 400 liters/capita/day in the United States), and
- Characteristics of commercial and industrial wastewater influent to the treatment plant.

There now seems to be serious concern in Jordan regarding the lack of adequate wastewater treatment and management practices; efforts are underway to remedy the situation. However, it is not clear what the outcome will be. The technical, financial, and legal resources necessary for these efforts are also in demand for other projects; and the priority for wastewater treatment and management has not been fully defined.

Table 3-13

Estimated Use Factors For Predicting Wastewater Flows

Consumer Group	1975	1985	2000
Amman, Irbid, Zarqa, Aqaba	0.60	0.65	0.70
Other Communities	0.40	0.55	0.60
Other Consumers of Water Supply Corporation	0.40	0.60	0.70
Industry	0.50	0.50	0.50

Source: "National Water Master Plan of Jordan, Volume IV-Domestic/ Industrial Water Demand," Report prepared by Agrar und Hydrotechnik, Gmbh for National Resources Authority, Jordan, 1977.

Table 3-14

Typical Raw Sewage Composition Range

(All values except settlable solids in mg/l)

Constituent	Amman[1]	U.S.[2]
1. Solids (Total)	1100-2500	1200
(i) Dissolved (Total)	800-1250	850
• Fixed	500-850	525
• Volatile	300-400	325
(ii) Suspended (Total)	300-1250	350
• Fixed	100-300	75
• Volatile	200-950	275
2. Settlable Solids, ml/l	6-75	20
3. BODs	350-1200	400
4. COD	700-1500	1000
5. Total Nitrogen	~200	85

[1]Ranges of values reported by Kruger [3-39] for the influent to the Amman Sewage Treatment Plan.

[2]Values for strong sewage as reported by Metcalf & Eddy. [3-41]

3.4.6.3 Transportation

Roads have always been the most important mode of transport within land-locked Jordan. In fact, three of today's major highways follow the ancient trade routes: the Damascus-Mecca Road is today's Upland Highway; the Amman-Jerusalem and Haifa-Baghdad roads are still in use, although east-west movements are presently restricted at the Jordan-Israel frontier. Roads carry more than 80% of international travel by people and about one-third of the shipments of goods. Domestic travel is even more dependent on the road system because the only other significant mode is the railway system. The railways, however, are presently limited in scope; the total trackage of 544 km (compared with 6175.1 km of usable roads) runs only from Aqaba through Amman and Zarqa to the Syrian border, as part of the Hijaz line from Medina to Damascus. Jordan's one port, Aqaba, is a deepwater port and has recently been extensively equipped for cargo operations. Air travel within Jordan is limited to two airports, at Amman and Aqaba. International services operate only from Amman. Pipelines are used both for carrying crude oil from Saudi Arabia to the Zarqa refinery and for supplying fresh water to Amman and other large cities.

Roads are classified as "primary," "secondary," and "village." Primary roads, comprising 26.8% of Jordan's total, connect the larger population centers and serve international travel. Secondary roads (15%) link the smaller population centers to the primary system. Village roads (58%) serve the agricultural areas and villages. The rail system has shown a four-fold increase in passenger and freight service from 1971 to 1977. About 600,000 tons of freight and 65,000 people are moved within Jordan annually by rail.

The port of Aqaba handled 4.5 times more freight in 1977 than in 1967. The increase was due mainly to strong growth in the phosphate industry. About 1000 vessels used the port annually in 1976 and 1977, compared with an average of 275 vessels per year during the period 1967 to 1974.

In 1976, 31.3% of the international goods imported, exported, or trans-shipped was moved by road, 46.7% by sea, and 21.6% by pipeline. Air and rail modes accounted for only 0.2% each of the total tonnage. All modes show an increase in tonnage since 1972; sea and pipeline movements have doubled (112% and 82%, respectively); use of the roads for international good shipments have increased by 56%. It has been suggested that congestion at Aqaba Port has caused the significant increase in goods traffic by roads, reflecting a higher percentage of trans-shipments than previously. The rails are used primarily for import and export.

During the same 1972-1976 period, the number of passenger car registrations grew by 153% and truck registrations by 130%. These figures represent an increase in ownership from 8.7 to 18.2 cars per 1000 persons. Road traffic volume increases reflected urban and economic growth. Average daily traffic (ADT) volumes were measured on two screen lines, one to the north of Amman and one to the south; ADTs at both locations nearly doubled over the 1972-1976 period.

3.4.6.4 Communications

Jordan is developing a modern communications network; while not yet up to the standard of the developed countries, it ranks among the better systems in the Middle East. Jordan's postal service is also one of the most reliable in the region; 500 post offices offer regular service both internally and internationally.

The telephone system, while small by developed country standards, is expanding; Table 3-15 shows the distribution of private and official telephones by governorate as of 1977. The telephone network at present serves only 3% to 4% of the population, mostly in the major cities which are now served internally by nine automatic and 180 semi-automatic exchanges. The objective of the current Five-Year Plan (1976-1980) is to increase the populations served in the major cities from 10% to 15% and in the smaller central towns from 5% to 8%. Cities and towns are interconnected

Table 3-15

Telephones (Official & Private) by Governorate-1977

Governorate	Private	Official	Total
Total	38286	4823	43109
Amman	28046	3316	31362
Irbid	4628	550	5178
Balqa	1919	370	2289
Karak	1860	390	2250
Ma'an	1833	197	2030

Source: Telecommunications Corporation.

by microwave networks in the north and the south plus a carrier network of 128 channels. Major overseas telephone service is handled by satellite; service to other countries is handled by the SPADE system which provides semi-automatic service to countries not accessible to the satellite.

For mass communication, the most developed and influential system is radio. As is common throughout the Middle East, battery-operated radio sets are available to most households rich or poor, and are the major instruments both for receiving news and for family entertainment. The cost of television sets has been the only deterrent to rapid spread which was introduced in 1968; but television is now becoming more accessible as electricity becomes available to people's residences. The government runs both the radio and television transmission facilities and is part of the larger network of Arab broadcasting operations. Access to radio and television is among the highest priorities for families of all statuses, in Jordan as in other Middle Eastern countries, and usually ranks above improved housing, appliances, or automobiles.

3.4.6.5 Electricity/Power

The electricity sector occupies a major position in Jordan's development program. Electric power generated in the country rose at an annual rate of 13% between 1972 and 1975. Of the 350 million kWh consumed in 1975, industry used 42%, households used 26.5%, commercial enterprises used 17.2%, and water pumping stations used 8.6%. An additional 22 villages were electrified in the Amman and Irbid areas; therefore, by 1975, 61 villages or 70% of the East Bank population were supplied with electricity.

Currently, much of Jordan's electricity is generated and distributed by regional, and frequently, small units. The rapidly growing industrial sector is dependent upon an increasing amount of electricity; growth in loads and growth in electricity supply is incompatible. This regional system operates at comparatively high generation and distribution costs.

According to the Five-Year Plan, the East Bank was to be divided into two or three centrally serviced power areas, each developed on an integrated basis to contribute to the national grid. Eventually, Jordan's grid is to be linked to systems in other Arab nations. Included in the goals are a 169% increase in generation capacity by 1980 and provision of additional electric power for production centers and water pumping projects. Construction of private generating stations was to be limited except to provide stand-by power for industrial and developmental projects.

Several electric power supply projects have been implemented in the past few years. The Hussein Central Thermal Power Station at Zarqa, begun in 1973, is being constructed to meet the needs of the northern region. When operational, a 132 kV high tension transmission grid will facilitate supply of power generated at the Hussein Station to greater Amman and the north. A project linking the Syrian and Jordanian electricity networks is being implemented as part of the Arab link concept. The Jordan Valley Electrification Project aims to provide electricity to the towns, villages, and water pumping stations in the Valley. Networks in both Amman and Irbid are being significantly expanded.

By 1980 a total of JD 43 million will be spent on electricity projects as indicated by the Five-Year Plan. Approximately 67% of that total will be obtained from foreign loans and 3% by local loans; 22% is allocated in the general budget, and the remainder comes from various municipal and private sources.

3.4.7 National and International Factors

Jordan's political life since 1948 has been dominated by uncertainties and dislocations resulting from the Arab-Israeli conflict. The Arab-Israeli conflict resulted in the destruction of the Valley town of

Karama and the damaging of the EGMC. Thus, in Jordan more than most countries, internal affairs and foreign relations are closely related.

Although Jordan is Arab, relations with Arab countries have often been tense. Jordan has been more willing than some to work toward peaceful resolution of the Arab-Israeli conflict, perhaps because it shares the longest border with Israel. Jordan has been politically closer to Saudi Arabia and the other Middle Eastern monarchies than to the states of Libya and Syria. In recent years, however, its relations with Syria have improved, an important factor inasmuch as cooperation is required for joint development of the Yarmouk River waters.

Elsewhere, Jordan has long maintained friendly relations with the United Kingdom, the United States, and other Western nations. Relations with the Soviet Union and China, by contrast, have been strained. It has close economic and military ties with Turkey and Pakistan.

Aid is a major factor in Jordan's political economy in order to compensate for its poor economic base and adverse balance of payments. Generous amounts come from the United States, the Federal Republic of Germany, the United Nations Development Program, the World Bank, the Kuwait Fund, and the Arab Fund. Kuwait stopped its aid between 1971 and 1973 due to Jordan's expulsion of the Palestinian guerillas. The Persian Gulf states are economically important to Jordan which lacks its own oil, both as a labor market for skilled Jordanians and as a market for high-value agricultural produce from the East Jordan Valley.

Jordan is a charter member of the Arab League. It belongs to the United Nations and a number of some specialized agencies such as the International Monetary Fund (IMF) and the Food and Agricultural Organization (FAO).

4.0 DESCRIPTION OF THE PROPOSED ACTION

4.1 INTRODUCTION

Chapter 4 describes the proposed action which, when undertaken, will impact the environment. The action will involve many different activities that will vary with respect to location, time of occurrence, and primary purpose.

In this chapter, the emphasis is on the direct activities which are defined as those dealing with water supply and allocation. These include the Maqarin Dam and Reservoir (Section 4.2), the diversion dam on the Yarmouk River (Section 4.3), the East Ghor Main Canal (Section 4.4), the hydroelectric power facilities (Section 4.5), irrigation facilities (Section 4.6), municipal and industrial water supply (Section 4.7), the physical system operation (Section 4.8), and the organizational system operation (Section 4.9).

The indirect activities are generally defined as those that will be undertaken or that will occur as a result of the water that is made available by the direct activities. The indirect activities, which include agricultural practices and village development programs, are summarized in Section 4.10; their detailed descriptions are given in Chapter 6 together with associated environmental impacts.

At the outset of this study, the proposed action was considered to have been fairly well defined and in accordance with the descriptions contained in the Stage II Feasibility Study prepared by Harza in association with Dar Al-Handasah Consultants, dated January 1978. [4-1][1] However, it was learned shortly after the start of field investigations that revised estimates of M&I water allocation had been developed as a result of recent studies conducted for Jordan with the

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[1] Numbers in brackets, e.g., [4-1], refer to references located in Appendix B.

result that substantially more of the water supplies associated with the project would be allocated to M&I use for upland cities with less water allocated to irrigation in the Valley.

A revised Stage II plan was then developed for the JVA by Harza Overseas Engineering Company and is described in its Civil Design Memorandum C-1 dated August 14, 1979 [4-2] and in its Planning Memorandum No. 1 dated September 1979. [4-3] It is this revised plan, also referred to herein as the "C-1" plan, that is described in this final EA report.[1]

The "C-1" project, however, does not necessarily reflect the final project design. Since the issuance of the plan, the donor group, headed by the World Bank, has been appraising the Stage II project and has proposed further changes. The Bank has prepared a draft report of its appraisal, but the report has not been released. Some of the Bank's concerns are known, however, and are indicated below together with comparative data about the Feasibility Study project and the "C-1" revised project.

(1) M&I Allocations (MCM/yr)

	Feasibility	"C-1"	Bank
Irbid	12	26	31
Amman/Zarqa	10	100	133
Valley	8	-	-
Total	30	126	164

The Irbid supply is from Maqarin Reservoir for all three cases. The Amman/Zarqa supply was from King Talal Reservoir

[1] Readers who may have copies of the draft final EA report, dated July 15, 1979, are cautioned that the initial revised project described therein, featuring a Maqarin Dam to El 168 m, is not the dam as the "C-1" revised project, which features a Maqarin Dam to El 178 m among other changes.

in the Feasibility Study and is from the EGMC in the "C-1" study. The Bank is considering a 50 MCM/yr supply to Amman from King Talal Reservoir, with the remainder coming from the EGMC. The Bank has also examined a range of M&I demands that increase from 74 MCM/yr in 1990 to 244 MCM/yr in 2010. The 165 MCM/yr shown above would represent the demand at or about the year 2000.

(2) Return Flows

The return flows from M&I use were not significant in the Feasibility Study, but would be important under the other studies because the return flows could be used for irrigation. In the "C-1" analysis, the return flows were assumed to be 50% of the allocation after deduction of 5% for treatment plant losses. The Bank has estimated return flows from each municipal area from the years 1990 to 2010, with results varying from 58% to 91%.

(3) Streamflow Input to Maqarin Reservoir

Under both the "C-1" plan and the World Bank studies, there would be a transfer of 48 MCM/yr of water from the Wadi Raqqad, in Syria, to the Maqarin Reservoir. This transfer would occur as a result of construction of a small diversion dam and a canal, and it would only apply to excess flows during wet periods (normally December through April). Because Wadi Raqqad discharges into the Yarmouk River below Maqarin Reservoir, the transfer would serve primarily to increase the volume of water subject to regulation and to decrease unregulated flows in the lower Yarmouk River.

The Yarmouk River flows to Maqarin Reservoir have been reduced in anticipation of developments by Syria in the Yarmouk River basin upstream of the dam site. The changes are:

	Inflow (MCM/yr)
Feasibility Study	240.3
"C-1" Plan	210.7
World Bank Studies	185.7

The streamflow record used in the Feasibility Study consisted of 22 years of historic data. The record has been lengthened to 25 years for the C-1 and World Bank studies.

The descriptions of the activities are presented in less detail than would be found in a planning or design report. The intent is to include only sufficient information to permit an understanding of the impact analysis in Chapter 6 without the need to refer to other reports. Additional technical information can be found in the appendices.

4.2 MAQARIN DAM AND RESERVOIR

4.2.1 Dam Design and Construction

4.2.1.1 Introduction

The Maqarin Dam will be located on the Yarmouk River about 90 km north of Amman, Jordan and 100 km south of Damascus, Syria. The left[1] embankment will be in Jordan, while the right embankment will lie in Syria. The dam will be located about 41 km upstream of the confluence of the Yarmouk River with the Jordan River and about 3000 m downstream of the point at which the Yarmouk River is formed by the confluence of Wadis Shallala, Nahr el Harir, and Nahr Allan.

In the Harza Stage II Feasibility Study [4-1], the dam crest was at El 158 m and featured an embankment design that would facilitate a future increase in the crest elevation to 200 m. The revised ("C-1") plan is to design the embankment without inherent features for future increases in the crest elevation. The new crest elevation will be at 178 m, with a maximum reservoir elevation of 170 m.

4.2.1.2 Embankment Dimensions

The layout, plan and sections of the Maqarin Dam are shown in Figures 4-1, 4-2, and 4-3.

4.2.1.3 Embankment Sections

The design of the embankment sections provides for free-draining upstream and downstream rock fill shells and a central vertical core of impervious fill with a maximum base width of about 60 m. Flanking the core will be graded, granular chimney filters 11 m wide. As shown in Figure 4-3, the upstream slope will be 1v:2h from the crest to El 70 m. The downstream slope will be 1v:2h from the crest to El 110 and 1v:3h below El 110.

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[1] As determined by looking downstream.

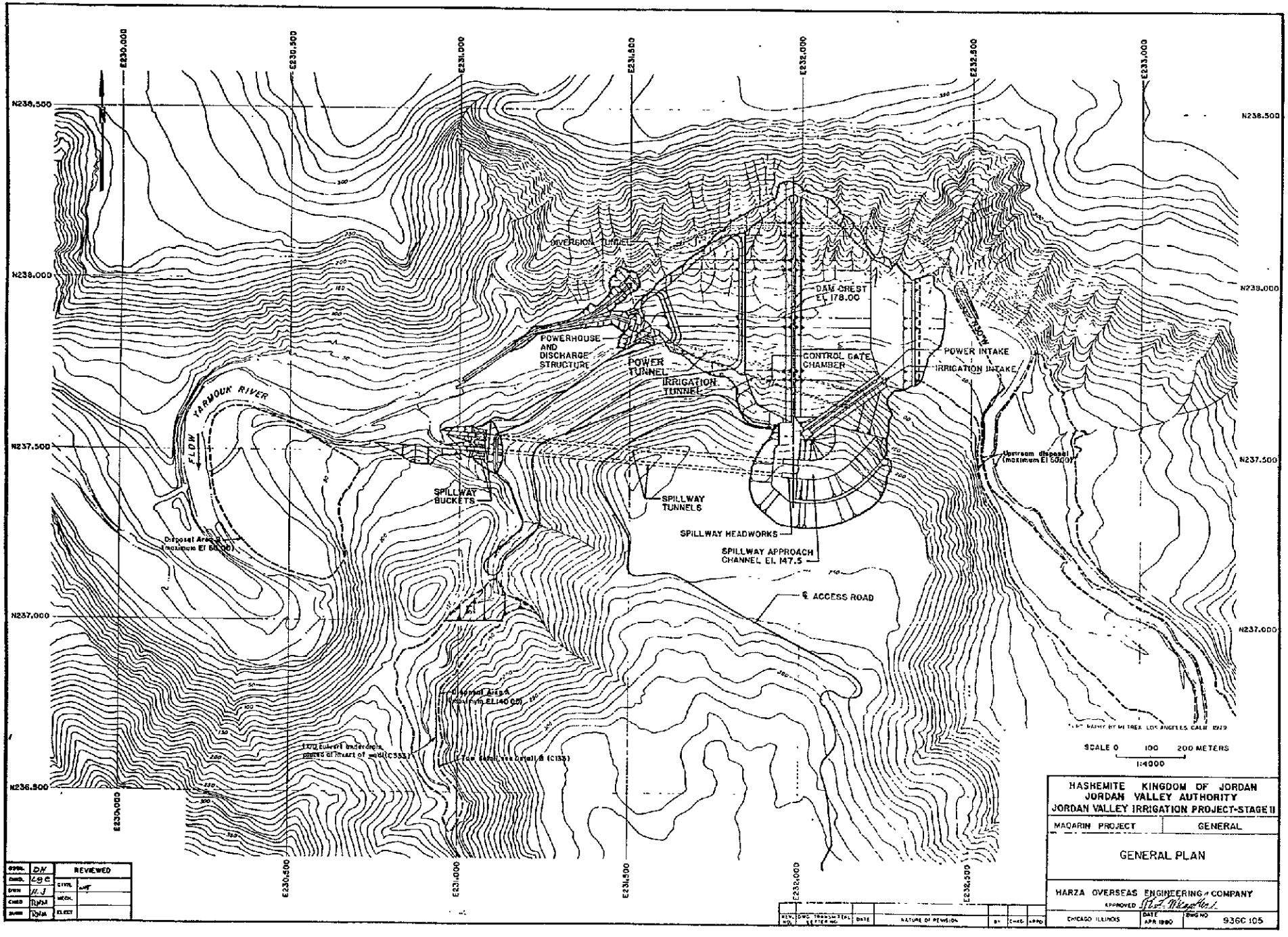

Figure 4-1 Project Site Plan for Elevation 178.0 Meter Dam

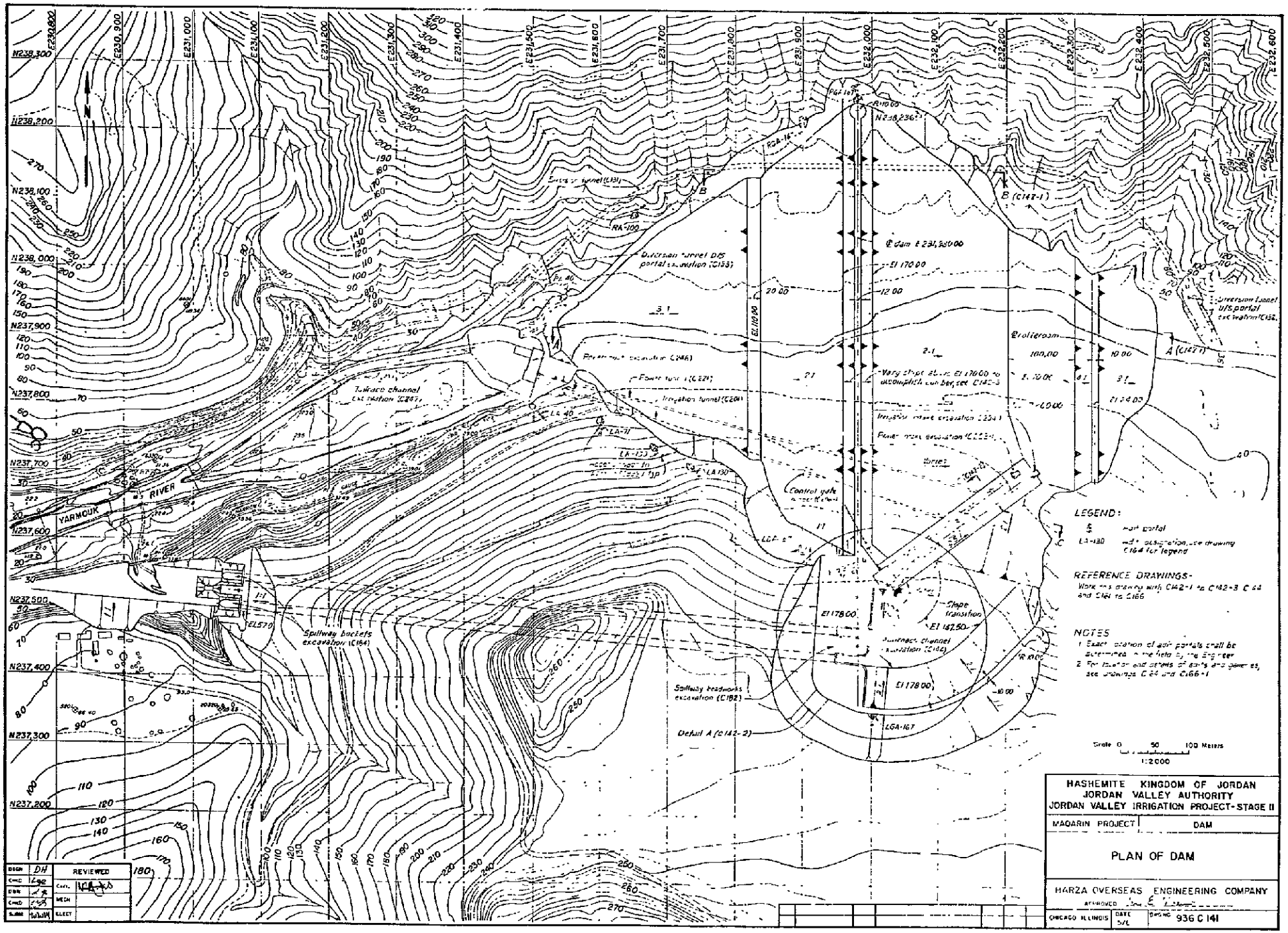

Figure 4-2 Plan of Elevation 178.0 Meter Dam and Appurtenant Structures

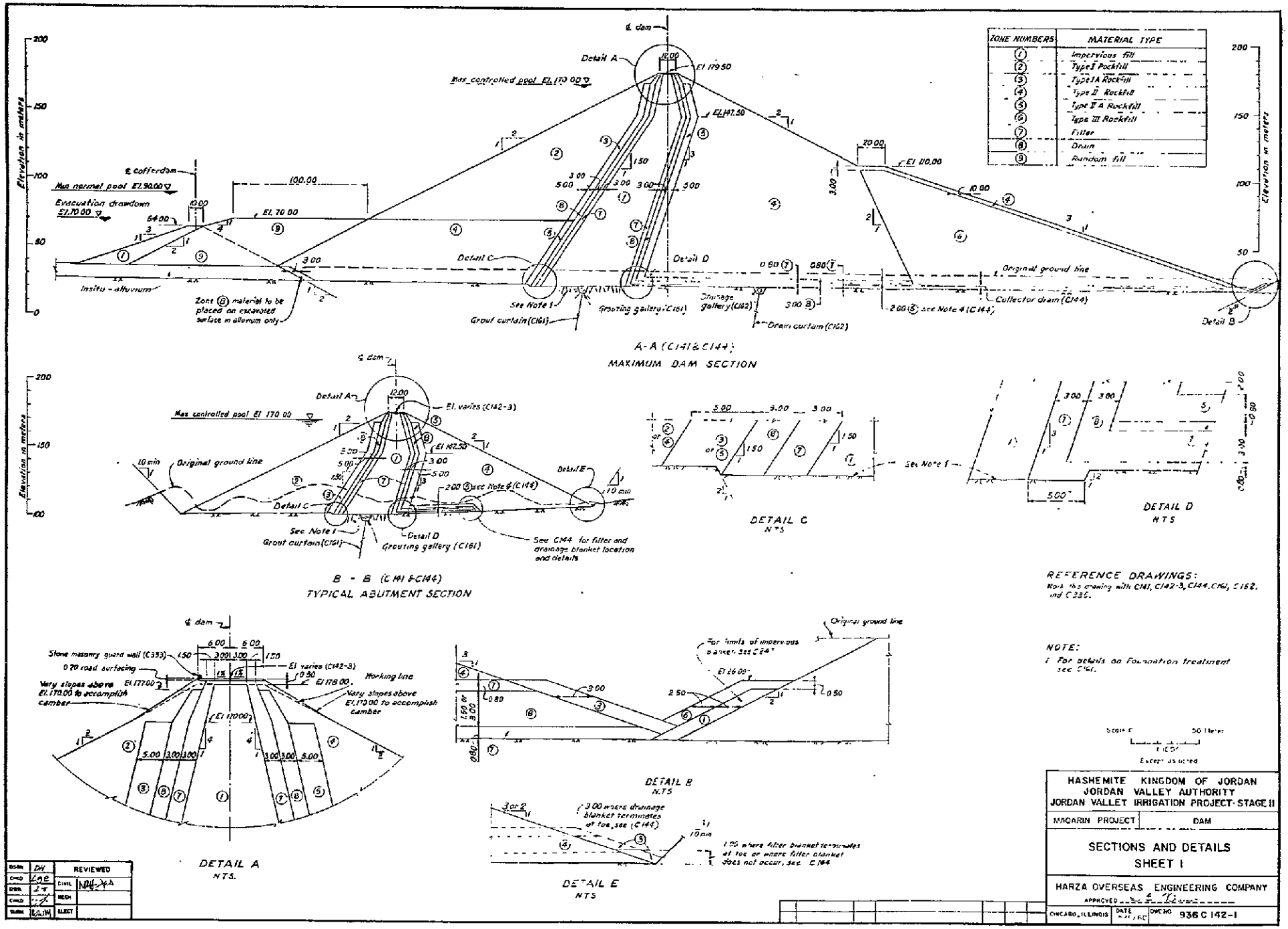

Figure 4-3 Typical Sections

4.2.1.4 Borrow Material

The properties and sources available embankment construction material have been examined in some detail. [4-4] Rock fill for the shells is easily accessible from basalt outcrops at or near the construction site. However, some rock fill will have to be processed to satisfy strength, durability, and free-draining requirements. The portion of the upstream shell exposed during maximum drawdown will be rock fill composed of processed basalt of good quality quarried from the north bank at the dam site. Basalt rock fill from poorer quality deposits on the south bank will be used in the downstream shell and the upstream shell below the minimum pool level. However, some of this basalt is deeply weathered and unusable. [4-5] Other rock fill will be supplied by material excavated for the diversion and/or spillway tunnel(s); therefore, it will be relatively inexpensive borrow.

The upstream berm does not require high-quality borrow and will consist of random fill (talus, alluvium, bituminous marl) excavated from the embankment foundation.

Impervious material for the core will consist primarily of residual clay weathered from basalt at the site. This montmorillonitic clay has high plasticity, low permeability, and variable natural moisture content. The average moisture content is approximately 4% dry of the prescribed optimum for maximum compaction, so that closely controlled moisture conditioning will be required before the clay can be compacted in the embankment.

Coarse- and fine-graded filters will be placed upstream and downstream of the clay core. These filters are designed to prevent internal erosion initiated by cracking due to embankment deformation or hydraulic fracturing.

4.2.1.5 Embankment Stability[1]

Parametric static stability analyses of preliminary design embankment cross sections have been performed to estimate the embankment and foundation stability. [4-6] Details of the analyses are presented in Appendix F. Because laboratory tests to measure the shear strength of the marl forming the embankment foundation are still continuing, estimated strength parameters have been varied to evaluate the minimum foundation strength required for stability. Representative strength parameters for the embankment materials have been obtained from the literature.

Although the safety of the preliminary embankment design against slope failure cannot be determined conclusively at this time, it has been recognized that the foundation strength is a critical factor. Because of the weathered and disturbed nature of the marl, laboratory measurements of residual strength of the marl and its discontinuities will be made by Harza to provide input to final stability analyses.

Pseudo-static analyses have not been conducted on preliminary cross sections. Because these analyses simply add earthquake accelerations to the static forces, it is expected that they will indicate that even greater foundation strength is required to provide adequate safety against failure under earthquake loading.

4.2.1.6 Abutment Stability

The morphology and structural discontinuities in the left abutment promontory might cause instability during rapid drawdown of the reservoir. Although stability calculations have not been made, several remedial measures to prevent failure have been proposed [4-7]:

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[1] Discussion of geotechnical considerations in Sections 4.2.1.5, 4.2.1.6 and 4.2.1.7.1 are based on the status of investigation that existed in April 1979, prior to completion of the "C-1" design.

1) Removing much of the upper portion of the abutment during spillway construction so as to reduce gravity forces that contribute to instability;
2) Placing a weighting berm of construction wastes on the downstream side of the promontory; and
3) Constructing several drainage adits in the left abutment to prevent excess pore pressure development during rapid drawdown.

At this time, it is expected that one or a combination of these treatments will provide the required stability of the left abutment.

4.2.1.7 Foundation Treatment

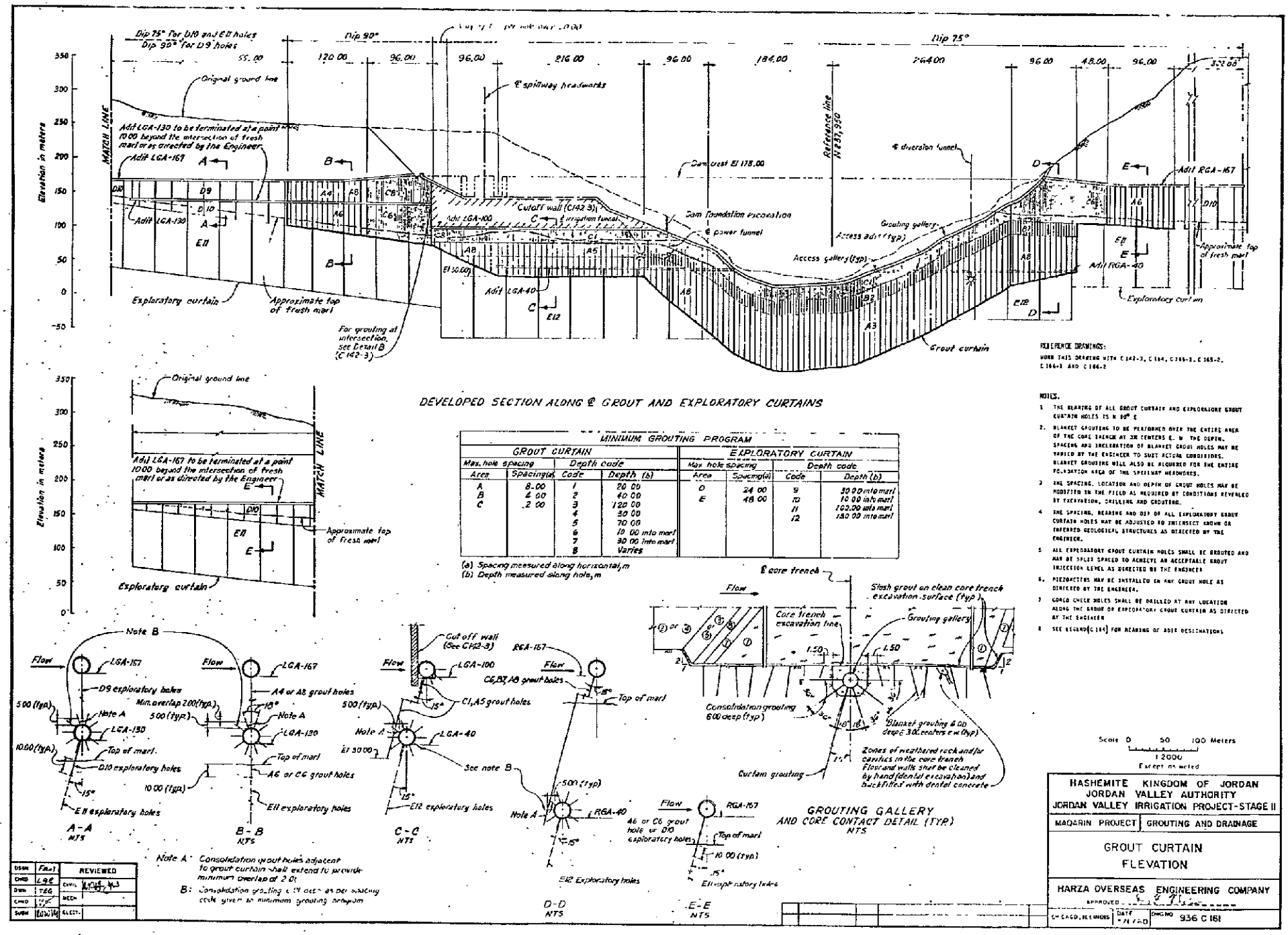
4.2.1.7.1 Excavation

All alluvium and incompetent rock will be removed from the embankment foundation to reduce potential embankment settlements, increase stability, and prevent liquefaction[1] under dynamic earthquake loading. At most locations, more than 35 m of talus, alluvium, and weathered rock must be excavated. Geophysical surveys [4-5] have shown the depth of weathered rock to vary over the proposed dam site, extending to 40 m below the top of limestone in the left abutment and 20 m below the valley floor. (See Section 6.2.1.1.1 of this report for a detailed description of the site geology.) This amount of excavation is not unprecedented in construction of dams this size.

4.2.1.7.2 Grout Curtain

A grout curtain design for the embankment foundation and abutments is shown in Figure 4-4 for the "C-1" plan. The grout curtain extends under the entire axis of the dam and into both the left and right embankments, where grout will be placed from adits. The spacing, location and depth of grout holes may be modified in the field as required by conditions revealed by excavation, drilling, and grouting.

[1] Liquefaction is a phenomenon in which loose sandy-to-silty saturated soils spontaneously liquefy under the impact of a sudden shock.



MINIMUM GROUTING PROGRAM							
GROUT CURTAIN				EXPLORATORY CURTAIN			
Max. hole spacing		Depth code		Max hole spacing		Depth code	
Area	Spacing(a)	Code	Depth (b)	Area	Spacing(a)	Code	Depth (b)
A	8.00	1	20.00	D	24.00	9	30.00 into marl
B	4.00	2	40.00	E	48.00	10	10.00 into marl
C	2.00	3	120.00			11	102.00 into marl
		4	30.00			12	150.00 into marl
		5	70.00				
		6	10.00 into marl				
		7	30.00 into marl				
		8	Varies				

(a) Spacing measured along horizontal, m
(b) Depth measured along hole, m

Figure 4-4 Grouting and Drainage

4.2.2 Reservoir, Dam Appurtenances and Relocations

4.2.2.1 Reservoir

The Maqarin Reservoir, when filled to El 170 m, will extend about 7 km upstream of the dam and will have a surface area of about 9 km^2. Its total volume will be 486 million cubic meters, of which about 98 million will be inactive storage. The latter, from the valley floor at El 35 m to El 105 m, will serve to store silt deposits. This space is expected to be adequate for at least a 100-year period. A map of the reservoir is shown in Figure 4-5, and the area-volume curve for the reservoir is shown in Figure 4-6.

It is expected that it will take about six years or more to fill the reservoir to an operational level under normal flows of the Yarmouk River. During the filling process, only excess flows would be impounded. Thereafter, the mean annual water surface level would vary as a function of streamflow trends (wet or dry years) and withdrawal policies. It is expected that during a period of several years the reservoir level would fluctuate from being completely full (El 170 m) to being completely empty with respect to usable storage (El 105 m). The fluctuation during any single year is expected to average about 20 m.

The perimeter of the reservoir will contact land which is steeply sloped along the sides of the wadis. No plans have been made for erosion protection against wave action at such locations. The stability of the reservoir embankments has been reviewed by Harza, and, at present, no significant sloughing or landslide problems are known to exist along the reservoir perimeter.

4.2.2.2 Dam Appurtenances

When used in a broad sense, the term "dam" refers to all constructed facilities associated with a reservoir. However, under the narrower engineering definition, "dam" refers only to the earthen or concrete structure that serves to impound water. Other essential features are

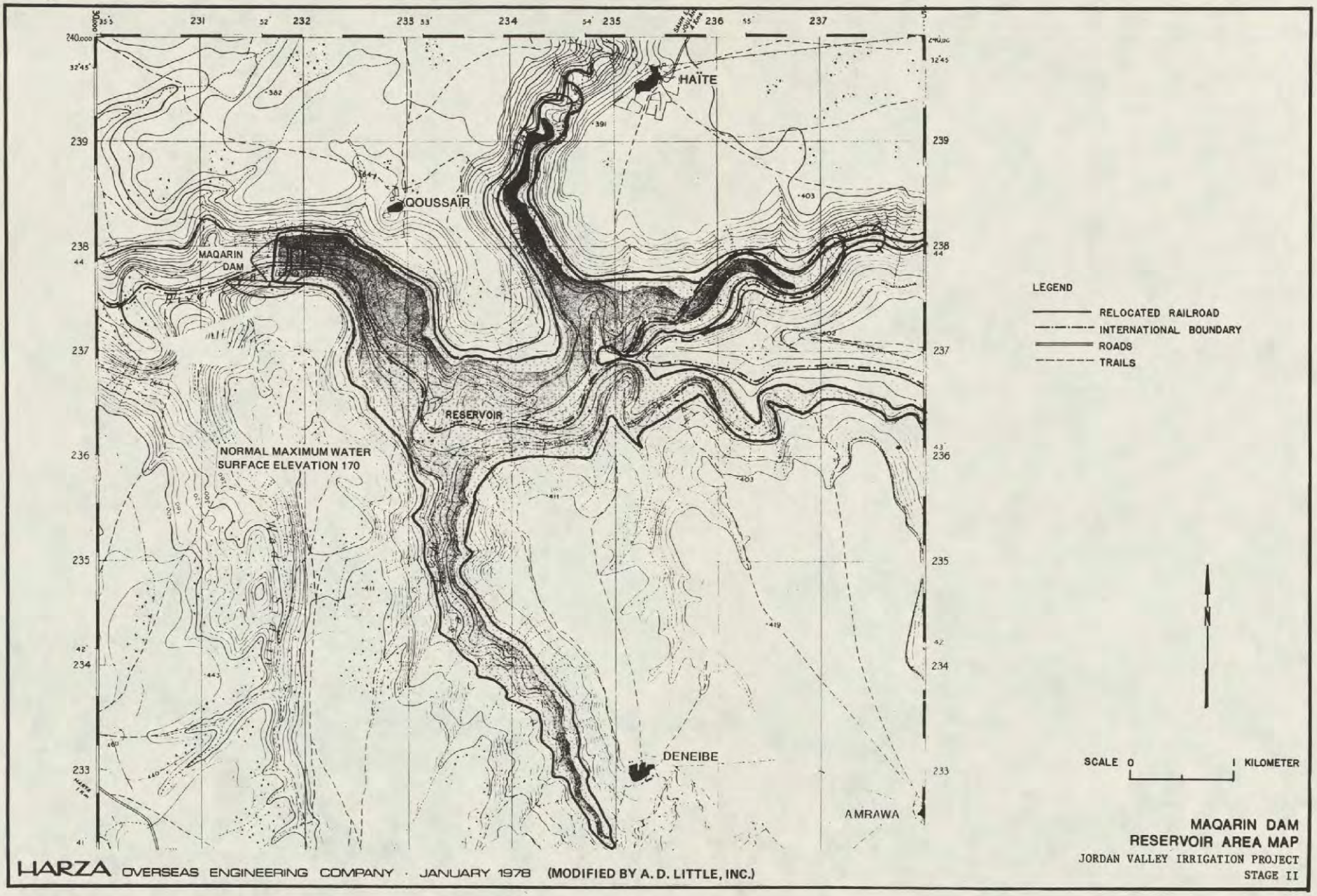
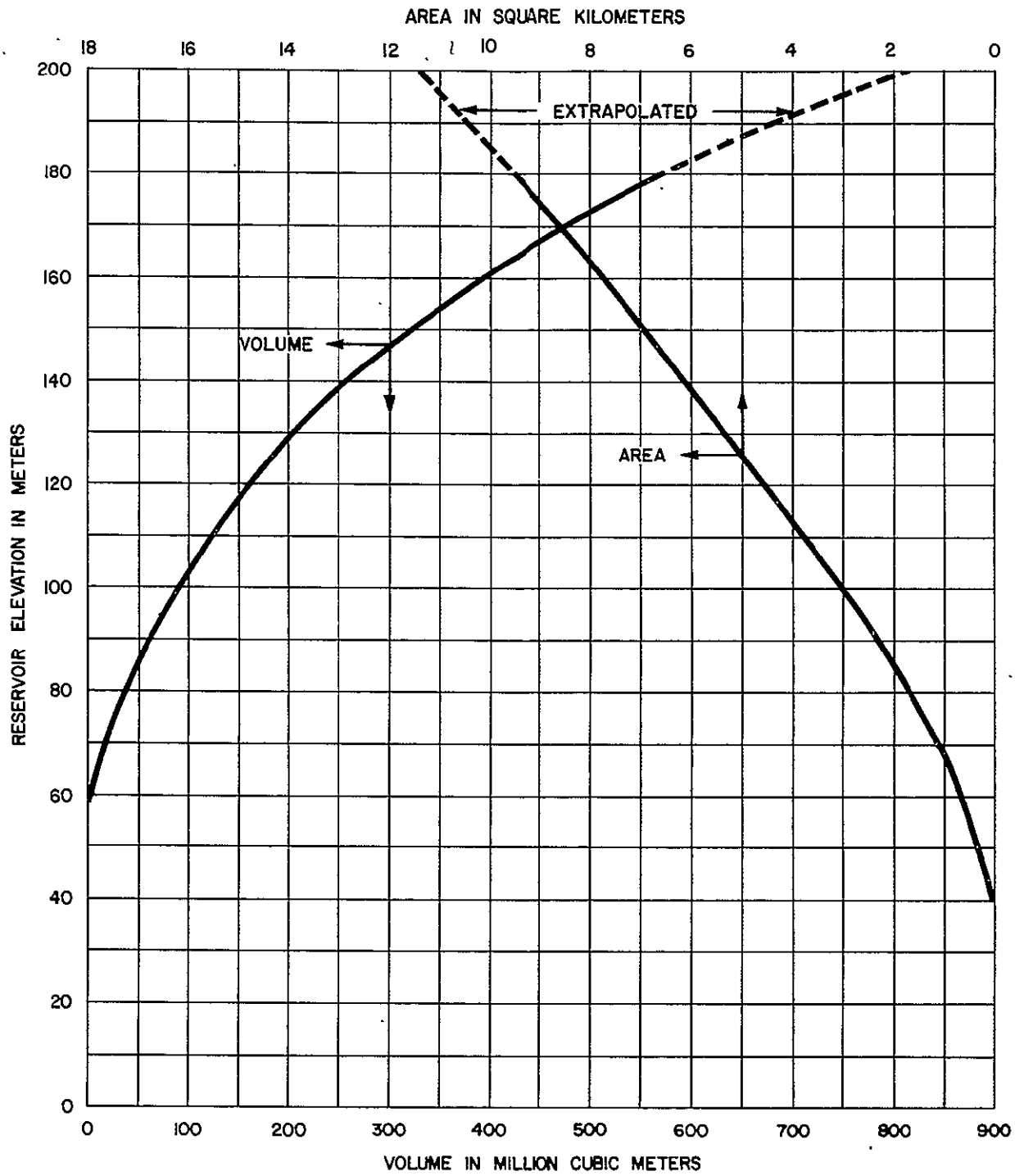


Figure 4-5 Maqarin Dam Reservoir Area Map



AREA VOLUME CURVE

Source: Harza Overseas Engineering Company, January 1978.

Figure 4-6 Spillway Hydraulic Data

the spillway, over which excess water passes when the reservoir is full, and the outlet works, through which releases from the reservoir are made. During construction of the dam, two other key appurtenances are used: (1) diversion dams, also called cofferdams and normally located across the river upstream and downstream of the main dam; and (2) a diversion tunnel or channel, which carries the streamflow around the dam site.

The appurtenances generally represent significant project costs, and considerable effort is involved in selecting the optimum designs. The selection involves consideration of site topography and geology as well as the dam height. The designs of the appurtenances for the Maqarin Dam to El 178 are shown as part of the plan in Figure 4-2 and are described briefly below.

- Diversion Tunnel. The tunnel will be located on the right side of the river. It will be 7.75 m in diameter and about 1000 m long. It can discharge 816 m^3/sec, corresponding to a 50-year flood event with a 75% upper confidence level. The tunnel will be plugged after the dam is completed.
- Upstream Cofferdam. This will be about 30 m high. It will be constructed of random fill material with an impervious upstream face, and it will remain as part of the upstream end of the main dam embankment.
- Downstream Cofferdam. This will be constructed to El 31 m and located along the downstream toe of the dam.
- Spillway. The spillway will be located on the left embankment along the axis of the dam. The spillway crest will be at El 155 m, and it will have two radial gates that will contain the reservoir to El 170 m in the closed position. The spillway will discharge into two concrete lined tunnels, each having an inside diameter of 9.25 m and a length of about 900 m. The lower ends of the tunnels will have concrete flip buck-

ets to dissipate energy prior to the water returning to the Yarmouk River. Spillway details are shown in Figures 4-7 and 4-8.

- Outlet Works. Two outlet tunnels are proposed, one for "power" and the other for "irrigation" releases. (See Figure 4-2.) Both tunnels will be used for an emergency drawdown of the reservoir. The power tunnel will be 3.0 m in diameter and about 900 m long, with an intake invert elevation of 80 m. The intake gate will be inclined so that it operates parallel to the reservoir embankment. The intake will be covered by a concrete frame and roof that contains the trashrack. The lower end of the tunnel contains a bifurcation with one side leading to the powerhouse and the other to a gated discharge port. The tunnel will be concrete lined and the lower end will have a steel liner. The irrigation tunnel will be similar to the power tunnel, except that its intake invert elevation will be 70 m. It will have a diameter of 3.0 m from the intake to a point along the dam axis where there is a gate shaft and structure. From this point to the discharge its diameter is 3.5 m.

4.2.2.3 Relocations

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 4 km of access road will be required. The Himma Railroad, which presently runs through the Maqarin Valley, could be relocated on the Syrian side of the reservoir. However, because of the limited use of this section of the railroad (one train per week), it may be decided to terminate the railroad above the reservoir and construct a new road to the one village serviced by the railroad downstream of the dam site.

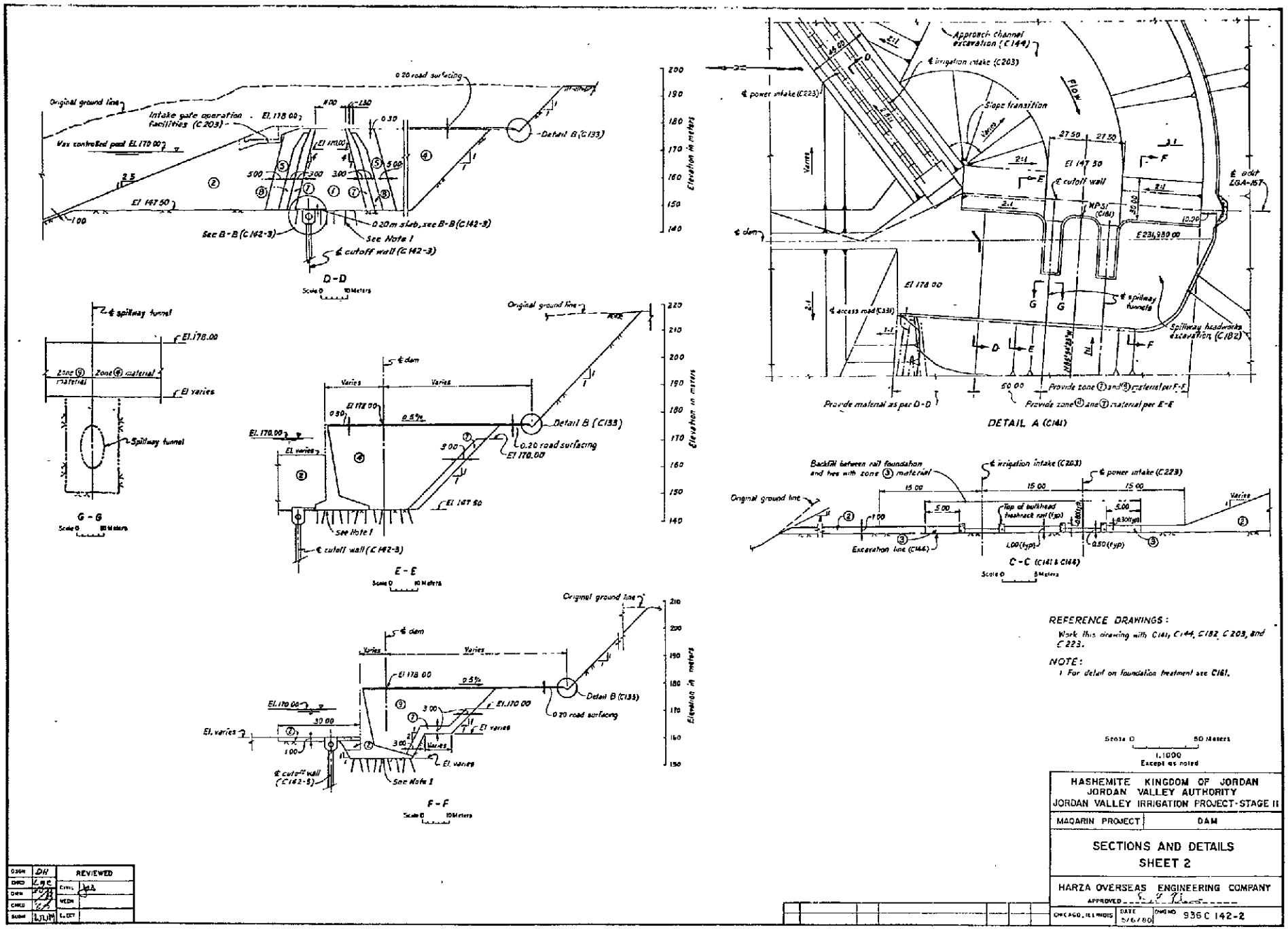


Figure 4-7 Tunnel Spillway for 178.0 Meter Crest Dam

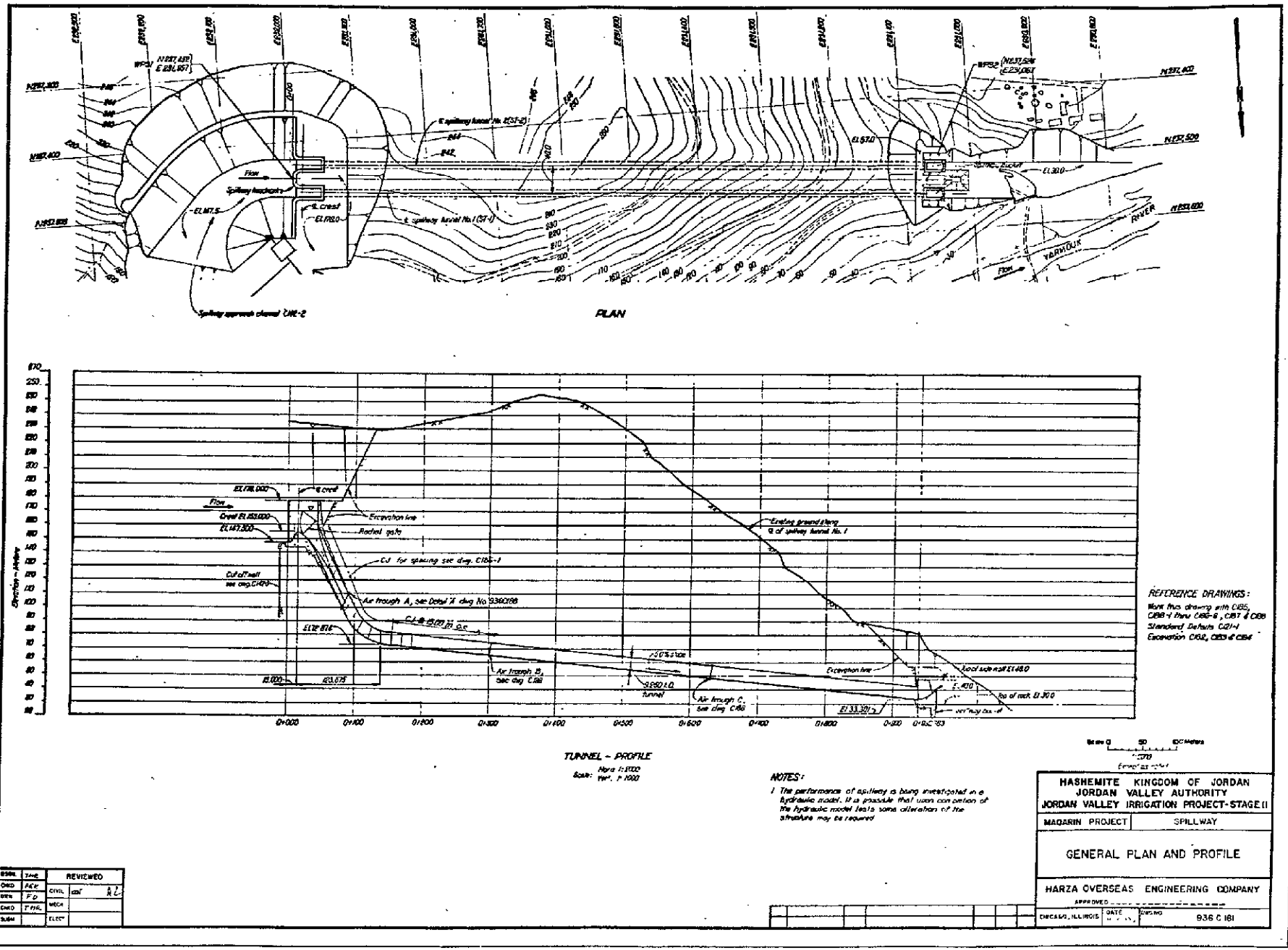


Figure 4-8 Plan and Profile of Discharge Works

4.3 DIVERSION WORKS ON THE YARMOUK RIVER

The water released from the Maqarin Reservoir will flow down the Yarmouk River for about 28 km to Adasiye, located below the Golan Heights and about 10 km upstream of the confluence of the Yarmouk and Jordan Rivers and at the northern end of the EGMC.

In order to cause the Yarmouk River flows to effectively enter the EGMC, it will be necessary to construct a low dam across the Yarmouk River. The current design for the diversion works calls for a concrete dam 3 m high and about 60 m wide. The dam will be designed as an overflow structure, thereby serving as the spillway for flood flows. In the upstream left abutment of the dam, there will be a set of five conduit pipes to divert water to the EGMC. At the center of the dam, about the midpoint of the Yarmouk River, there will be a 0.6 m diameter steel pipe with a valve and gatehouse to divert water to the Yarmouk Triangle (Israeli land north of the Yarmouk River and south of Lake Tiberias). Plan and section views of the proposed diversion are shown in Figure 4-9.

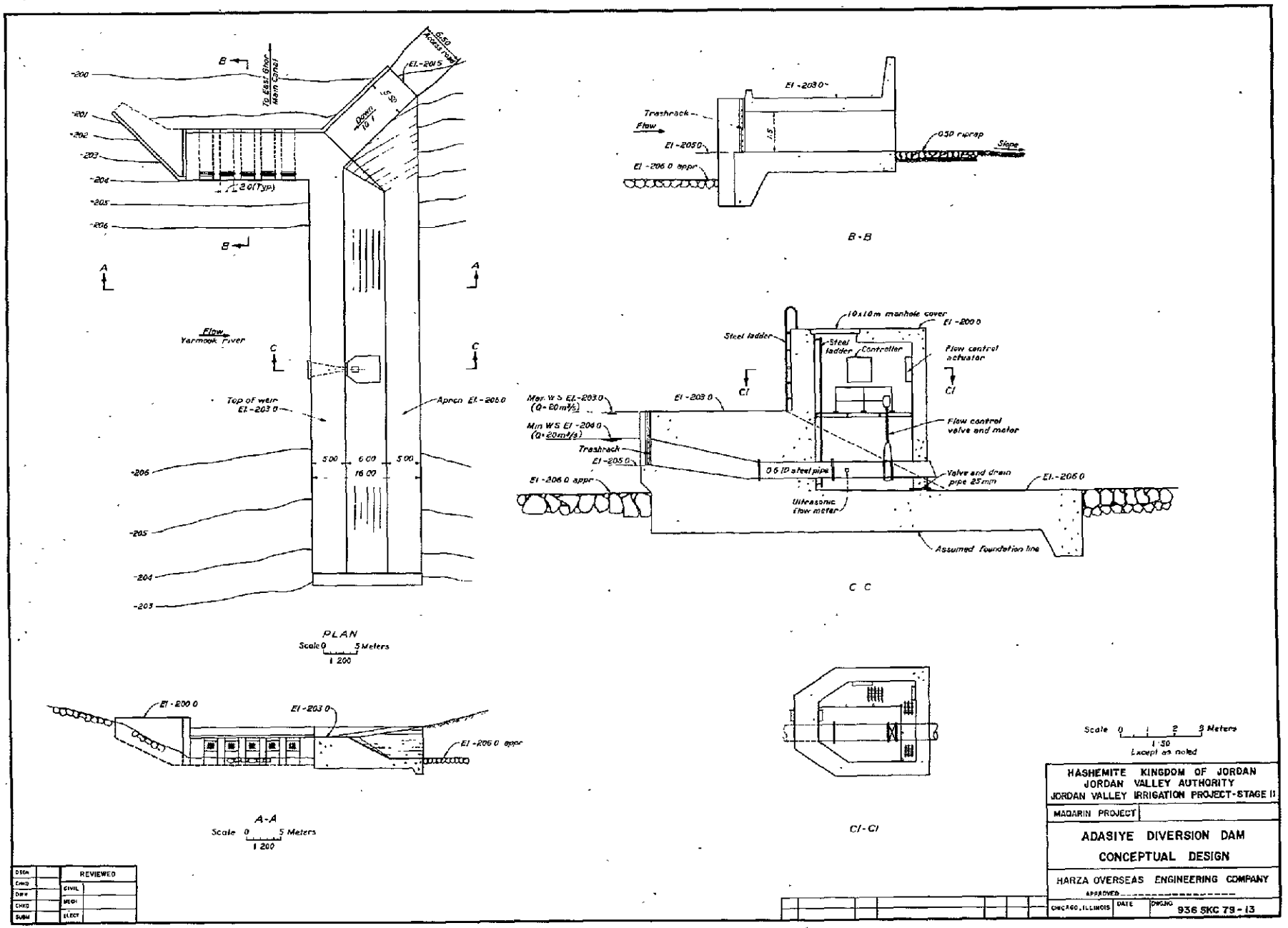


Figure 4-9 Adasiye Diversion Dam Conceptual Design

4.4 EAST GHOR MAIN CANAL

4.4.1 Canal Extension

The original section of the EGMC was constructed in the late 1950's. The canal has since been extended in several segments, and it presently ends at Station 95+955.[1]

A new extension of the EGMC as described in the Harza Feasibility Study [4-1] would extend the canal 14.5 km southward to Station 110+332, nearly to the Dead Sea. The design criteria applicable to the 14.5 km EGMC extension are the same used for the 18 km extension now being completed. The slope of the new canal is 28 cm/km, compared to 18 cm/km for the existing canal. The canal is concrete-lined where it is below grade, and it has a trapezoidal shape with side slopes 1v:1.5h and a base width/depth dimensions varying between 3.0/1.7 (Station 95+955) to 1.8/1.1 (Station 110+332). On both sides of the EGMC, the earth embankment continues above the top of the lining, with a slope of 2v:5h for a vertical depth of about 30 cm. The freeboard from the design water surface to the top of the concrete lining is 30 cm.

Structures associated with the canal extension are:

- Wadi crossing structures (cross-drainage culverts, flumes, inverted siphons);
- Control structures (lateral turnouts, check structures, wasteways);
- Protective structures (interceptor drains, spillways); and
- Pumping plants.

The 14.5 km extension would serve about 8709 ha [4-1] of new lands not presently irrigated. Together with the other completed or on-going projects, this would have brought the total area under sprinkler irrigation to 36,000 ha. [4-1] However, under the revised "C-1" plan,

[1] Canal stations refer to distances along the canal and are expressed in km. The number before the "+" is kilometers; the number after is meters.

which allocates more water to M&I use, it is expected that the total area irrigated could be reduced by about 3600 ha, depending on the outcome of additional studies. (See also Section 4.6.)

4.4.2 Wadi Diversions

A portion of the flows of the three Wadis--Yabis, Kufrinja and Rajib--will be diverted to the EGMC as part of the Stage II activity. During a briefing trip to the Valley, it was learned that flows of small perenial wadis originating from various springs are presently used for irrigation purposes, and in case of water excess, a portion of their flow is diverted to the EGMC via primitive structures. These random structures will probably continue to exist but are not considered as wadi diversions.

Presently, no weir exists on Wadi Rajib. The weir on Wadi Kufrinja is damaged, and the weir across Wadi Yabis is in fairly good repair. No design or rehabilitation plans exist for these weirs, but a typical diversion including the connection to the EGMC is shown in Figure 4-10. The typical structure will be a buttress-type dam with an uncontrolled spillway in the center. Low-level releases will be controlled by stoplogs. Flows into the diversion canal will be regulated with a 0.65 x 0.80 m sluice gate at the entrance of the canal. The diversion canal will be a rectangular concrete-lined structure 0.8 m wide and 0.65 m deep. Estimates of flow diversion are given in Section 4.8.

The Wadi Rajib diversion will be constructed about 100 m to the west of the Jordan Valley highway. The weir will be 40 m wide and the connecting canal to the EGMC will be 400 m long. The diversion across Wadi Kufrinja will be constructed immediately upstream from the existing diversion and a new 1700 m lined canal will connect with the EGMC.

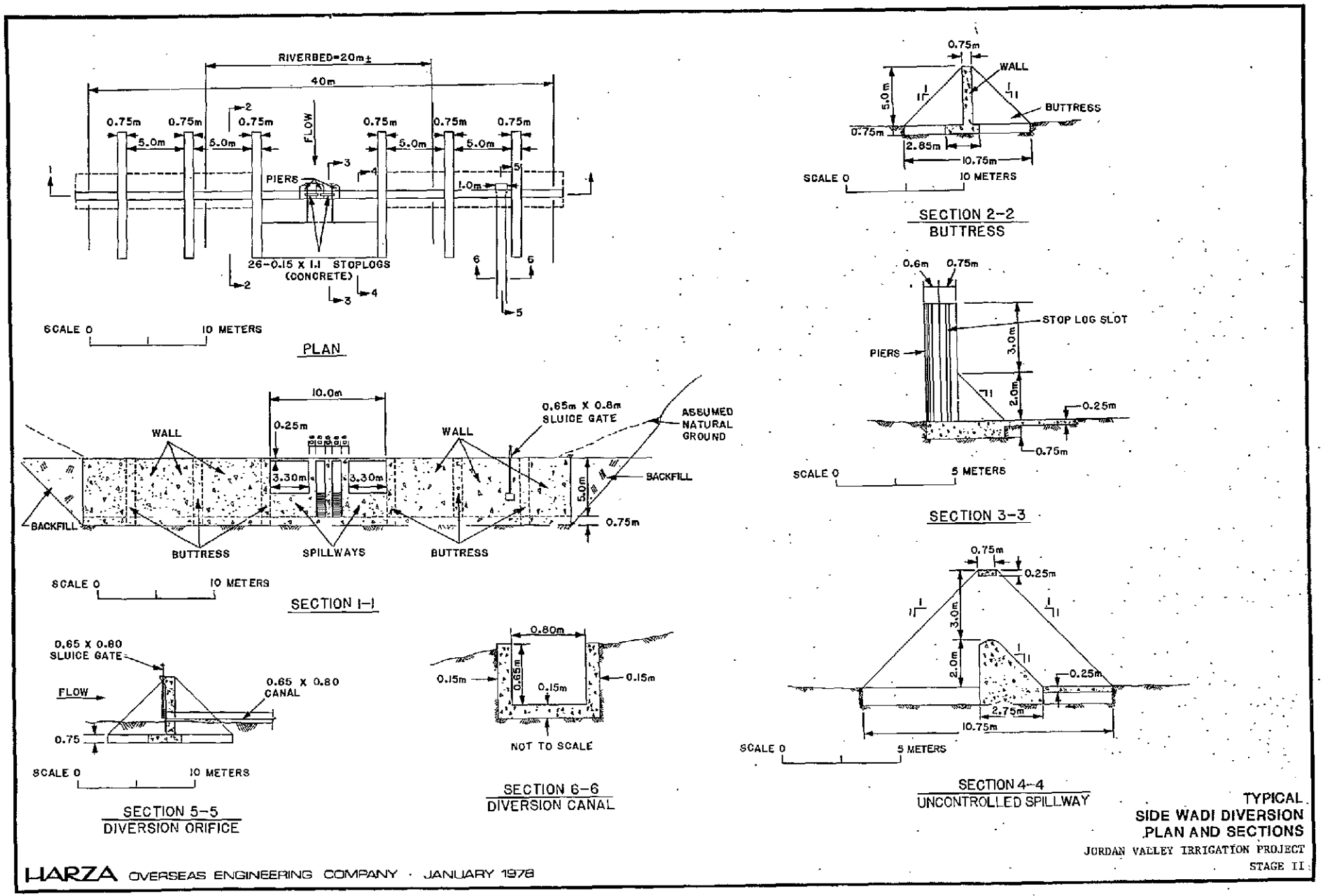


Figure 4-10 Typical Side Wadi Diversion Plan and Sections

Finally, the Wadi Yabis diversion will be located about one km east of the Jordan Valley highway. The existing diversion and the connecting canal are in fair operating condition and do not require much 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.

4.5 HYDROELECTRIC POWER FACILITIES

The hydroelectric power facilities included in the Stage II Feasibility Study were a 20-MW plant at the proposed Maqarin Dam and a 2-MW plant at the existing King Talal Dam. The power facilities included: intake structures, water conductors, powerhouse structures, and electro-mechanical equipment and transformer facilities. It is expected that these facilities will be included in the final design, but the respective power ratings may be revised somewhat to match the water release patterns. The descriptions that follow generally are based on the Feasibility Study plan.

4.5.1 Powerplant at Maqarin Dam

The powerplant will be located immediately downstream from the dam. (See Figure 4-2.) The installed capacity will be 20 MW in two units; each generator will have a nominal rating of 11.1 MVA, 0.9 power factor at 60°C temperature rise and will be capable of continuous operation at 115% of rated power without injurious temperature rise. The generators will be designed to permit generation with a 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 (maximum 142 m; minimum 82) and will be designed to release 20 m^3/s, which is the EGMC system capacity and produce about 12 MW at the minimum head. Their operating speed will be 750 rpm. Average energy production is estimated to be 60 GWh/yr. The layout is subject to change as final designs are made.

4.5.2 Powerplant at King Talal Dam

The powerplant at King Talal Dam will have an installed capacity of 2 MW and is expected to produce 8.7 GWh annually using one generating unit at a rated head of 67 m (maximum 84 m, minimum 43 m) and a rated discharge of 3.4 m^3/s. The generator will be rated 2222 kVA, 0.9 power factor at 60°C temperature rise. The generator will be capable of continuous operation at 115% of rated power without injurious temperature rise. The turbine will be a vertical-shaft Francis-type

machine operating at a speed of 1000 rpm. The existing low-level outlet and diversion tunnel will be used as water conductors for the power facilities. The intake for the existing outlet works is at El +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 valve in the valve chamber will be replaced by a spherical valve. The diameter of the water conduit will be reduced by a bifurcated steel pipe from 6.5 m in the diversion tunnel to 1.5 m in the bypass pipe and 0.75 m in the penstock. The penstock will be placed in a 2 m diameter unlined tunnel from the diversion tunnel to the powerplant. A 2 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 bypass.

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 will be at El +70 and the powerhouse roof will be near ground surface at El +90.

Because of the increased return flow to the Zarqa River as a result of the new M&I allocations to Amman and Zarqa, it is expected that the energy produced at the plant will be increased over the original estimates. No data are available regarding the final plan.

4.5.3 Transmission Lines

The two Maqarin powerplant units will be served by one three-phase power transformer. It will be oil insulated, self cooled, and rated at 26 MVA 13.8/60 kV. A single-circuit 66 kW transmission line will lead from the switch yard to Irbid, approximately 30 km away.

The King Talal powerplant unit will also be served by one three-phase transformer, which will be oil insulated, self-cooled and rated at 2600 kVA, 2.4/33 kV. A single-circuit 33 kV transmission line is connected to the Amman-Salt transmission substation, about 9 km from the power station.

4.6 IRRIGATION FACILITIES

4.6.1 General

The agricultural production of the lands irrigated under Stage I of the Jordan Valley Irrigation Project is primarily based on open ditch irrigation systems. The production fell short of expectations, one reason being that land leveling was not carefully carried out during the Stage I project implementation. The results of examination of experimental farms in the Valley indicated that conversion from surface irrigation to sprinkler irrigation would permit the achievement of much higher yields on many crops in the Valley. Accordingly, the Feasibility Study called for conversion of existing facilities to sprinkler irrigation and extending the system to irrigate additional arable land in the Valley.

(Although only the use of sprinkler systems was contemplated in the Feasibility Study, it is now expected that farmers will select either sprinkler or drip systems as they deem best for their type of crop. Although the discussion that follows concentrates on the sprinkler method described in the Feasibility Study, it is expected that the drip method will also be used extensively, and the term "sprinkler" should generally be interpreted to now mean "sprinkler and/or drip" with respect to irrigation method.)

The existing EGMC and the proposed 14.5 km[1] extension will serve as the main water conveyor. Gravity turnouts and pumping stations will be located along the canal. Carrier pipes will convey water from the various turnouts to the distributaries. The distributaries will supply the headgate unit mains which, in turn, will supply individual farms through the farm mains. The farm sprinkler laterals (fly lines) with sprinkler heads will be connected to the farm mains.

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[1] Whether the EGMC will be extended for the entire 14.5-km length remains to be determined in view of the 3600-ha reduction in irrigable land between the Feasibility Study and the "C-1" plan.

Whenever possible and economically justified, gravity flow will be used to supply the pressure required for the sprinklers. The economic analysis consists of comparing the annual cost (capital, operating and maintenance costs) of providing the required pressure by gravity conveyance pipe against that of a conveyance pipe and a pumping plant. When pumping costs were analyzed, consideration was given to using either smaller pipes and larger pumps or larger pipes and smaller pumps. The selection of optimum pump and pipe size combinations was based on annual cost, while maintaining the pipe flow velocity within the accepted limits, up to 2.5 m/s.

4.6.2 Pumping Stations

Stage II development is expected to require six high-head pumping stations and 12 low-head pumping stations. Low-head pumping refers to pump stations which act as booster pressure stations for areas adjacent and below the EGMC. These are areas which would not have adequate pressure to operate sprinklers if served by gravity diversions. High-head pumping refers to pumping stations supplying water to areas lying above the EGMC. All pumps will be horizontal, centrifugal pumps supplied with a positive intake pressure. A stand-by potential of one-third of the required capacity will be included for emergencies. The high-head pumping stations will be equipped with hydraulic valve surge controls.

4.6.3 Distribution and Pipe Networks

A detailed irrigation system layout (1:10,000) was prepared by Dar Al-Handasah Consultants. Their plan shows pipe diameters and lengths of the carriers and distribution pipes. The capacity of the distribution system (canal; carrier; distribution pipes; headgate unit mains) was based on meeting the peak irrigation requirements of the average cropping pattern (85 mm/month), which was further augmented by between 25% to 60%, depending on the delivery area considered. Headgate unit mains were sized on the basis of the area they serve and the criteria of the system capacity presented above. Distributaries, carriers

(also the main canal extension), and pumping plants were sized on the basis of the area they serve and the criteria of the system's capacity.

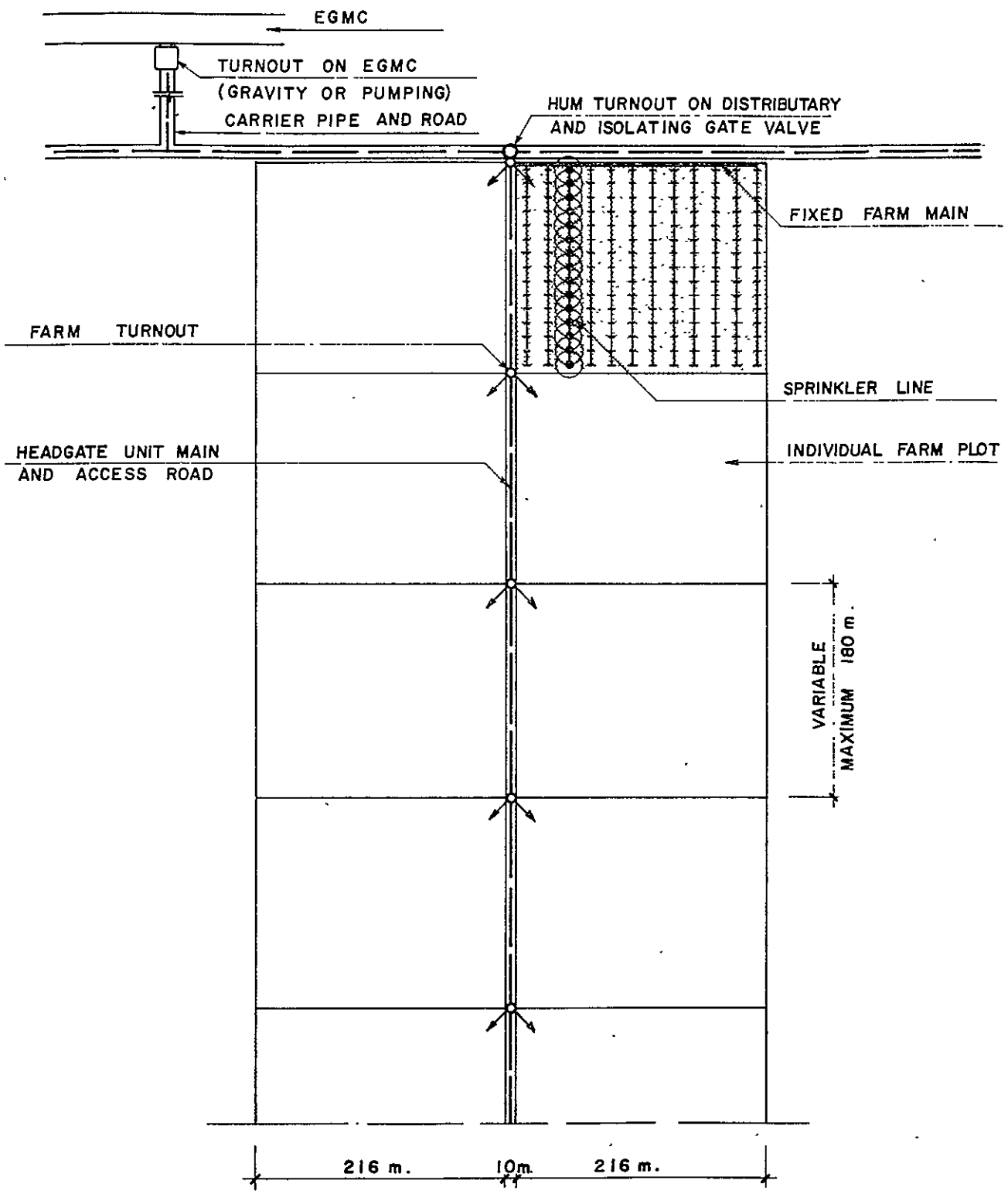
The maximum allowable pipe flow velocity is 2 m/s, and the pressure required at the beginning of a farm turnout is 3.5 kg/cm^2. Pressure regulators are incorporated into the system. Gravity delivery was adopted wherever feasible for areas located downhill of the EGMC and as long as the pressure obtained would be adequate to operate the pipe network (including sprinklers).

The Rajid-Arda irrigation (3950 ha), which lies between Wadi Rajid and the northern limit of the existing 18 km EGMC extension was given special consideration because it will be irrigated from two water sources, namely, with water obtained from the King Talal Dam (Zarqa River; gravity system) and water obtained from the EGMC (pumping system).

The feasibility design for the farm irrigation system was based on supplying the peak water use demand (7.50 mm/day for alfalfa) which occurs during July. The majority of the project farms have been planned with dimensions of 216 x 180 m based on a sprinkler spacing of 12 x 18 m for an average area of 4 ha. The sprinkler flyline area is located perpendicular to the ground contour lines as much as practicable to utilize slope as effectively as possible and wherever possible to reduce the pipe diameters. A typical laycut of the pipe network is shown in Figure 4-11.

4.6.4 Portable Farm Systems/Drainage Systems

Part of the irrigation facilities is the portable farm system which includes the sprinklers and the main line. The sprinklers were selected on the basis of 11.5 hour operation on an area of 12 x 18 m. The design flow of each sprinkler is 0.365 l/s and the nozzle pressure is 2.7 kg/cm^2; each sprinkler line will have 15 elements and 100%



Source: Harza Overseas Engineering Company.

Figure 4-11 Typical Layout of the Pipe Network

overlap between adjacent sprinkler is proposed. An asbestos cement pressure pipe serves as the main farm line.

A drainage system is recommended as an integral part of the irrigation development. This should provide for runoff with surface drainage and water table level control with sub-surface drainage. The design criteria for the surface drainage are given in the Dar-Nedeco report of 1966, Annex C [in 4-1] which recommends among others that one-third of the peak 24-hour rainfall having a five-year recurrence interval be used for computing the surface runoff from natural rainfall. All surface drains are unlined earth channels designed to prevent erosion.

Subsurface drainage is recommended for about 500 ha (in addition to a nearly equal area for which the JVA is presently planning sub-surface drains) for areas: (i) where high water tables are caused by upward flow from artesian aquifers, (ii) where there is lateral seepage from upstream areas, and (iii) that need artificial drainage to leach salts from the soil profile.

The areas with upward artesian flow require pumping to relieve the pressure as well as tile drainage. Water tables caused by lateral seepage are lowered with widely spaced (250 m or more) interceptor drains. Areas with high salts will need tiles spaced at 90 to 125 m depending on the soil permeability and leaching requirements. Sulfate resistant concrete pipes or plastic pipes would be used. Finally, a grid of observation wells and piezometers is recommended for areas likely to have drainage problems.

4.7 MUNICIPAL AND INDUSTRIAL WATER SUPPLY

An allocation of water for M&I use was made by Harza in the Feasibility Study [4-1] for the Irbid Governorate, Amman, and the Jordan Valley. M&I water included domestic and industrial needs and livestock watering. The water requirements, based on estimates of population and daily use were: 10 MCM/yr for Amman, supplied from the King Talal Reservoir[1]; 12 MCM/yr for Irbid, supplied from the Maqarin Reservoir; and 8 MCM/yr for the East Jordan Valley, supplied by the EGMC. The total M&I use was 30 MCM/yr. [4-1]

As a result of subsequent water demand studies, it is now proposed (in the "C-1" plan) to allocate a total of 26 MCM/yr of water for M&I use to the Irbid area and 100 MCM/yr to the Amman area. The supply to these cities will be about 25 and 95 MCM/yr, respectively after allowing 5% for conveyance and treatment plant losses. Fifty percent of the supply is expected to reappear as return flows, with the Irbid supply returning to Wadi Arab and the Amman supply returning to the Zarqa River.

4.7.1 Upland Cities

4.7.1.1 Irbid

A pipeline capable of carrying 24 MCM/yr will be constructed from the Maqarin Reservoir site to Irbid. Initial pumping and water treatment plant capacities will only be half of the pipeline capacity, i.e., 12 MCM/yr. Work on this is expected to begin very soon, with withdrawal from the Yarmouk River being made prior to the construction of the Maqarin Dam.

4.7.1.2 Amman

A pipeline capable of carrying 72 MCM/yr will be constructed from the EGMC to Amman. The initial pumping and treatment plant capacity will

[1] Wastewater from Amman would discharge to the Zarqa River and eventually flow back into the King Talal Reservoir. The 10 MCM/yr figure represented estimated net losses for the circulating system.

be 36 MCM/yr. With this approach, it is easy to add to the pumping and treatment plant capacities, whereas it is less expensive to construct the pipeline to its eventual size from the beginning. The conveyance system, even when completed to 70-MCM/yr capacity, will not be able to handle the 100 MCM/yr shown for M&I allocation to Amman in the "C-1" plan. It is assumed that an additional pipeline, pumps and treatment plant capacity would be added at a future date to provide the necessary additional conveyance and treatment capacity.

It is assumed that 50% of the M&I water supplied to Amman and Irbid will reappear as streamflow as a result of wastewater release. Wastewater from the city of Irbid is expected to return to the Wadi Arab and add to the Wadi Arab streamflows. Return flows from Amman and Zarqa will be to the Zarqa River.

4.7.2 Villages in the Valley

The village development in the Valley will be an induced activity as a result of the Stage II development. Potable water will be supplied to each housing unit in all the villages. Water will be taken from various springs in the Valley or from wells next to the wadis. In the Feasibility Study, it was estimated that 8 MCM/yr would be required for M&I water uses and would be supplied by the EGMC and from the wells/springs. In the "C-1" study, there is no explicit allocation of M&I water from the project system, i.e., Maqarin Reservoir and the EGMC, for the villages in the Valley. We assume that any water that cannot be supplied from wells and springs could be obtained from the EGMC. The volume supplied from the EGMC, if any, is expected to be less than 8 MCM/yr, which is small compared to the nearly 300 MCM/yr that is allocated to irrigation use.

4.8 PHYSICAL SYSTEM OPERATION

4.8.1 Introduction

This section describes the overall water uses and allocations associated with the Stage II development, including water withdrawn from the watershed in Syria and water which will flow past the diversion dam and be used in the Yarmouk Triangle.

For the original Stage II Feasibility Study, Harza conducted simulation studies to determine safe yields as a function of Maqarin Reservoir sizes. For a reservoir with a maximum pool elevation of 150 m (dam height to 158 m), it was found that 25,353 ha could be irrigated with 94% reliability, assuming use of sprinklers for irrigation. The system also provided 20 MCM/yr for M&I use in the Valley and for the city of Irbid and 25 MCM/yr for the Yarmouk Triangle area. The reservoir was sized to allow storage for 50 years of sediment accumulation. The simulation study was performed using monthly flows for a period of 22 years (October 1953 to September 1975), a time interval representing the period of reliable record at the Maqarin Dam site.

Under the "C-1" plan, revised M&I water allocations of 126 MCM/yr have been proposed in order to satisfy newly developed population projections for the upland cities including Amman and Irbid. This will result in a decrease in the total area of land that can be irrigated under the Stage II project of about 3600 ha, or from 25,353 to 21,750 ha. To provide sufficient storage for these allocations, a dam height of 178 m will be necessary.

In this section, mean annual water supplies and demands have been shown for the present (1978) and the future. The "future" is used to symbolically represent the time period when the full M&I demand of 126 MCM/yr would be reached, and irrigation activities would have been developed to the extent shown in the "C-1" plan. Numerical estimates are generally given using two numbers (e.g., 240.3/210.7) indicating the projected flows at a specific location for the present and future,

respectively. Reference to specific locations may be made using "node" numbers as shown in Figure 4-12.

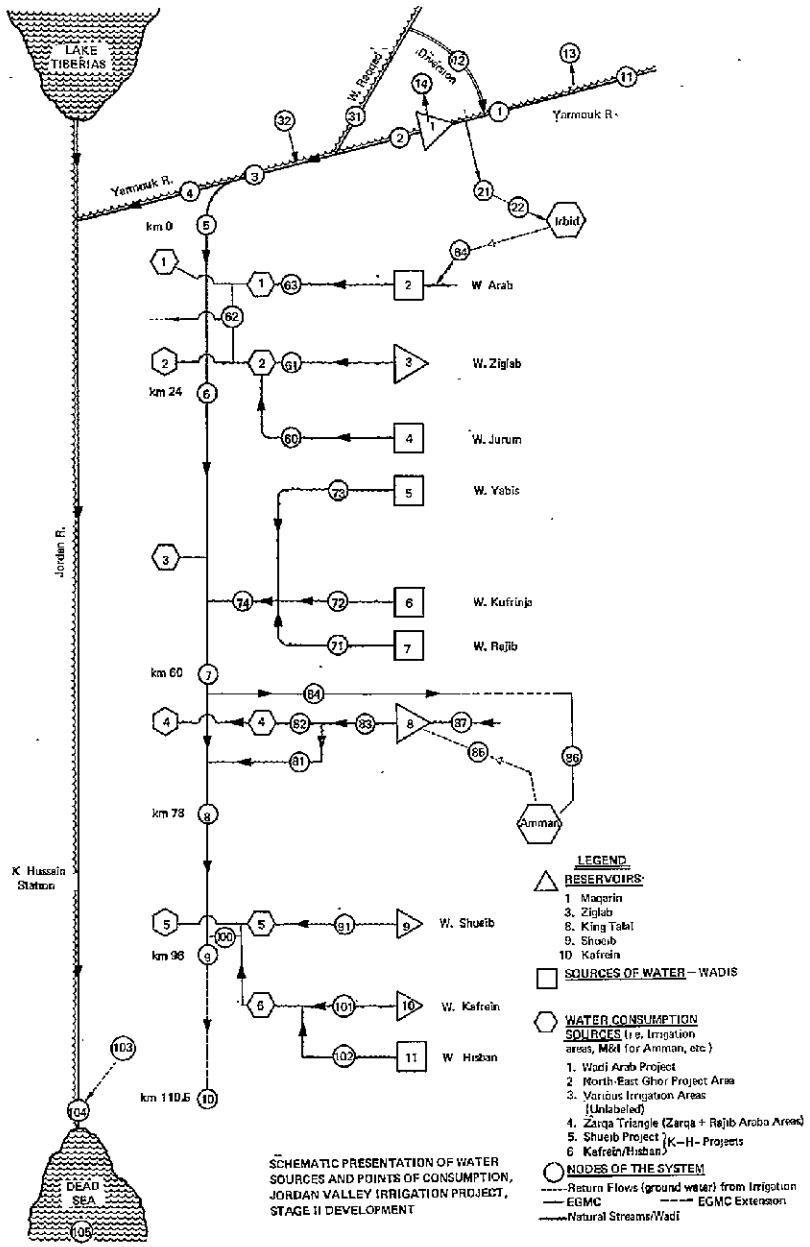
The system operation described in this section deals mainly with: (a) water released from the Maqarin Reservoir, (b) flows diverted from the Yarmouk River to the EGMC, (c) M&I water supply requirements and return flows, and (d) water required for irrigation. More detailed information regarding monthly estimates and assumptions used in projecting water allocations can be found in Appendix G. This analysis is only indicative of the probable water balance for the Stage II project, and it cannot be regarded as a planning document since it does not account for the stochastic nature of the water supply. The numerical estimates are given as absolute numbers in the following paragraphs for the purpose of facilitating reading, but they must be treated as rough estimates only.

Water supply and demand projections are summarized in Figure 4-12, under "Present" and "Future."

4.8.2 Maqarin and King Talal Reservoirs

The Maqarin Reservoir is the major source of water supply for the irrigation and the M&I systems. Net inflows to the reservoir are hydrologically time-dependent and project-time-dependent. Project-time-dependent flows are functions of: (a) the withdrawals from the drainage basin in Syria (node 13); (b) reservoir evaporation (node 14); (c) the M&I withdrawals for the Irbid area water supply system (node 21); and (d) the diverted flood flows of the Wadi Raqqad, Syria (node 12).

The "C-1" design calls for a dam crest of El 178 m which would provide for the downstream water requirements and a sediment deposition in the reservoir of 98 MCM for 100 years. The projected downstream releases from the Maqarin Reservoir are based on meeting downstream requirements after allowance for unregulated inflows into the lower Yarmouk



SCHEMATIC PRESENTATION OF WATER SOURCES AND POINTS OF CONSUMPTION, JORDAN VALLEY IRRIGATION PROJECT, STAGE II DEVELOPMENT

NODE	PRESENT (1978)	FUTURE[1] (Harza Study)	AFFECTED FLOWS (IMPACTS)[2] (Absolute Values)
Principal			
1	240.3[19]	210.7	(29.6)[3]
2[12]	240.3	202.3[14]	(38.2)
3	390.3	304.1	(86.2)
4	261.4	25.6[14]	(236.4)
5	128.9[13]	279.1[12]	150.2
6	96.4	230.7	134.3
7	65.1	174.6	110.5
8	51.6	53.9	2.3
9[5]	37.4	27.9	(9.5)
Secondary			
11	240.3[18]	240.3	0.0
12	0.0	48.0	48.0
13	0.0	29.6[19]	29.6
14	0.0	8.1	8.1
21	0.0	26.0	26.0
22	0.0	24.7	24.7
31	73.3	35.3	(48.0)
60	11.2	11.2	0.0
61	3.6	3.6	0.0
62[11]	0.0	12.3	12.3
63	28.8	41.2	12.4
64[6]	0.0	12.4	12.4
71	7.1	7.1	0.0
72	6.1	6.1	0.0
73	3.3	3.3	0.0
74[16]	16.5	16.5	0.0
81	11.9	15.5	3.6
82	55.4	99.3	43.9
83	67.3	114.8	47.5
84	0.0	100.0	100.0
85	0.0	47.5	47.5
86	0.0	95.0	95.0
87[6]	67.3	67.3	0.0
91	7.9	7.9	0.0
100[4]	10.2	10.2	0.0
101	14.3	14.3	0.0
102	5.0	5.0	0.0
103[7]	53.9	70.7	16.8
104	1009.0	795.5	(204.5)
Dead Sea (Elevation in meters)			
105	-392.9	-403.1	(10.2)

IRRIGATION AND M&I WATER REQUIREMENTS FOR THE VALLEY AND AMMAN[8]

• Wadi Arab and North Irrigation Projects; Source of Water: Wadis Arab, Ziglab, Jurum, EGMC			
Areas [ha].	4010.0	4010.0	0.0
W. Demand	43.7	43.7	0.0
W Supply	49.5	61.9	0.0
W Surplus.	5.8	18.2	12.4
• Zarqa Triangle Irrigation Projects; Source of Water: Zarqa River, EGMC			
Areas [ha]:	5077.0	9097.0[17]	4020.0
W. Demand	55.4	99.3	43.9
W Supply	67.3	114.8	47.5
W Surplus	11.9	15.5	3.6
• Kafrein-Hisban (K-H) Project; Source of Water: Wadis Shueib, Kafrein, Hisban			
Areas [ha]:	1560.0	1560.0	0.0
W Demand	17.0	17.0	0.0
W. Supply	27.2	27.2	0.0
W Surplus.	10.2	10.2	0.0
• Other Minor South Irrigation Projects[9]; Source of Water: Wells/EGMC			
Areas [ha]	2132.0	2132.0	0.0
W Demand.	23.3	23.3	0.0
W Supply	23.3	23.3	0.0
W Surplus:	0.0	0.0	0.0
• EGMC Irrigation/M&I Projects, Source of Water: EGMC			
Areas [ha]:	11927.0	17730.0	5803.0
W Demand (inc M&I):	130.1	295.4	165.3
W Supply (inc M&I):	167.5	321.3	153.8
W Surplus.	37.4	27.9	(9.5)
Potential Irrigation from EGMC	3428.0[10]	2557.0	(871.0)
• Total Irrigation/M&I in the Valley and Amman			
M&I Amman	0.0	100.0	100.0
Areas [ha]	24706.0	32397.0[15]	7691.0
W. Demand (inc M&I):	269.5	476.7	207.2
W Supply (inc M&I)	334.8	548.5	213.7
W Surplus	65.3	71.8	6.5

FOOTNOTES

1) With reference to the assumptions made in Section 4.8, Physical Systems Operation with the Project (future), and in Section 6.2.3.2.1.1, Flows Without the Project (present).

2) The analysis is performed for a "typical" year using average annual expected streamflows and water demands and is only indicative of the probable water balance. A "typical" year does not account for "spills" from the reservoir which will probably take place two or three times in a 25-year period and which water quantities cannot be used. The unused spill quantities equal: (a) Maqarin Reservoir--22.5 MCM/yr (node 2); (b) lower Yarmouk River--17.9 MCM/yr (node 4); and (c) excess inflow to the EGMC--5.3 MCM/yr (node 5).

3) Numbers in parenthesis indicate negative impacts. Negative impacts indicate water decrease (MCM/yr) or lowering of the Dead Sea surface.

4) The excess of water (including flood flows) from the side wadis is discharged into the EGMC.

5) No canal extension beyond Km 96 is assumed for the future in the analysis.

6) Groundwater return flows equal 50% of the water quantity supplied to the city.

7) Irrigation groundwater return flows equal 20% of the consumed water quantities.

8) In the present analysis, irrigation water requirements equal 10,910 m^3/ha/yr; however, irrigation requirements may not equal the above estimate because future irrigation practices may lead to more efficient water uses.

9) The present water source of this project is a well system. In the future, irrigated land will be supplied by the EGMC.

10) Available water quantities at the EGMC and are theoretical estimates and should be used with caution. The available flows can irrigate up to 3428 ha at present and up to 2551 ha in the fucure.

11) Excess of water (including flood flows) in the future is not discharged into the EGMC but is used locally.

12) The net reservoir annual evaporation equals 8.10 MCM/yr.

13) This estimate equals the 1978 inflow record to the EGMC (JVA, 1979).

14) This is an estimate for the reservoir operation given by the Harza Operation Studies (September 1979). This estimate does not account for spill flood flows; see footnote 2, above.

15) This is the new estimate for the total irrigated area in the Valley (Harza Operations Study, September 1979).

16) The total flow of the wadis is assumed to be diverted into the EGMC, from which various irrigation areas are supplied.

17) Total irrigated area as determined by the recent Harza Operations Studies (September 1979).

18) Based on a historical mean annual discharge of 255.6 MCM/yr, adjusted for estimated historic Syrian withdrawals of 15.3 MCM/yr.

19) Estimated future additional Syrian withdrawal is 29.6 MCM/yr.

Figure 4-12 Projected Surface Water Resources
Jordan Valley Project Stage II Development

River and return flows from M&I supplies. The average annual release from Maqarin Reseroir is expected to be about 202 MCM (node 2).

The Maqarin Reservoir releases will serve three purposes: (a) the Yarmouk Triangle requirements of 25 MCM/yr from May to October (node 4); (b) the EGMC irrigation and M&I requirements (node 5); and (c) the hydroelectric power requirements at Maqarin Dam. The hydroelectric power purpose is secondary to the other purposes. The releases from the Maqarin Reservoir will reach the EGMC after flowing down the Yarmouk River.

Under the Feasibility Study, the King Talal dam was to have a powerplant involving releases of about 3.4 m^3/s. Under the "C-1" plan, the inflow to the King Talal Reservoir will be increased by 47.5 MCM/yr or 1.5 m^3/s as a result of return flows from the M&I supply to Amman (node 85). These additional flows will be available for the powerplant.

4.8.3 Municipal and Industrial Water Supply

A total water allocation of 126 MCM/yr for M&I use is planned for the cities of Irbid and Amman and their surroundings. Water for the Irbid system will be withdrawn from the Maqarin Reservoir. For Amman, M&I water will be taken from the EGMC (node 84). Villages are supplied by wells (groundwater resources) which are next to the wadis which also supply the EGMC.

It has been assumed that 50% of the withdrawal from the EGMC for Amman's M&I use (after allowance for 5% less for conveyance and treatment plant) will return to the Zarqa River (node 85) and that 50% of the allocation to Irbid, after allowance for 5% loss, will appear as return flow to the Wadi Arab (node 64).

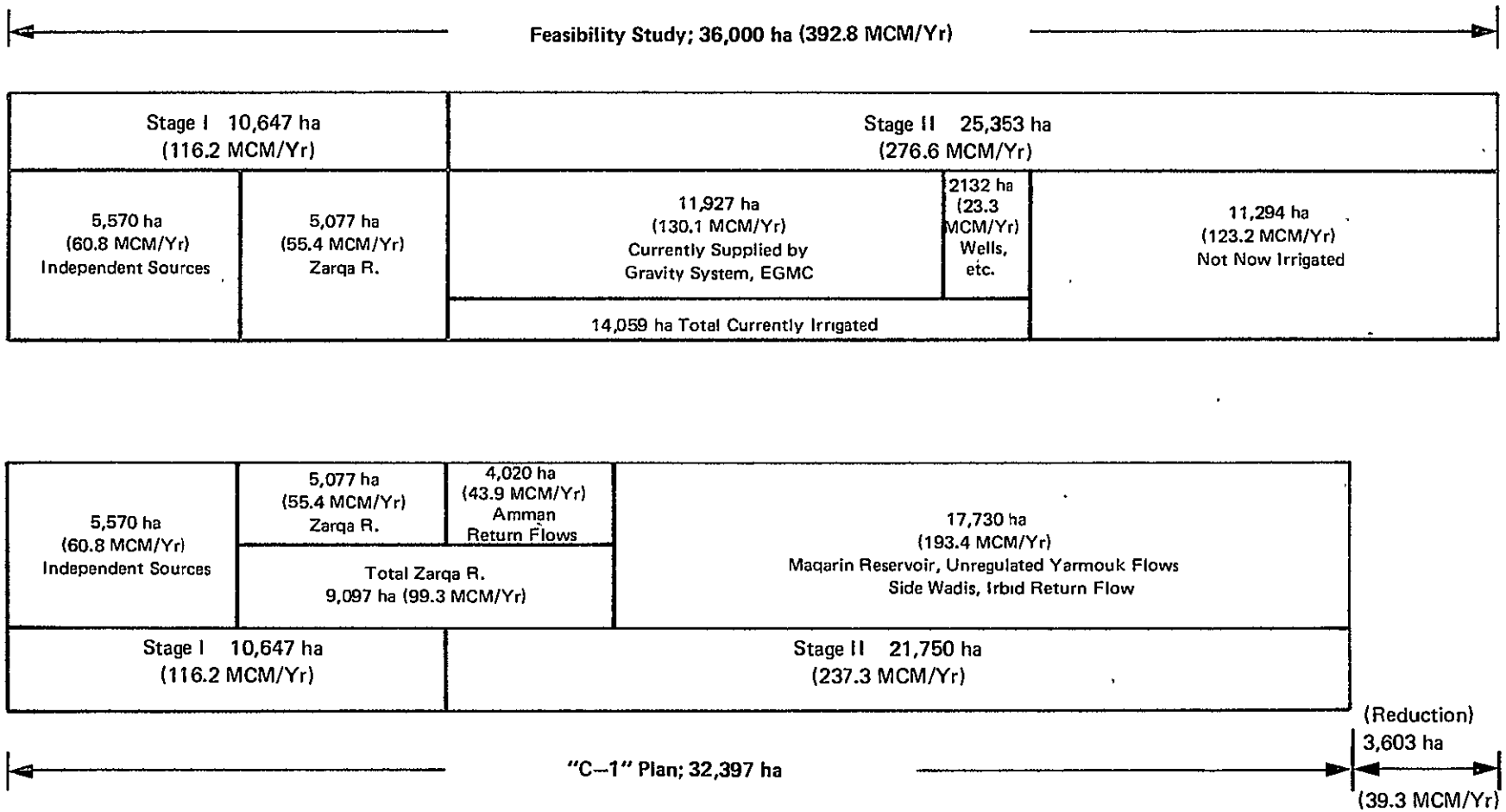
4.8.4 Irrigation Supply

The irrigation supply for Stage II as proposed under the "C-1" plan has been reduced somewhat from that proposed in the Feasibility Study, but a direct comparison between the two plans is complicated by the larger reservoir of the "C-1" plan as well as the increased M&I allocations and hence increased return flows. The areas to be irrigated under each plan and the associated mean annual allocations of water for both Stage I and Stage II projects are shown in graphical form in Figure 4-13.

The upper bar graph shows the irrigation allocations that were proposed under the Feasibility Study. The Stage I areas, which were essentially completed and operational, consisted of two parts: (1) 5570 ha supplied from independent water sources, and (2) 5077 ha supplied from the Zarqa River. The independent sources included the Wadis Hisban and Kafrein Project (1560 ha), the Northeast Gohr Project (2760 ha) supplied by the Wadis Arab and Jurum and regulated supplies from the Wadi Ziglab, and the JICA Project (1250 ha) supplied from the Wadi Arab.

The Stage II project as defined in the Feasibility Study consisted of three parts: (1) 11,927 ha that were already being irrigated by a gravity system but which would be converted to sprinkler irrigation; (2) 11,294 ha to be irrigated using new water supplied from the EGMC under Stage II development; and (3) 2132 ha of area that had been irrigated by independent sources such as wells and base flows of side wadis but which would tend to lose their supply as Stage I facilities were completed and which would, therefore, be irrigated by sprinkler supply from the EGMC. The total area that was to be irrigated by firm water supply using sprinklers (Stage I and Stage II) in the Feasibility Study amounted to 36,000 ha.

Under the "C-1" plan, shown in the lower bar graph in Figure 4-13, the Stage I irrigated area is unchanged at 10,647 ha. The Stage II proj-



Note: Water allocations are based on an average annual irrigation requirement of 10,910 m^3/ha.

Figure 4-13 Irrigation Allocations

ect, as analyzed in the "C-1" study, deals only with water associated with the Maqarin Dam project. This includes Yarmouk River flows, diversion from Wadi Raqqad, diversions to the EGMC of water from Wadis Yabis, Kufrinja and Rajib, return flow from Irbid to Wadi Arab, and return flow to the Zarqa River from Amman. The return flows from Amman (43.9 MCM/yr) would provide irrigation for 4020 ha. The total Stage II irrigation is 21,750 ha, which when combined with the Stage I irrigated area would provide a total irrigated area of 32,397 ha.

The location of the 21,750 ha to be irrigated under Stage II are not known exactly. Presumably, the 11,927 ha currently supplied by the EGMC will be included, as would the 2132 ha currently supplied by wells and side wadi base flows. The 3600-ha reduction would therefore be applied to the 11,294 ha shown as not now irrigated in the Feasibility Study.

The irrigation requirements discussed in this report are those shown in the "C-1" plan. However, the JVA and the donor group are continuing their studies or irrigation schemes, and it is possible that the irrigated area could be increased from that shown in the "C-1" plan. This could occur as a result of changes in the cropping pattern to favor crops having lower water requirements, changes in the type of irrigation, or reduction in the proposed length of the growing season.

In fact, all of these options will have to be considered over the next 30 and more years because of the gradual increase in M&I water allocations with associated reductions in irrigation allocations. This shift in allocations would also affect the locations where irrigation water is available, since the return flows from M&I use will reappear in the Wadi Arab (from Irbid) and the Zarqa River (from Amman). The return flows from Irbid to the Wadi Arab are not expected to be diverted into the EGMC, but some of the Zarqa River flows could be diverted into the EGMC at a point below the withdrawal for Amman.

The average annual irrigation water requirement is 10,910 m^3/ha (10,100 north area; 11,720 south area; the Zarqa River being the demarcation between north and south). This requirement is estimated using the Blaney-Criddle method with modified crop factors to compensate for humidity and wind. The net irrigation requirements are increased to allow for an application efficiency (75%) and a conveyance efficiency (94%) yielding an overall system efficiency of 70%.

4.8.5 Water Shortage Analysis

The water allocation for the "C-1" plan were determined by Harza Engineering Company from a computer simulation model using 25 years of monthly hydrologic input. The project operations are modeled as follows:

> "Maqarin Reservoir regulates the streamflow of the Yarmouk River and diversions from Wadi Raqqad. All other supplies essentially are unregulated. The reservoir will be operated to hold water when demands can be met from unregulated supplies downstream from Maqarin thus making maximum use of the available supply. The irrigation requirements in the Jordan Valley are met from reservoir releases, unregulated Yarmouk River flows and side-wadi flows diverted to the irrigation area, and return flows from the M&I supply to Irbid and Amman. The M&I supplies for Irbid are withdrawn directly from the reservoir. M&I supplies for Amman are released into the river through the power station, diverted into the EGMC, and rediverted into the EGMC-Amman water carrier. Mandatory releases for the Yarmouk Triangle are released into the river and are either passed over the diversion weir at Adasiye or diverted into a pipe at the weir and conveyed by gravity to the Triangle area." [4-3]

The model operates by examining a range of trial irrigation allocations. Each trial value is tested using the 25 years (600 months) of

hydrologic input, and for each trial the program determines the number of months that the desired irrigation volume was unavailable, that is, that a shortage occurred. The criteria for shortages was established at not more than 6 ±0.5% of the months during the 25-year period. The selection of the 6% as a criterion "will result in acceptable irrigation conditions based on the analysis of the degree, pattern and timing of shortage for several criteria ranging from four to ten percent." [4-3]

Under actual operations, it is expected that a notice would be given to each farmer regarding the water quality to be allocated to his farm for the coming month or season from the EGMC. The development of such a plan will require data acquisition of main canal, reservoir and stream levels, study of the past records (climate, flows, agricultural data, etc.), and use of a computer information processing facility. The potential benefits of such a plan are evident but the difficulty in ensuring continued success of an automatic control system must not be underestimated.

4.8.6 Jordan River and the Dead Sea

It is anticipated that the water allocation as presented in this study will reduce the Jordan River flow to 795 MCM/yr upstream of the Dead Sea (node 104). Consequently, the Dead Sea elevation is expected to be lowered to about El -403 m. More details regarding the rough calculation procedure are given in Chapter 6 and Appendix G.

4.9 ORGANIZATIONAL SYSTEM AND OPERATING PLANS

4.9.1 The Jordan Valley Authority

The agency charged with executing the projects described in this chapter is the Jordan Valley Authority (JVA). The JVA is one of a number of public enterprise corporations responsible for developing and providing market-oriented goods and services beyond the capacities of private sector firms. Its predecessors were the Jordan River and Tributaries River Corporation and the Jordan Valley Commission. The JVA operates under the Jordan Valley Development Law (Temporary Law No. 18, gazetted on May 16, 1977) which confers broad legal and financial powers, for example, to construct public works, to take and redistribute lands for agriculture and housing, to develop towns and villages, to design and construct roads, to develop tourism, to develop the social status of the Valley's inhabitants, and to manage and allocate all surface and subsurface water resources. No private person or government agency may construct buildings or other structures without the JVA's permission.

JVA' jurisdiction includes Jordanian lands along the Jordan River and its tributaries, the largest being the Yarmouk River, and was recently extended south from the Dead Sea to the Gulf of Aqaba to include Wadi Araba. JVA's president is not a member of the National Planning Council, but enjoys the status of a Minister. The JVA staff of about 2000 is organized in four departments (water resources, irrigation and drainage, rural development, and administration and finance) and works from headquarters in Amman and field stations throughout the Valley. Its financial resources come from budget appropriations, earned revenues, and grants and loans from foreign donors. Planning, design, and construction for JVA is done largely on contracts by Jordanian and foreign engineering firms.

4.9.2 Operation Plans

The performance of any water resource system depends on the hydrologic inputs (which can be expressed statistically but not determined ex-

actly in advance), the constructed facilities, and the operating plans for the system. The operating plans represent an important system variable and can have a significant effect on the economic benefits that are derived from the system.

Operating plans fall into two categories. One serves short-term operations (i.e., hourly to daily controls) and must take into account water flow energy as well as mass balance. With respect to the Stage II operations, this would include operational controls to assure the delivery of Maqarin Reservoir releases, including the peak power hydroelectric releases to the EGMC in a manner that would avoid either a surplus or a shortage of water. The releases would have to be modified to reflect variations in inflows from the side wadis, the unregulated portion of the Yarmouk River, return flows, and variations in withdrawal rates.

A plan for a short-term operations system that would feature an automated control system, including automated gates, a communication system and a computer for analysis, is outlined in the Stage II Appraisal Study. [4-8] The system would also have the capability of longer-term planning, including data monitoring, collection, and analysis. JVA reports that Harza is now detailing plans for implementing this system.

The second category of operating plans serves long-term operations, generally monthly or seasonal to annual or longer with respect to the planning horizon. Only mass balance of water is involved, subject to delivery system constraints. The decisions that are required for long-term operations include:

- Annual allocation plan--determined after the rainy season when reservoir storage is known but before agricultural plans are finalized and serving as an input to crop planning.

- Seasonal adjustments to existing annual allocation plan--determined in the summer and fall and serving to reallocate irrigation water in response to abnormal hydrologic conditions in other sources of supply such as the side wadis or wells.
- Long-term adjustments--made annually or at longer intervals to reflect changes in M&I demand and to reflect changes in irrigation requirements.

Long-term planning is a continuous process; it must respond to both hydrologic changes (wet and dry periods) and water use changes. The long-term adjustments must be based on the best projections available in order to allow time for planning and shifts in investment plans. The major tools needed for long-term planning analyses are sufficient data and reliable analytic techniques, including system models and optimization programs. With these tools, the operating agency, the JVA, would have the information that would be necessary to develop long-term plans.

JVA has not yet published formal documents regarding the establishment of long-term operations plans, but reports orally that procedures will be developed prior to the completion of the Stage II construction. Among the items that will have to be considered is the manner in which the gradual reduction in water allocated to irrigation use, and the change in the locations of such water that comes from return flows from M&I use, will be handled.

4.10 INDIRECT ACTIVITIES IN THE EAST JORDAN VALLEY

4.10.1 Introduction

Indirect activities are those that occur as a result of the direct activities. Although the Stage II plans form a comprehensive set of activities involving both water supply and other Valley-related activities, the former has been somewhat arbitrarily classified as the direct action and the latter as the indirect action. Descriptions that preceded this section of Chapter 4 have dealt with the direct actions. This section serves to summarize the indirect actions. Detailed descriptions of the indirect activities will be found in Chapter 6, together with their impacts.

4.10.2 General Plan

The Maqarin Dam and related extensions to the irrigation system in the East Jordan Valley are part of a larger long-range comprehensive plan and the program for development of the Jordan Valley and the related development of the Kingdom's scarce water resources. This program was actually begun in the late 1950's when the notion of developing a high-intensity agricultural economy in the low-lying Jordan Valley (using the water resources of the upland valleys on the East Bank of the Jordan) was first submitted to detailed development planning. The first result was the diversion above Adasiye of some water from the Yarmouk River into the EGMC and the resulting irrigation of some 13,500 ha of farmland in the northern half of the East Jordan Valley. This occurred in the mid-1960's.

Since that time and in spite of the troubled, virtually continuous wartime status of the Valley during the late 1960's and early 1970's, the plan and program for development of the Valley has been moving ahead. The current plan and program has a large number of separate but interrelated elements including:

- Major dams--including the King Talal Dam and the Maqarin Dam, the latter being designed to provide M&I water to upland urban areas as well as irrigation water to the East Jordan Valley.

- Smaller dams--in the stream valleys upland of the East Jordan Valley for the exclusive use of the Valley. There are three of these smaller dams now built.
- Irrigation projects--including plans for bringing water from the upland sources to various sections of the 100-km-long Valley, distributing it, and for technological improvements to the irrigation system (e.g., sprinklers).
- Agricultural development programs--including redistribution of agricultural land, extension of credit, introduction of new farming technologies, and reorganization of the market system.
- Basic infrastructure programs--including the provision of electricity, domestic water, and new improved roads and highways for both local farm-to-valley access and for access from the Valley to upland areas, and provision of better telecommunications facilities.
- Village development program--for the improvement of housing, living, sanitary access, land availability, health, education, commercial, and administrative conditions in the villages of the East Jordan Valley.
- Economical development programs--covering a number of non-agricultural projects for small industry, commercial development, and tourism.

The total cost of Stages I and II has been estimated to be about $1 billion.

With participation by all ministries of the Jordanian government and with funding from U.S. AID and other international sources, prime responsibility for the development planning and program implementation rests with the JVA. The complex program has many component projects, many with separate funding, priorities, and schedules. Each project's impacts and results are mingled with those of other projects; so, it is difficult to isolate and judge the impact of any one project separately from the status and impacts of the others.

4.10.3 Agricultural Sector

As proposed under the "C-1" plan, the Jordan Valley Irrigation Project, Stage II, would involve agriculture in the following ways:

- Inundation of a small area of agricultural production behind the proposed dam site below the 170 m contour;
- Irrigation for the first time (using a sprinkler system) of approximately 7750 ha of land (primarily the "new lands") in the East Jordan Valley;
- Conversion of approximately 14,000 ha of currently irrigated land (primarily the "converted lands") in the East Jordan Valley from surface or flood irrigation to sprinkler irrigation; and
- Introduction throughout the project area of additional modern agricultural production inputs and techniques to include more optimal timing of water applications to crops.

In addition to the 22,000 ha that are to be newly irrigated or converted to sprinkler irrigation under Stage II, nearly 11,000 ha are to be sprinkler irrigated from projects already underway. The sources of water for these ongoing irrigation activities are side wadis and the Zarqa River.

The Jordan Valley Irrigation Project, Stage II, is simply one component of the Jordan Valley Development Plan 1975-1982 which includes a number of investment proposals which together attempt to form a comprehensive rural development program. Other agriculturally related projects within this plan that will affect the Jordan Valley Irrigation Project are:

- Construction or improvement of four grading and packing stations in the Valley,
- Operations of the Jordan Valley Farmers Association (JVFA),
- Construction of farm roads,
- Strengthening the agricultural research and extension efforts in the Valley, and

- Implementation of a land redistribution program.

4.10.4 Village Development

The village development program is one of the most important components of the overall plan for the development of the Valley. Its objective is to provide major improvements in the villages that house the population--farmers and their families--now residing in the Valley, or which could be attracted to the Valley with improved living conditions. The ability of the Valley to hold and attract a farming population is key to the whole concept of Valley development, and as a result, a major effort is being put into the following actions:

- Designating a series of existing villages or on adjacent to non-agricultural land for major infrastructure improvements,
- Replatting[1] village land so that utilities and streets can be provided, and lots allocated to eligible farming and other families,
- Providing electricity, potable water, and sanitary facilities to existing and new houses,
- Providing new standard housing both low cost for farming and other families, and governmentally supplied for civil servants, along with low cost mortgage funds,
- Providing of new schools, health facilities, and public buildings to improve the quality of public services, and
- Encouraging development of new industrial and commercial enterprises.

There are 36 villages that have been studied for these improvements. The program is being implemented in phases. Phase I is just approaching completion, and plans are moving ahead for Phase II. U.S. AID is participating in these programs.

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[1] Plats are official land ownership maps covering an area such as a township, also showing streets and right-of-way.

4.10.5 Transportation and Telecommunications

The two transportation projects designed by JVA for Valley development have been completed. Plans for the transportation system are part of the Ministry of Public Works' (MPW) long-term planning efforts rather than a subset of Valley development plans. They are seen as infrastructure improvements necessary to meet the existing and future demands of the country's population and economic growth.

In December 1977, work on the Yarmouk-Dead Sea Road (Route 45) was completed. Because this is the main road in the East Jordan Valley, it was upgraded from a secondary to a primary classification by widening, resurfacing, and realigning the south end to provide better connections with the Amman region. The other Valley project, finished in July 1978, involved surfacing certain farm roads to provide all-weather access to irrigation systems and permit movement of produce to the markets. Some new roads were surfaced to connect communities previously not on the road network.

Three transportation projects under the aegis of MPW which will, however, have an effect on the agricultural development in the Jordan Valley are presently under way. Two projects are in planning which will affect the Valley (as well as the rest of Jordan): a U.S. AID sponsored program to plan maintenance of roads and equipment, and an MPW project to inventory, survey, and number all the village roads. Serious consideration is being given to construction of a new road to the Valley which would parallel the Zarqa River. Two of the current Valley-related projects involve the correction of road alignment--the most serious of all problems facing the MPW. The dangerously curved and steep-banked sections of Route 48 (the Southern Valley connector) are being widened and realigned. On Route 30 (the Amman-Jerusalem Highway), the recurring hazard of slides of loose geolgic material for a 2- to 3-km section is being solved. Route 20 from Mafraq and Jarash now ends in Kufrinja; on completion, it will connect with Route 45 at Kreiymeh, in the middle of the East Jordan Valley.

The Feasibility Study by the Jordan Telecommunications Corporation for the installation of a complete telephone system in the Valley is finished; the next step, a design study, has been delayed by lack of funds. The system calls for four major switching centers in the Valley, at South Shuneh, North Shuneh, Wadi El Yabis, and Deir 'Alla, which would connect lines to all the villages. The few telephones now in the Valley are part of an antiquated and tedious system. Telephones will be available to all who request service, but will be supplied on the basis of the ability to pay as measured by income.

4.10.6 Institutional Support

In addition to the many proposed constructed projects described above, several kinds of intangible institutional activities will also be required if the full benefits of construction are to be realized.

Although the JVA's charter includes social development for the Valley's inhabitants, its plans and projects published to date deal almost exclusively with the construction of physical infrastructure facilities. When completed, these will be handed over to government ministries for their use. Moreover, JVA sees itself as only a temporary organization, which will end upon completion of construction. Therefore, institutional support programs fall mainly within the responsibilities of other government agencies. However, JVA retains an interest because of its role as overall coordinator of the Valley's development.

The numerous activities related to agriculture were noted in Section 4.10.3.

Schools and clinics will be staffed by the Ministries of Education and Health. The government recognizes that high-quality education and health services are essential for attracting and retaining new inhabitants, especially in making the Valley's quality of life competitive with that offered by the upland cities. The JVA is allocating houses for government teachers, doctors, and health workers.

JVA's coordination with the Ministry of Education occurs with the Ministry's Planning Directorate in Amman. This official works closely with JVA staff to identify in which villages schools should be constructed and whether of the elementary or secondary type. The construction of 28 schools in the Valley at a time when educational resources throughout the country are strained, is indicative of the commitment of the JVA, the Ministry, and the national government to developing the Valley. The Ministry of Education has had little difficulty in assigning teachers to Valley villages compared to other rural areas in sparsely inhabited eastern and southern (south of the Dead Sea) regions of Jordan. This was confirmed in interviews with male and female teachers assigned to Valley schools. The Valley's attraction is its proximity to urban centers and its relatively moderate climate compared with lower-lying and more arid districts of Jordan.

The Ministry of Health is also supposed to post doctors and health workers as JVA completes clinics and hospitals. The Ministry did participate in initial planning for these facilities. However, the Ministry may face greater difficulties than will the Ministry of Education in attracting personnel to the Valley, because of staff shortages and competing needs and opportunities elsewhere.

Similarly, JVA is to transfer the completed local government and community center buildings to municipal and village councils. However, councils do not exist or operate poorly in a number of villages. Moreover, there appear to be no explicit plans for developing or strengthening the capacities of municipal and village councils to service the expected increases in population.

General functions of the central government are exercised through the two Governorates of Irbid and Balqa. The Valley's northern section is assigned to Irbid's North Shuneh District, while the middle and southern sections are administered by Balqa's Deir 'Alla and South Shuneh

sub-districts. These three district offices exercise police powers, supervise municipal and local councils, and generally supervise internal security, public safety, and development programs. There appear to be no explicit plans for changing or increasing civil administration capabilities. However, the idea of creating a single regional government or governorate for the whole East Jordan Valley has occasionally been considered.

Finally, institutional support is presumably needed in the areas of labor and social welfare. The Ministry of Labor has responsibility for labor conditions, supervision of temporary foreign workers (mainly from Egypt and Pakistan), and the welfare of women and children.

Although not a part of JVA's Village Development Program, a vocational center is being constructed in the center of the Valley at Deir 'Alla. JVA is building another at Kreimeh. Programs to be offered at Deir 'Alla are intended primarily for adults, including:

- adult literacy programs,
- child-care,
- dressmaking, and
- trades (types are not yet specified).

Social workers will move into Valley villages to encourage participation in the center's programs. To encourage female participation, child-care services will be available. Despite these efforts, there is some uncertanity as to whether the center will be fully utilized by adults. Should adult participation be less than expected, portions of the center will be utilized for children's education and social programs. When the center is constructed, it will be placed either under the Ministry of Labor's Department of Social Affairs or under a joint board of the Ministries of Education and Labor. The Kreimeh Vocational center and its programs will be experimental; if they prove successful, similar centers will be constructed elsewhere in the Valley.

5.0 RELATIONSHIP OF PROPOSED STAGE II ACTIONS TO JORDAN'S LAND AND RESOURCES, POLICIES AND CONTROLS

Section 3.4.5 described both the general structure of Jordan's economy and several important sectors. Chapter 4 described the projects proposed by JVA in Stage II. This chapter discusses how these projects would fit into Jordan's national development plans. It also reports the expected economic costs and benefits, the rationale upon which Stage II plans are based.

5.1 JORDAN'S DEVELOPMENT PLANNING AND GOALS

5.1.1 Planning Between 1952 and 1976

Jordan established its Development Board in 1952 essentially to supervise the expenditure of development loans from the United Kingdom. While early plans were restricted to public sector expenditures, the first five-year plan in 1961 covered both public and private investment. This plan was shortly superseded by a seven-year plan, 1964-1970, to (1) reduce payment deficits and dependence on foreign aid, (2) raise per capita income, and (3) increase jobs. It focused on agriculture, water resources and irrigation, mining, tourism, and manufacturing. Despite Israeli occupation of the West Bank in 1967, the government pushed forward with many of its original projects.

The National Planning Council (NPC), established in 1972, introduced the three-year plan of 1973-1975 which was, in effect, the interrupted 1964-1970 plan. The new plan's objectives were to:

- Increase employment and improve the quality of the labor force,
- Increase GDP by 8% per year in real terms while maintaining price stability,
- Gradually reduce reliance on foreign aid, and
- Increase investments in industry and mining.

5.1.2 The Current Plan 1976-1980

This plan, substantially more ambitious than its predecessors, calls for an annual real growth rate in GDP of 11.9%. Sector growth rates

are presented in Table 5-1, and their contributions to GDP in Table 5-2.

Public and private sector investments (see Table 5-3) envisioned by the plan include the following:

- Investment in mining and manufacturing is forecast to rise by over 29%, largely at the expense of the service sector. Major investment projects in this sector include a chemical fertilizer plant, expansion of oil refinery capacity and phosphate and cement production, exploitation of copper deposits, new potash projects, and development of the textile industry.
- Investment in transportation infrastructure is targeted for 15.7%, namely in large-scale road construction, extension of the rail network, and expansion of Aqaba's port and Amman's new international airport.
- Water projects will account for 12.7% of total investment.
- Agricultural investments are expected to rise by 5.2%. The plan calls for a significant shift away from cereals and into fruits and vegetables with strong export potential. Land cultivated for grain will be reduced to about 70% of its 1975 size.

5.1.3 The 1980-1985 Plan

Although major work has not yet begun on the second five-year plan, NPC staff members have made known that its major goals are not likely to differ greatly from those of the current plan. However, certain emphases are expected, in particular:

- More attention to equitable distribution of development benefits among all socioeconomic groups;
- Greater emphasis on regional planning, for such areas as Irbid, Amman, and Aqaba; and
- Priority to major projects: (1) Maqarin Dam, (2) fertilizer and potash development, and (3) phosphate development.

Table 5-1

Projected Growth Rates by Sector--1976-1980

Sector	Overall Growth, 1976-1980 (%)	Average Annual Growth Rate (%)
Agriculture	40.0	7.0
Mining & manufacturing	220.0	26.2
Construction	22.0	4.1
Electricity & water supply	120.0	17.1
Total Productive Sectors	161.8	21.1
Transport & communications	65.4	10.6
Trade (wholesale & retail)	41.8	7.2
Financial institutions	120.0	17.1
Ownership of dwellings	76.0	12.0
Public administration & defense	40.0	7.0
Other services	50.0	8.5
Total Services Sectors	51.1	8.6
GDP at factor cost	75.2	11.9
Indirect taxes	57.5	9.5
Net factor income from abroad	65.8	10.6
GNP at market prices	73.3	11.5

Source: Five-Year Plan for Economic and Social Development, 1976-1980, National Planning Council.

Table 5-2

Contributions by Sector to GDP--1975 and 1980

(%)

Sector	1975	1980
Agriculture	10.3	8.3
Mining & manufacturing	15.6	28.3
Construction	7.6	5.3
Electricity & water supply	1.7	2.2
Total of Productive Sectors	35.2	44.1
Transport & communications	9.0	8.4
Trade	19.0	15.3
Financial institutions	1.7	2.2
Ownership of dwellings	5.9	5.9
Public administration & defense	19.0	15.2
Other services	10.3	8.9
Total of Services Sectors	64.8	55.9
Gross Domestic Product	100.0	100.0

Source: Five-Year Plan for Economic and Social Development, 1976-1980, National Planning Council.

Table 5-3

Five-Year Plan Investments, Public and Private, By Sector--1976-1980

Sector	Investment (JD Million)	% of Total
Agriculture	40.0	5.2
Water	97.4	12.7
Mining & manufacturing	229.1	29.9
Tourism & antiquities	24.4	3.2
Electricity	42.8	5.6
Transportation	119.9	15.7
Communications and information	23.0	3.0
Trade	3.8	0.5
Subtotal of Economic Sectors	580.4	75.8
Education & youth welfare	34.6	4.6
Health	9.0	1.2
Social Welfare	1.0	0.1
Labour & vocational training	3.8	0.5
Housing & government buildings	86.0	11.3
Municipal & rural affairs	38.8	5.1
Waqfs (religious endowments)	5.5	0.7
Statistics	1.0	0.1
Royal Scientific Society	4.9	0.6
Subtotal of Social Sectors	184.6	24.2
TOTAL	765.0	100.0

Source: Five-Year Plan for Economic and Social Development, 1976-1980, National Planning Council.

5.1.4 Beginnings of Social Planning

Inspired by Crown Prince Hassan, and led by the Minister of Labor, representatives from about eight ministries and agencies are outlining the possible scope, procedures, and framework of an explicit social plan, to complement the 1980-1985 economic plan. The committee is analyzing the social content and implications of the 1976-1980 economic plan. It is also writing briefs on various social topics or sectors, such as the role of women in development, changing lifestyle of the bedouin, nutrition, and employment. It intends to propose specifically social projects for ministries to execute in 1980-1985. General supervision is likely to be assigned to the Ministry of Labor.

This beginning suggests that Jordan's leaders will no longer concentrate their attention and resources exclusively on tangible engineering projects, while leaving intangible social and institutional development to tradition and chance.

5.2 JORDAN VALLEY DEVELOPMENT

5.2.1 Strategy and Stage I

Far-sighted men have long dreamed of harnessing the waters of the Jordan River and its tributaries to bring to life potentially fertile lands on both banks of the Jordan Valley. Planning for the East Jordan Valley began in the 1950's. Construction of the EGMC began from the Yarmouk River, bringing water and benefits to the northern Valley in the 1960's. Stage I projects, begun in 1972 and now being completed, include:

- King Talal Dam for storing the flood water of the Zarqa River;
- 18 km extension of the EGMC to irrigate 3,600 ha of new land;
- Zarqa Triangle Irrigation Project to irrigate about 1,550 ha of arable land, involving a diversion dam 12 km downstream from the King Talal Dam;
- Northeast Ghor Irrigation Project to irrigate another 2800 ha;
- Hisban-Kafrein Irrigation Project to irrigate 1550 ha;
- Yarmouk-Dead Sea Road, which improved 98 km of existing road and extended the southernmost portion by 7.7 km;
- Farm roads, improving access to irrigation lateral canals and to farms and upgrading these feeder roads to all-weather roads;
- Schools, health clinics, community and local government centers, streets, parking areas, etc. for 36 villages (by 1982); and
- Electrical power to all 36 villages and to EGMC pump stations to supplement the gravity head in operating the sprinkler system on farms.

JVA's seven-year plan for 1975-1982 calls for the conversion of existing fields from surface gravity flow to sprinkler irrigation. The total irrigated area, including both conversion and new lands, was projected to be 36,000 ha. JVA estimated that new agricultural activities would create approximately 40,000 new jobs. Current manpower levels in the

Valley are inadequate, however, requiring that JVA examine incentives for attracting more labor. Hence, village development has become a major component of JVA's plan.

To arrive at optimum community sizes, JVA estimated manpower requirements for the agricultural activities cited in the national and regional plans and the necessary support functions for agriculture. JVA claims that a direct relationship exists between the community size and the incremental benefits from irrigation and road projects. It examined several alternative "annual rates of attraction," between 4000 and 14,000 persons over a period of 5 to 10 years and selected one based on attracting 8000 additional persons to the Valley over the six-year period 1976-1981. In Table 5-4, JVA attempts to calculate the manpower shortfall that will occur if the existing rate of population inflows is not accelerated. The calculated needed population is cited as the manpower levels needed to meet agricultural production targets. The revised population, in turn, is indicated as the summation of the baseline population and the induced emigration into the Valley, adjusted for growth. While JVA's figures may be subject to question, the effort to quantify potential manpower shortages is worthy of note. JVA's efforts to attract population center on providing adequate housing, social services, public utilities, irrigation, agricultural services, and job opportunities.

5.2.2 Jordan Valley Irrigation Project - Stage II

Set in the context of both the National Development Plan and the Jordan Valley Development Plan, Stage II seeks to bring water resources into the southern Valley. It is consistent with Jordan's overall planning objectives of (1) diversifying the national economy, (2) shifting agricultural production into crops with greater export potential, and (3) creating a pole of regional development in the Valley able to attract population from upland cities, especially Amman.

Table 5-4

Estimated Jordan Valley Population Pattern--1975-2001

Year	Calculated Needed Population	Baseline Population	Difference (Percent)	Attracted Population	Revised Population	Difference (Percent)
1975	66090	67920	+ 2.7	0	67920	+ 2.7
1976	66090	69957	+ 5.8	0	69957	+ 5.8
1977	80000	72056	-10	8000	80055	+ 0.1
1978	91000	74218	-18	8000	90457	- 0.6
1979	91000	76444	-15	8000	101171	+11
1980	91000	78737	-13	8000	112206	+23
1981	91000	81099	-10	8000	123572	+36
1982	147000	83532	-43	8000	135279	- 8
1983	147000	86038	-41	0	139337	- 5
1984	147000	88620	-39	0	143517	- 2
1985	147000	91278	-37	0	147822	
1986	147000	94017	-36	0	152256	+ 4
1987	147000	96837	-34	0	156828	+ 7
1988	147000	99742	-32	0		
1989	147000	102734	-30	0		
1990	147000	105816	-28	0		
1991	147000	108991	-25	0		
1992	147000	112261	-23	0		
1993	147000	115629	-21	0		
1994	147000	119097	-18	0		
1995	147000	122670	-16	0		
1996	147000	126350	-14	0		
1997	147000	130141	-11	0		
1998	147000	134045	- 8	0		
1999	147000	138067	- 6	0		
2000	147000	142209	- 3	0		
2001	147000	146475	0	0		

Source: "Jordan Valley Development Plan 1975-1982," Jordan Valley Commission. (Modified by Arthur D. Little, Inc.)

5.2.2.1 Direct and Tangible Benefits Expected from Stage II

Estimates of possible economic benefits were calculated in Harza's Stage II Feasibility Study in January 1978. Harza justified Stage II economically in terms of internal rates of return. In comparing benefits and costs over a 50-year period, beginning with the first year of construction, the internal rate of return for the project using direct benefits and costs was calculated at 13.4%; including also indirect benefits and costs, the internal rate of return increased to 15%. Using a discount or interest rate of 10% over the 50-year period, Harza calculated a benefit-cost ratio of 1.4 using direct benefits and costs only, or 1.6 using also indirect benefits and costs. (See Table 5-5.)

Harza indicated that benefits would be realized from irrigation, hydroelectric power, M&I water supply, and flood control. Irrigation benefits were defined as the increase in net farm income which can be attributed to Stage II development. The benefits were computed as the difference in expected future net income with and without Stage II development services. First, the water stored behind the Maqarin Dam would make possible the delivery of a large volume of water for crop development. Second, a sprinkler system as opposed to surface irrigation would permit important economies in the use of water. Third, the project would lead to the use of more modern technologies and better seeds, pesticides, and fertilizers.

For M&I needs, Stage II, as defined in the Feasibility Study, would have supplied 20 MCM/yr--12 MCM/yr to Irbid and 8 MCM/yr to the Valley. The benefits, according to Harza, for both irrigation and M&I users are calculated in Table 5-6. The cost of providing an M&I water supply was calculated by Harza as the incremental cost of raising the Maqarin Dam so as to provide an additional 20 MCM/yr more than would be required to meet the irrigation requirements of the project. Harza used the 20 MCM/yr figure as the projected demand based on per capita water use and population trends over the 1983-2000 period.

Table 5-5

Summary of Economic Justification
(JD)

Item	Direct Only	Indirect Only	Direct Plus Indirect
Annual Benefits	17,495,000	11,957,000	29,352,000
Annual Costs	12,295,000	6,083,000	18,378,000
Benefit-Cost Ratio[1]	1.4	1.9	1.6
Internal Rate of Return	13.4	17.0	15.0

Summary of Average Annual Benefits
(JD)

Purpose	Direct Benefits	Indirect Benefits	Average Annual Benefits
Irrigation	16,308,000	11,857,000	28,165,000
Hydroelectric Power	332,000	-	332,000
M&I Water Supply	855,000	-	855,000
Total	17,495,000	11,857,000	29,352,000

[1]Based on assumed discount rate of 10%.

Source: "Jordan Valley Irrigation Project Stage II Feasibility Study," Harza Overseas Engineering Company, 1978.

Table 5-6

Economic Costs and Benefits for Stage II Development
(JD 000's)

		Costs			Benefits					
								Irrigation		
Order	Year	Construction	OM&R	Total	Power Maqarin Dam	Power King Talal Dam	Municipal and Industrial	Conversion	New Lands	Total
0	1972	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

Source: "Jordan Valley Irrigation Project Stage II, Feasibility Study," Harza Overseas Engineering Company, 1978.

Under the revised "C-1" plan, the M&I water allocation would be increased to 126 MCM/yr (of which 120 MCM/yr would be available as supply after losses), the irrigated area would be decreased by 3,600 ha, and Maqarin Reservoir increased in height from El 150 to El 170 (dam elevations are 8 m above reservoir elevations). The economic implications of these changes have been under study by the appraisal mission of the donor group, headed by the World Bank, but its study results are unavailable at this time.

In order to assist the JVA in making their recommendation for the height of dam to the appraisal mission and to provide the mission with the latest cost and benefit data for the "C-1" project, Harza performed an economic dam height analysis. [5-1] The analysis compares the benefits from irrigation and M&I uses with the costs for projects featuring various heights for Maqarin Reservoir. The economics of power development were not included because they would not have a significant effect on the height of the dam and because the total cost allocated to power is the separable cost of the power plant. The economic analyses were based on a reservoir operation simulation using a mean annual Yarmouk River inflow of 210 MCM/yr and an average diversion of 48 MCM/yr from Wadi Raqqad to Maqarin Reservoir. Price levels for 1979 were used.

The studies indicated that a single purpose project to either (1) increase the currently irrigated area of 11,930 ha to 21,750 ha, or (2) provide an M&I supply of 120 MCM/yr and meet current irrigation requirements was economically justified. Justification was based on a minimum rate of return of 10%. Increasing the size of the single-purpose irrigation project to provide an M&I supply of up to 120 MCM/yr or increasing the size of the single-purpose M&I project to provide an irrigation supply for 21,750 ha also was economically justified.

The rates of return for a reservoir to El 170 were:

Feature	Purpose	Rate of Return (%)
Base Project	Irrigation	13
Increment	M&I	20
Total Project	Multiple	15
Base Project	M&I	11
Increment	Irrigation	17
Total Project	Multiple	15

An optimization study was made which indicated that a project with a reservoir to about El 155 m represented the optimal development level for a 10% rate of return. However, Harza recommended development to reservoir El 170 because (1) no alternative source of water is available in the region and the full economic impact of rejecting the larger size project cannot be quantified, (2) construction of either sized dam will preclude construction of additional storage on the Yarmouk River in the near or medium term future because the development cost per unit of unregulated water will be very high after construction of the Maqarin Dam, and (3) the cost, at current price levels, of increasing development El 155 m to 170 m amounts to only 15% of the cost of recommended project.

5.2.2.2 Indirect and Intangible Benefits Expected from Stage II

Harza defined indirect benefits in the Feasibility Study as follows: (See Table 5-7)

Benefits Stemming from Newly Cultivated Land

- Profits earned on commodities produced on the project and sold directly by retail merchants and
- Profits resulting from handling, processing, and marketing between the farmer and the final consumer.

Induced Benefits

- Profits of all enterprises supplying goods and services for increased production. These are profits made through purchases induced by activities of the project.

Table 5-7

Estimated Annual Indirect Benefits at Full Development

Item	Increased Value (JD)	Indirect Benefit Factor (%)	Estimated Benefits to the Economy
Benefits Stemming From Newly Cultivated Lands			
Increased Sales of Farm Products to Retail Businesses	30,000,000	10	3,000,000
Increased Sales of Farm Products to Processors	10,000,000	25	4,000,000
Subtotal			7,000,000
Induced Benefits			
Increased Purchases For Production Purposes	8,500,000	15	1,300,000
Public Benefits			
Farm Settlement Opportunities	3,000	100,000	3,000,000
Permanent Employment Opportunities	9,600	50,000	4,800,000
New Investment Opportunities	150,000,000	2	3,000,000
Increased Tax Revenues	-	-	2,100,000
Stabilization of the Economy	28,376,000	5	1,400,000
Subtotal			14,300,000
Total Annual Indirect Benefits			JD 22,600,000

Source: "Jordan Valley Irrigation Project Stage II Feasibility Study," Harza Overseas Engineering Company, 1978.

Public Benefits

- Benefits from settlement opportunities, employment opportunities, new investment opportunities, increased tax revenues and economic stabilization.

Intangible benefits, to which monetary values cannot be attached, were enumerated as follows:

- Improve the Balance of Trade -
  Jordan has suffered a serious agricultural trade imbalance for many years. Agricultural exports have accounted on average for no more than 20% of food imports. Whether new food production is used for domestic consumption or export, its impact on the trade balance would be positive. Increasing hydroelectric power would likewise strengthen the trade balance by reducing dependence on oil imports. (See Table 5-8 for structure of Jordan's exports.)

Table 5-8

Main Domestic Exports

	Thousands of JD 1975	1976	1977	% Change 76/75	% Change 77/76
Industrial and Mining Exports	24,692	23,110	26,854	- 6.4	+ 16.2
Cigarettes	751	809	997	+ 7.7	+ 23.2
Batteries	88	18	71	-79.5	+294.4
Worsted Textiles	634	872	282	+37.5	- 67.7
Sole Leather	215	299	345	+39.1	+ 15.4
Paper	513	683	407	+32.9	- 40.3
Cement	1,655	13	2	-99.2	- 84.6
Phosphates	19,585	19,233	17,257	- 1.8	- 10.23
Medical and Pharmaceutical Products	1,251	1,184	7,493	- 5.4	+532.8
Agricultural Exports	7,403	11,555	13,393	+56.1	- 15.9
Tomatoes	1,276	2,517	2,480	+97.3	- 1.5
Citrus Fruits	5,645	8,453	10,026	+49.7	+ 18.6
Eggplants	482	585	887	+21.4	+ 51.6
Other Exports	7,980	14,887	20,006	+86.6	+ 34.4
Total Domestic Exports	40,075	49,552	60,253	+23.6	+ 21.6

Source: Department of Statistics.

- Improve the Economy's Structure -
  Jordan's economy has been heavily service oriented and the national plans have repeatedly emphasized the need to strengthen and expand the productive sector. Expanding agriculture in the Valley is the only way to expand the agriculture sub-sector significantly.
- Help Supply Domestic Food Requirements -
  Harza cited the effects of population increases, expanding purchasing power, and improved diets as evidence that domestic food demands will increase rapidly in coming years. Expansion of agricultural production in the Valley would help to meet that demand.
- Improve Living Standards -
  Spill-over effects can be expected in the form of increased earnings, commercial activity, and greater public investment in health, education, transportation, and utilities. Similarly, it is supposed that improved literacy, housing, diet, community life, and health will be fostered by Stage II.
- Improve Efficiency in Providing Public Services -
  The greater concentration of population which will result from irrigated farming enables better provision of public services than is possible in sparsely settled areas. Health and education facilities, utilities, potable water supplies and other amenities can be provided more adequately to village groupings than to dispersed rural populations.

5.3 DEMOGRAPHIC FACTORS

The success of Jordan's national development program depends highly on the government's ability to utilize and mobilize the full potential of all segments of Jordanian society. Like other middle income countries, Jordan's primary development problem is how to balance its growth rather than growth per se. This awareness has prompted the government to place increased emphasis on ensuring participation of rural residents, lower income groups, and women in the social and economic benefits that are expected to accrue from development programs. The proposed Jordan Valley development program is designed to increase economic income and opportunity and to improve the standard of living of Valley residents by introducing and upgrading existing physical and social infrastructure programs.

Prior to the JVA program, investment in rural areas was limited. Financial institutions, commercial centers, health services, electricity and, in many cases, potable water was limited to urban areas. Although the level of modernization, as measured by percentage of children attending school, adoption of new technologies, and exposure to other cultures, is high in Jordan's rural villages, provision of public services has been limited to schools, postal service, and an occasional clinic which was poorly staffed and frequently failed to provide maternal and child care.

Given the comparatively modern attitudes and behavior of rural residents, they have reacted to their limited opportunities for advancement by leaving rural areas to work in urban centers or outside the country. Arthur D. Little, Inc.'s survey found few men under 30 working the land; instead, many were working in the Persian Gulf states as teachers or construction workers.

One aim of the JVA program is to stem the exodus from rural areas by providing increased economic opportunities and services. Through

expansion of the irrigation system and extension of agricultural credit systems, rural incomes are expected to rise to a level competitive with urban employment. The increase in irrigated lands and higher crop yields resulting from growing three crops rather than two per year is expected to result in the creation of 5200 to 7200 jobs by 1990. NPC officials feel that young people between the ages of 20 and 30, the prime age group which has sought employment outside of the country, will either decide to remain or be attracted back to the Valley. These people will find the Valley an attractive place to settle not only because quality housing, education, health, electricity, and potable water, are available, but also because the severe housing shortage in Amman, Irbid, and other cities will be a deterrent to settling in urban centers.

Despite the ambitious plans of the JVA and the optimism of the NPC, there is some question whether young people will find farming sufficiently lucrative to offset the stigma currently attached to agricultural activity. It is unlikely that sufficient manufacturing or commercial activity will be drawn to the Valley to create a substantial non-agricultural employment base. As discussed further in Chapter 6, Jordanian male labor is in very short supply in the Valley. Most farmers and sharecroppers supplement family and female labor with Pakistani and Egyptian labor.

Modernization is associated with greater participation in the development process. Participation, broadly defined, includes increased income distribution as well as involvement in organizations such as cooperatives, schools and a general feeling that an individual and his or her immediate community is part of the modernization process. The survey of rural villagers found that the effects of the JVA program were already apparent in the increased sense of importance and involvement that villagers felt as a result of facility construction and the active presence of the JVA. Rural residents associated the JVA with positive change in their lives. Their status as agriculturalists was enhanced by the obvious

government concern in their village as evidenced by new schools, clinics, houses, and the ever present JVA vehicles as well as occasional visits from JVA officials and staff. Perhaps one of the most important, although least tangible, impacts of the Valley program will be the increased pride and efficacy of rural peoples.

6.0 DESCRIPTION OF THE ENVIRONMENT AFFECTED AND PROBABLE ENVIRONMENTAL IMPACTS

6.1 INTRODUCTION

Chapter 4 described Stage II's proposed direct actions in detail. This chapter describes the baseline environment in the project areas, details of the indirect actions (mainly the Village Development Program as opposed to the water supply systems), and the probable impacts to the environment of both direct and indirect actions.

6.1.1 Definition of Impacts

For the benefit of readers not familiar with environmental analysis, environmental impacts can be defined as the difference between the state of environmental conditions without and with the action. Conditions without the action are termed "baseline"; these include both the present conditions and those projected into the future assuming that the action is not undertaken. Conditions with the action are always those projected into the future, starting with the project construction and extending through its expected operating life. The impacts are the differences between the "without-action" or "baseline" projection and the "with-action" projection.

Impacts have many characteristics, some of which are:

- Direct/Indirect/Induced. These terms refer to the hierarchy of impacts and are related to the terms primary, secondary, and tertiary. Direct impacts are the immediate consequences of an action, while indirect and induced impacts are those that occur as a result of the predecessor actions.
- Temporary/Permanent. Impacts have magnitude and duration. Temporary impacts may last for a few weeks (e.g., piledriving noise) to a few years (e.g., disruption during construction). Permanent impacts are those lasting for several decades or longer.

- Significant/Insignificant. These expressions cannot be defined precisely and are best explained as value judgments of qualified environmental analysts in each discipline. The first step in an analysis is to identify the impacts; the next, to quantify them to the extent possible. Then, if the effect on the environment appears small or not important, the impact is classified as "insignificant." Conversely, if the effect is large and/or important, the impact is termed "significant."
- Adverse/Beneficial. While these descriptors require some value judgment, they tend to relate to specific environmental classifications. For example, using DDT to eradicate mosquitoes may benefit public health, but adversely affect the food chain required by wildlife. When the positive and negative impacts on all specific environmental classifications are integrated, the result is a "net" adverse or beneficial impact.
- Avoidable/Unavoidable. If a significant adverse impact is identified, it may be possible to avoid the impact by a design change or by taking additional steps to eliminate or reduce the adverse effects. These are called "mitigating actions" and generally involve increased costs.
- Normal/Abnormal. Normal impacts are those expected as a result of the action, even though they may be infrequent. Abnormal impacts are those not expected, for example, the failure of a dam, and have a very low probability of occurring. Impacts associated with abnormal events can be of great magnitude and are sometimes examined as a risk assessment.

6.1.2 Applicability of Analysis

The field investigations and the bulk of the analyses of impacts were performed in the spring of 1979. They were based on the Harza Feasibility Study reports, but with forewarning that the project as defined in the Feasibility Study was expected to change to increase the M&I water allocations and decrease irrigation allocations, and that the height of the Maqarin Dam was expected to be increased.

A revised plan, referred to herein as the "C-1" plan, was described in supplemental reports prepared for the JVA by Harza and dated August and September 1979. The features of the "C-1" plan are described in Section 4 of this report. In general, the magnitude of the changes introduced by the "C-1" plan were somewhat greater than had initially been anticipated.

In preparing this final EA report, we have reviewed the entire original analysis of impacts in Chapter 6, and we have made selected modifications in order to reflect the changes brought about the "C-1" modifications. However, not all potential changes have been incorporated, primarily because of a lack of detailed revised data about the indirect changes that would be associated with the "C-1" plan. For example, the "C-1" plan features some 3,600 ha less irrigation than was projected in the Feasibility Study. However, just where and how this reduction will be applied is not known at this time.

The "C-1" plan itself cannot be considered as the final project. The donor group, headed by the World Bank, is continuing its appraisal studies and it is possible that the "final" project, when agreed upon by all parties, will be somewhat different from the "C-1" project.

As is typical with most projects having the scope of the Stage II project, one must recognize that both the project and its impacts are dynamic rather than fixed in nature. The population of Jordan is projected to increase substantially during the next 40 to 50 years,

and the water supply made available by Maqarin Dam will be subject to competing demands between M&I and irrigation uses. To some extent, the return flows from M&I use will serve to mitigate irrigation losses, but not completely.

The Stage II project, upon completion of construction and initial filling of Maqarin Reservoir, will provide a discrete increase in the water available for irrigation use. But from that time on, the total irrigation allocations will gradually decrease as M&I allocations increase. However, because of the increasing return flows from Amman, the irrigation water in the Southern Valley supplied by the Zarqa River will increase at the expense of irrigation allocations in the Northern Valley.

This dynamic change in water supply would continue into the long-term future if the population of Jordan continues to increase. It is a manifestation of a problem that is facing nearly all developing countries and indeed the entire globe. The supply of water and food is limited and cannot sustain indefinite population growth. This is perhaps the most significant impact that can be associated with the project, yet it is beyond the scope of this analysis to evaluate the impact completely.

What we have evaluated is one step in the struggle to provide water, and through irrigation to provide food, in Jordan. While recognizing the dynamic nature of water needs, we focus on one time in the future, approximately the year 2000, at which time the fixed allocations defined in the "C-1" plan crosses the dynamic needs of an increasing population.

In the text which follows, we have in general identified with notes the development plan to which the impact analysis applies. In most instances, the qualitative nature of the impacts applies to any development plan, and it is only the quantitative values that would vary in response to dynamic changes.

6.2 PHYSICAL ENVIRONMENT

6.2.1 Terrestrial Regime

6.2.1.1 Maqarin Dam and Reservoir

Note: The descriptions in this section are generally based on design studies available in April, 1979, and on a dam height of El 168 m.

6.2.1.1.1 Site Geology

6.2.1.1.1.1 General Description

The Maqarin Dam site is located in a narrow part of the Yarmouk River Valley, approximately 100 m wide across the floor. The Yarmouk River is formed by the confluence of three tributaries, a short distance upstream from the site. The steeply sloped, talus-covered valley walls rise at the site to El 230 m on the Jordanian side and El 350 m on the Syrian side. An irregular promontory extends into the valley from the Jordanian side and forms the left abutment for the dam. The Syrian side of the valley is relatively featureless. Several alluvial terraces are evident. Early Tertiary period limestones and marls and Quaternary period basalts outcrop at the dam site.

6.2.1.1.1.2 Stratigraphy

The formations described below and illustrated in Figure 4-3 are those believed to influence the storage properties of the Maqarin Dam and Reservoir. These formations have been explored by drilling and aditing programs (totalling 10,400 m and 1800 m, respectively [6-1],[1] and seismic and magnetic surveys [6-2] supervised by Harza Overseas Engineering Company.

Amman Formation

Exploratory drilling has extended only 90 m into the Amman formation (to El -200 m); and therefore, the thickness of the formation at the dam

[1] Numbers in brackets, e.g. [6-1], refer to references located in Appendix B.

site is unknown. The upper portion of the Amman is a siliceous, cherty limestone that forms an artesian aquifer with a piezometric head reaching EL 35 m (approximately 5 m above the valley floor). Zones of intense fracturing and high permeability with occasional deposits of loose and believed by Harza to be residual products of solutioning have been found near the top of the formation. Because drilling has been concentrated in known shear zones, it is uncertain if solutioning is structurally controlled by joints and fissures or if the Amman is a karstic[1] formation with open solution channels randomly distributed.

Muwagger Formation

The Muwagger is approximately 220 m thick and contacts the Amman near El-80 m at the project site. Commonly referred to as bituminous marl, some facies of the Muwagger may be described more accurately as argillaceous limestone. The calcium carbonate ($CaCO_3$) content ranges from 26% to 79% and is sufficient to allow karstic solutioning in an active environment. [6-3] The depth of weathering in the marl varies from 2 m to 20 m below its surface. Solutioning at the site appears to be concentrated in structural discontinuities. For example, joints and fissures are enlarged, and while plugged with clay and silt beneath the valley floor, open solution cavities have been found in shear zones. No solutioning has been found in the unjointed and undisturbed marl.

Fissures in the left abutment are filled with alluvial terrace material believed by Harza to have entered daylighted fissures when the Yarmouk River existed at elevations higher than at present.

Rijim Formation

The Rijim formation consists of chalky limestone 150 to 180 m thick that weathers into a light-colored clay to a maximum depth of 40 m below the top of the formation. Locally, weathering extends even deeper in joints and fissures. There is generally dissolution and formation of open and

[1] A topography formed over limestone, dolomite, or gypsum and characterized by sinkholes, caves, and underground drainage.

filled solution channels, enlarged joints, and vertical caves filled with terrace alluvium. Because of this solutioning, the rock is generally permeable. The contact between the Rijim and the relatively impermeable Muwagger formation outcrops at El 140 m near the proposed dam axis. The chalky limestone is a perched aquifer with highly calcium hydroxide water (pH of 12+ in some locations).

Plateau Basalts

At the project site, the Plateau Basalts unconformably overlie the chalky limestone well above the proposed reservoir level. The basalts are jointed, deeply weathered with interspersed layers of residual clay (especially on the left abutment) and very permeable. Their thickness at the dam site varies from 150 m on the north bank to 50 m on the south bank of the valley. Leaching of the basalts by rain percolating into the chalky limestone produces the ultra-basic, perched groundwater.

Surficial Deposits

Surficial deposits in the Yarmouk Valley consist primarily of cemented alluvial gravel, talus and landslide debris. The alluvium is typically 10 m thick on the valley floor, but in one location it reaches a thickness of 50 m. Alluvium is preserved in isolated terraces at several elevations in the valley. Talus and landslide debris derived from past episodes of shallow landsliding during river downcutting is common and may be found up to 25 m thick.

6.2.1.1.1.3 Structure

The axis of a northward trending anticline can be found a short distance upstream from the dam axis. This structure produces shallow dipping rock at the Maqarin site and raises the permeable chalky limestone (the Rijim Formation) to its highest elevation in the Yarmouk Valley so it can be economically cut off to prevent possible reservoir seepage.

A northward trending fault is located approximately 500 m downstream from the dam axis. Several shear zones which have localized solutioning

accompany the fault beneath the valley floor. This fault appears to terminate in the valley; outcrops of marl and limestone on the north bank do not show fault displacement.

Geophysical surveys suggest a possible east-west trending fault crossing the left abutment promontory, but this has not been verified by exploratory drilling. Zones of calcite veins and cemented breccia beneath the valley may also indicate a possible fault trending along the valley, but the absence of such structure in boreholes near the proposed dam axis is not consistent with this interpretation. Another possible fault striking northwest across the left abutment, upstream from the dam axis near Maqarin Station, has been suggested. Little offset is visible and more exploration is needed to verify its existence.

Three joint sets are found in rocks on both abutments at the Maqarin site. The dominant set which is oriented about N10W has localized karstic solutioning in the marl near the downstream fault. Exploratory drilling upstream from the fault has shown the joints of this set to be closed and more widely spaced. In the chalky limestone, minor joint sets trending NE-SW and NW-SE exist. On the left bank, low-angle stress relief joints have been found in adit (exploratory tunnel) portals.

6.2.1.1.1.4 Potential Impact of Site Geology on Maqarin Dam

Uncertainties exist about how, and to what extent, geologic conditions at the Maqarin site could affect the performance and, consequently, the design of the embankment dam. For example, the nature and extent of potential karstic solutioning at the dam site has not been settled. It is Harza's opinion that solutioning in the bituminous marl is localized near the downstream fault in what are presently plugged cavities and joints with insignificant lateral extent. This has been supported by exploratory drilling upstream from the fault, although a more extensive investigation is needed to obtain conclusive results. It has been hypothesized that artesian groundwater ascending from the Amman through structural discontinuities produced the vertically oriented solution

features observed in adits downstream from the dam axis. Vertical solutioning has much less impact on the water retention characteristics of the dam and reservoir than does horizontal solutioning, and this is reflected by the cutoff design. If horizontal solution features in the marl are hydrologically connected and are not adequately treated, water seeping under a hydraulic head produced by reservoir impoundment could erode plugged cavities and permit seepage under the dam or through the abutments. Some borings at the Maqarin site have shown that solutioning may not be entirely controlled by structural discontinuities. The nature of solutioning in the marl should be understood before grouting plans are finalized.

Karstic solutioning and seepage through the Amman Formation is another possibility. This formation has not been extensively explored, and it is not known if karst is widely developed or structurally controlled. If the Amman Formation contains continuous solution channels, faults in the reservoir rock could allow connection between the reservoir and the shear zone near the downstream fault. This shear zone will be covered by the downstream embankment shell and berm, and such communication could lead to excessive leakage and possible damage to the embankment.

If the E-W fault indicated by geographical surveys in the left abutment promontory exists and is permeable, it could provide a seepage path into the abutment. Without cutoff or drainage of this feature, seepage could spread through the extensive joint system in the chalky limestone and enhance instability.

The extremely high pH and hot spring type of deposition observed in perched groundwater may cause plugging of filters and drains placed in the abutments. It is not known if dilution with reservoir water alone is sufficient to prevent plugging, and additional drainage adits may be required to provide prolonged drainage of the abutments.

Karstic solutioning in the chalky limestone has been identified, and treatment to reduce seepage at the dam site has been prescribed. However, reservoir seepage into the chalky limestone is possible on the southeast limb of the anticlinal fold upstream from the dam, where the limestone-marl contact can be found as much as 20 m below the proposed reservoir level (El 160 m) over a significant portion of the reservoir. (The maximum reservoir level in the "C-1" design is El 170 m.)

6.2.1.1.2 Site Seismicity

Harza has consulted records (dating back to 1927) of instrumented earthquakes affecting the project area to estimate the seismicity of the Maqarin Dam site. [6-5] Since 1950, seven earthquakes with magnitudes greater than 4.0 have occurred along the Jordan Valley, suggesting that the rift is still tectonically active. The largest recorded earthquake occurred in 1927 at a 100 km epicentral distance from the dam site. Surficial fault movement attributed to this disturbance occurred only 25 km from the site. On the basis of these instrumented records, the 1927 earthquake has been chosen as the design earthquake. Seismic coefficients reflecting the maximum expected ground acceleration at the site have been chosen to range between 0.1 g and 0.2 g.

Because of the short time span represented by the instrumented records compared to the span considered when identifying "active" fault movement (2 million years) [6-6], it is difficult to predict future seismic activity accurately without examining the geologic record of fault movement related to earthquake activity. Seismicity studies in Turkey [6-6] show that large seismic events important in classifying site seismicity could be overlooked if only instrumented earthquakes are examined. If the site seismicity and embankment response to earthquake shaking are properly estimated, the embankment design can be altered to minimize the following potential impacts on the integrity of the embankment.

1) Dynamic forces may induce liquefaction of loose granular materials or may otherwise promote instability.

2) Embankment settlement, combined with earthquake seiches (reservoir "tidal waves") may allow the reservoir to overtop the dam and cause downstream flooding and erosion of the embankment.
3) Large differential settlements within the embankment may cause cracking and seepage through the core.

6.2.1.1.3 Terrestrial Impacts in the Maqarin Reservoir

The Maqarin Reservoir will inundate part of the Yarmouk Valley and the lower reaches of the Wadi Shallala, Wadi Ehrer, and the Nahr Allane. The borders of the reservoir will intersect land which has steep slopes in some locations. Landslides at such locations, in addition to presenting a threat to any structures in the landslide area, could also displace reservoir waters that could overtop the dam.

Harza investigated the stability of the reservoir slopes and identified three areas as being potentially most hazardous. These were reported in some detail; however, it was concluded that none were likely to involve a large slide. The largest slide, estimated at 4 MCM, would be only 1% of the total reservoir volume of 400 MCM.

The reservoir will collect sediments during its operating life. About 98% of these sediments, which presently are transported down the Yarmouk River, will settle in the bottom of the reservoir at an estimated rate of 0.92 MCM/yr. Total accumulation after 50 years would be about 45 MCM, and 90 MCM after 100 years. (The "C-1" design assumes 98 MCM after 100 years.)

No information was found on the effect on the Yarmouk or Jordan Rivers as a result of the loss of transported sediment. One result could be additional riverbed erosion, particularly in the upper reaches of the Yarmouk River (below the Maqarin Dam); another could be less silt

deposits in the Dead Sea. However, if the existing riverbeds are fairly stable, the results may simply be cleaner streamflows.

6.2.1.1.4 Spoil and Borrow Areas

The Maqarin Dam will have a high rockfill embankment with a clay core. Construction materials will be obtained from the area surrounding the dam site and from material excavated from the tunnels. The exact limits of the borrow area will depend on the final design of the dam.

The design plans for treatment of the surfaces of the borrow and spoil areas is not known; however, if protection from wind and water erosion is provided, there should be no significant impacts associated with these areas after construction.

6.2.1.1.5 Relocations

The Himma branch of the Hejaz Railroad runs along the Yarmouk Valley and through the reservoir site. The railroad is considered to be the boundary between Jordan and Syria where it runs south of the Yarmouk River; otherwise, the river is the boundary.

The Himma branch at one time connected the rail line running from Damascus to Ma'an with the port of Haifa, but the western part of the line was destroyed during hostilities with Israel. At present, the line continues only a few kilometers below the Maqarin Dam site before terminating. A train is reported to run once a week to the end of the line providing limited freight and passenger service to the few valley inhabitants.

Harza prepared a relocation plan for the Himma branch which would relocate the line on the Syrian (north) side of the dam and reservoir. The alignment would be about 21 km long and would require six tunnels with a total length of about 2500 m and six bridges. The cost is estimated to be roughly JD 5,900,000; however, this cost is not included in the costs to be allocated since it was not assumed to be a reimbursable project cost.

There have been unofficial reports that a new road is being considered in lieu of the railroad relocation. Although no tentative designs are available, it is likely that a road would be less expensive to construct and that it would provide a more flexible link to the outside world.

6.2.1.2 East Bank of the Jordan Valley

The information presented in this section was taken from Harza's Stage II Feasibility Study. [6-5]

The Jordan Valley soils, highly calcareous and gypsiferous, and low in organic matter, are typical of regions with little rainfall. The soils are of sedimentary origin, having been deposited by the waters of ancient lakes and streams and outwash from the uplands. Most of the Valley's soils are permeable.

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% 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 waterholding capacity, and are quite fertile. Salinity and alkalinity problems occur on only about 5% 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 alluvial fans of Wadis Shueib, Kafrein, and Hisban. The soils range from moderately fine-textured silty loams to moderately coarse-textured sandy loams. Soils on these fans are deep, porous, and relatively free of soluble salts and alkalis. In the northern part of the South Ghor, clay loams predominate and the soluble salt content is relatively high.

The soils in the Jordan River floodplain are stratified deposits of the Jordan and its tributaries. The Yarmouk River floodplain soils are moderately fine and medium textured, including silt loams, sandy loams, and sandy clay loams.

Because of Jordan's dry climate, the finer clay and silt particles having no water to bind them, have a tendency to become windborne as fugitive dust. The Stage II project will increase the area under irrigation thus reducing the potential for dust generation. However, because there is so much more vacant land on slopes than under cultivation, the increase in the latter will have a negligible overall impact. Water erosion, a process which has been occurring in the Valley ever since its formation, and which is responsible for its soil profiles, is mainly controlled by maintenance of a good vegetative cover. The ongoing reforestation program on some of the country's slopes is having a positive impact but is not yet completely implemented. The increase in available water will likely guarantee the continued success and expansion of this program.

In establishing new farms, many small slopes are altered to facilitate the use of farm machinery. The primary impacts of such earth moving are archaeological and are discussed in Section 6.4.1.1

As new lands are converted to crop production, their use for grazing will be curtailed. This could cause overgrazing of marginal land with consequent increase in erosion, unless herd sizes were reduced or alternate supplies of feed were provided.

6.2.2 Atmospheric Regime

There is no documentation of air quality in Jordan. One sampling station has been located at Shobak, a remote site south of the Dead Sea in the uplands, to establish background pollution levels. Therefore, analysis of air quality must be limited to potential and theoretical problems rather than accurate observations.

Air pollution occurs when there is a source of pollutants and meteorological conditions are not conducive to rainout, dispersal, or mixing (dilution). Jordan is fortunate in its meteorology: the average conditions are excellent year round for mixing. The consistent daily winds, the lack of persistent cloud cover, the topography, and the warm sunny climate all contribute to steady dispersal. The valleys and the uplands are subject to overnight inversions, however, in which a capping layer of colder air prevents the upward movement of warmer ground level air. The air below the inversion often contains significant accumulations of pollutants emitted from ground sources. The Meteorological Department is confident that the daily winds and warmth are responsible for breaking up these inversions within 6 to 8 hours of their formation.

The discussion of air quality is thus contingent upon identification of sources of pollution within the two distinct meteorological regions of the impact area, the Valley and uplands. The Valley's only man-made sources of pollution are motor vehicles and small boilers which generate carbon monoxide, hydrocarbons, nitrogen oxide, and particulates. Natural sources of fugitive dust from eroding hillsides and unirrigated fields, and water evaporating from the Dead Sea, contribute to the creation of a haze during much of the day. Due to the small number of vehicles involved--700 cars registered in the Valley in 1975 [6-7] and the low number of trips--the pollution generated is insignificant. In the uplands, there is a larger variety and number of sources. In addition to cars, trucks, boilers, and fugitive dust sources, the concentration of Jordan's industry in the Amman-Zarqa region is responsible for many other pollutants.

Air quality impacts as a result of the project are expected to be minimal. The increased acreage of irrigated land will reduce wind erosion somewhat, but the effect will be small with respect to dust particulate concentration. Because the present export market is for fresh produce, no food processing plants have been constructed in the Valley. If such industries were introduced in the future, they may attract related

industry such as plastic container manufacturers, which often emit significant amounts of air pollutants. The major change in Valley air quality will be due to auto and truck emissions as traffic is expected to double by the year 2000. [6-7] Using a model developed and sanctioned by the United States Environmental Protection Agency to estimate a worst case for carbon monoxide levels, the concentrations resulting from present Valley traffic were two orders of magnitude less than the U.S. National Ambient Air Quality Standards for the 10 meter strip bordering the highway (Route 45). (Details of the modeling process are given in Appendix H.) Although future emissions are expected to double, the concentrations would still be well below unhealthful levels.

In the uplands, the topography and source array are too complex to permit modeling in the absence of data. The nightly temperature inversions at Amman, coupled with congested traffic and the existence of over 150,000 small and inefficient oil furnaces, suggests that during the inversions sufficient pollutant build-up may be occurring to reach unhealthy levels. While these inversions are broken up and rarely persist longer than six to eight hours, the population of Amman is being exposed to these potentially harmful levels of pollutants for one-fourth to one-third of the time. With projected population and traffic increases, the situation can only worsen. In addition, the many stone quarry operations contribute to observed dust levels which are considered to be high.

The Maqarin Dam project, in supplying M & I water to Amman, will ensure the presence of a large and growing population. While the project itself will not contribute directly to industrial growth, such growth will likely occur as a result of increased population. In the Five Year Plan, an increase of 86% in production is predicted in this region. [6-8] If the present types of industries, which include cement manufacture, phosphate mining and processing, paint, detergent, textile, paper and pulp processors, dairies, distillers, and chemical and petroleum refiners, is nearly doubled or broadened without control, air pollution problems may very well ensue. Already, observers have described a pall of dark haze between Amman and Zarqa over the main industrial region.

Because Jordan has no air quality laws at present, such controls if enacted would be completely new and probably not easily accepted by industry. The first step must be to gather enough data on present pollution levels to justify the institution of controls. The use of a model to estimate the economic cost and physical efficacy of various control strategies will be a valuable tool.

6.2.3 Hydrologic Regime

Note: This section has been modified to reflect the "C-1" plan, and to incorporate additional water quality data.

6.2.3.1 General

Water resources in the project area are limited because of limited rainfall. The Maqarin Dam is being designed to optimally allocate the surface water supplies that are available along the East Bank. Following full implementation of the project, all East Bank tributary waters entering the Jordan River downstream from Lake Tiberias will have been intercepted and utilized for project purposes and for the Yarmouk Triangle. In addition, some existing groundwater supplies might continue to be used, particularly in the southern part of the area.

The Stage II development will impact both the surface water resources (stream flows and quality) and the groundwater resources (groundwater flows and quality) of the project area. The area consists of the surface water catchments of wadi and river groups defined in the National Water Master Plan of Jordan [6-9] and shown in Figure 6-1. They are:

(a) the Yarmouk River Basin,
(b) the Northern Riftside Basin (Wadis Arab, Ziglab, Jurum, Yabis, Kufrinja and Rajib,
(c) the Zarqa River Basin, and
(d) the Southern Riftside Basin.

In the following sections, water resources are described in reference to the above general regions, and for the Jordan River itself and the Dead Sea into which it discharges.

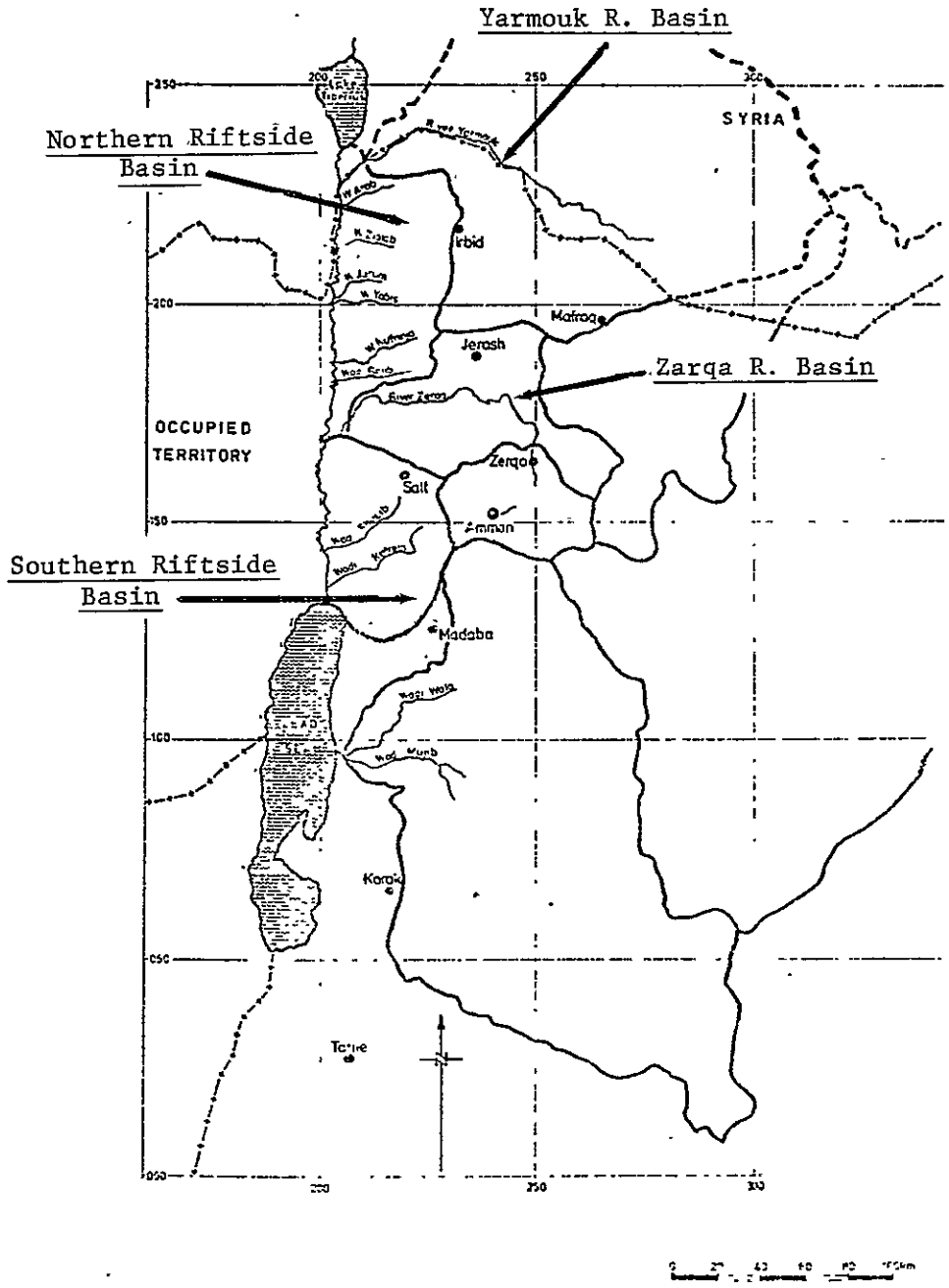


Figure 6-1

Subdivision of the Study Area

Data were obtained from existing reports and from information gathered during field visits; however, no new field data were collected. Detailed information regarding the rationale for water resource projections is given in Appendix G. The baseline water resources projections (i.e., projections without the project) and the future impacted water resources projections (i.e., projections with the "C-1" project) are presented for the project area. These estimates, as also explained in Section 4.8, should not be considered as definitive numbers for planning purposes, because the increasing volume of groundwater levels and surface baseflow make it difficult to establish the natural regime from published or measured data. Accordingly, the estimates serve only to roughly quantify the availability of surface waters under the "C-1" plan.

6.2.3.2 Surface Water Resources

6.2.3.2.1 Water Quantity

6.2.3.2.1.1 Flow Projections Without and With the Project

The Jordan River is the largest river in the area and drains from Lake Tiberias in the north to the Dead Sea in the south. There is no outlet to this sea and, at the present time, the sea level is declining as a result of more evaporation from the surface than total inflow. Flowing into the Jordan River from the east are two rivers (Yarmouk, Zarqa) which drain from the plateau area and nine major wadis located along the escarpment. These are shown schematically in Figure 6-2. The mean monthly water resource data are given in Appendix G; their mean annual values are given in Figure 6-2.

The EGMC serves mainly irrigation purposes at present and is supplied by:

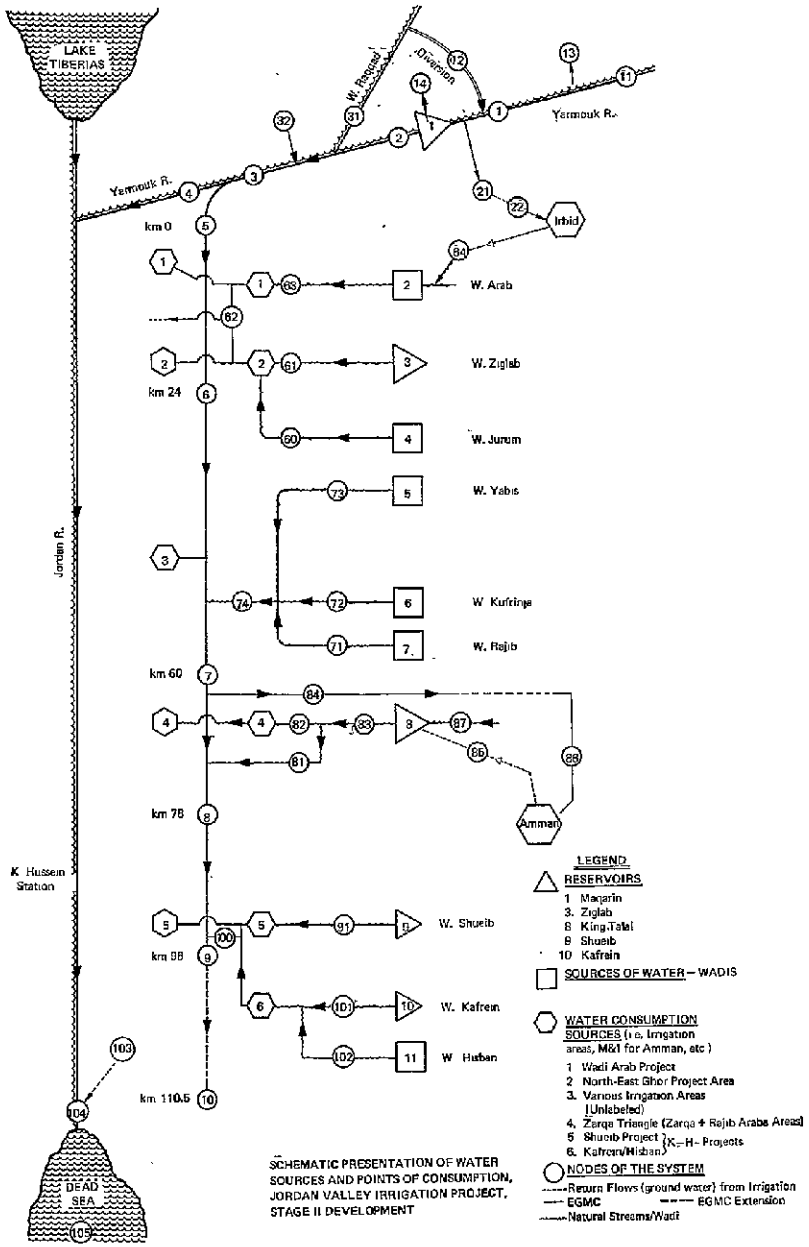
(a) the Yarmouk River,

(b) the side Wadis Yabis, Kufrinja and Rajib,

(c) Wadi Ziglab (Ziglab Reservoir), and

(d) the Zarqa River (King Talal Reservoir).

The projected mean annual water flows of the above streams are summarized in Figure 6-2 and discussed further below. Flow values are shown for the present time and after implementation of the "C-1" project. The two values are separated by slashes, e.g. 240.3/210.7.



SCHEMATIC PRESENTATION OF WATER SOURCES AND POINTS OF CONSUMPTION, JORDAN VALLEY IRRIGATION PROJECT, STAGE II DEVELOPMENT

NODE	PRESENT (1978)	FUTURE[1] (Harza Study)	AFFECTED FLOWS (IMPACTS)[2] (Absolute Values)
Principal			
1	240.3[19]	210.7	(29.6)[3]
2[12]	240 3	202 1[14]	(38 2)
3	390.3	304 1	(86.2)
4	261.4	25.0[14]	(236.4)
5	128 9[13]	279 1[2]	150.2
6	96 4	230.7	134.3
7	64 1	174.6	110.5
8	51 6	53.9	2.3
9[5]	37.4	27.9	(9.5)
Secondary			
11	240 3[18]	240.3	0.0
12	0 0	48.0	48.0
13	0.0	29.6[19]	29.6
14	0 0	8 1	8.1
21	0.0	26.0	26.0
22	0.0	24.7	24.7
31	73.3	25.3	(48.0)
60	11.2	11.2	0.0
61	3.6	3.6	0.0
62[11]	0.0	12.3	12.3
63	28.8	41.2	12.4
64[6]	0 0	12.4	12.4
71	7.1	7.1	0.0
72	6.1	6.1	0.0
73	3.3	3.3	0.0
74[16]	16.5	16.5	0.0
81	11.9	15.5	3.6
82	55.4	99.3	43.9
83	67.3	114.8	47.5
84	0.0	100.0	100.0
85	0.0	47.5	47.5
86	0.0	95.0	95.0
87[6]	67.3	67.3	0.0
91	7 9	7.9	0.0
100[4]	10.2	10.2	0.0
101	14 3	14 3	0.0
102	5 0	5 0	0.0
103[7]	53 9	70 7	16.8
104	1000.0	795.5	(204.5)
Dead Sea (Elevation in meters)			
105	-392.9	-403.1	(10.2)

IRRIGATION AND M&I WATER REQUIREMENTS FOR THE VALLEY AND AMMAN[8]

- Wadi Arab and North Irrigation Projects; Source of Water: Wadis Arab, Ziglab, Jurum, EGMC

Areas [ha]:	4010.0	4010.0	0.0
W Demand.	43.7	43.7	0.0
W Supply:	49.5	61.9	0.0
W Surplus:	5.8	18.2	12.4

- Zarqa Triangle Irrigation Projects, Source of Water: Zarqa River, EGMC

Areas [ha]:	5077 0	9097.0[17]	4020.0
W Demand	55 4	99 3	43.9
W. Supply:	67.3	114.8	47.5
W Surplus:	11 9	15 5	3.6

- Kafrein-Hisban (K-H) Project; Source of Water: Wadis Shueib, Kafrein, Hisban

Areas [ha]	1560 0	1560 0	0.0
W Demand:	17 0	17 0	0 0
W. Supply:	27 2	27 2	0.0
W Surplus	10 2	10 2	0 0

- Other Minor South Irrigation Projects[9]; Source of Water: Wells/EGMC

Areas [ha]	2132.0	2132.0	0 0
W. Demand:	23 3	23 3	0 0
W. Supply.	23.3	23.3	0.0
W. Surplus.	0 0	0 0	0.0

- EGMC Irrigation/M&I Projects; Source of Water. EGMC

Areas [ha]	11927 0	17730 0	5800.0
W. Demand (inc. M&I):	130 1	290 4	160 3
W. Supply (inc. M&I):	167.5	321 3	153.8
W. Surplus	37 4	27 9	(9 5)
Potential Irrigation from EGMC:	3428 0[10]	2557 0	(871.0)

- Total Irrigation/M&I in the Valley and Amman

M&I Amman	0 0	100.0	100.0
Areas [ha]	24705 0	32397 0[15]	7691.0
W. Demand (inc. M&I)	269 5	476 7	207.2
W. Supply (inc. M&I):	334 8	548.5	213.7
W Surplus	65.3	71 8	6.5

FOOTNOTES

1) With reference to the assumptions made in Section 4.8, Physical Systems Operation with the Project (future), and in Section 6.2.3.2.1.1, Flows Without the Project (present).

2) The analysis is performed for a "typical" year using average annual expected streamflows and water demands and is only indicative of the probable water balance. A "typical" year does not account for "spills" from the reservoir which will probably take place two or three times in a 25-year period and which water quantities cannot be used. The unused spill quantities equal: (a) Maqarin Reservoir--22.5 MCM/yr (node 2); (b) lower Yarmouk River--17.9 MCM/yr (node 4); and (c) excess inflow to the EGMC--5.3 MCM/yr (node 5).

3) Numbers in parenthesis indicate negative impacts. Negative impacts indicate water decrease (MCM/yr) or lowering of the Dead Sea surface.

4) The excess of water (including flood flows) from the side wadis is discharged into the EGMC.

5) No canal extension beyond Km 96 is assumed for the future in the analysis.

6) Groundwater return flows equal 50% of the water quantity supplied to the city.

7) Irrigation groundwater return flows equal 20% of the consumed water quantities.

8) In the present analysis, irrigation water requirements equal 10,910 m^3/ha/yr; however, irrigation requirements may not equal the above estimate because future irrigation practices may lead to more efficient water uses.

9) The present water source of this project is a well system. In the future, irrigated land will be supplied by the EGMC.

10) Available water quantities at the EGMC end are theoretical estimates and should be used with caution. The available flows can irrigate up to 3428 ha at present and up to 2551 ha in the fucure.

11) Excess of water (including flood flows) in the future is not discharged into the EGMC but is used locally.

12) The net reservoir annual evaporation equals 8.10 MCM/yr.

13) This estimate equals the 1978 inflow record to the EGMC (JVA, 1979).

14) This is an estimate for the reservoir operation given by the Harza Operation Studies (September 1979). This estimate does not account for spill flood flows; see footnote 2, above.

15) This is the new estimate for the total irrigated area in the Valley (Harza Operations Study, September 1979).

16) The total flow of the wadis is assumed to be diverted into the EGMC, from which various irrigation areas are supplied.

17) Total irrigated area as determined by the recent Harza Operations Studies (September 1979).

18) Based on a historical mean annual discharge of 255.6 MCM/yr, adjusted for estimated historic Syrian withdrawals of 15.3 MCM/yr.

19) Estimated future additional Syrian withdrawal is 29.6 MCM/yr.

Figure 6-2 Projected Surface Water Resources
Jordan Valley Project Stage II Development

(a) Yarmouk River Basin - The majority of water in the Yarmouk River system originates in Syrian territory; however, attention need be focused only upon the river flow in the lower reaches of the drainage basin (Maqarin site, node 1) where the water becomes available for use by Jordan. It is estimated that the additional Syrian withdrawals (node 13) would be 0.0/29.6 MCM/yr and that the adjusted Yarmouk flows at Maqarin (node 1) would be 240.3/210.7 MCM/yr.

The Yarmouk flows at Adasiye (node 3) would be 390.3/304.1 MCM/yr because of the Irbid M&I water supply project (node 21) which is expected to withdraw 0.0/26.0 MCM/yr from the Yarmouk River. The Wadi Raqqad (node 31) contributes 73.3/25.3 MCM/yr to the lower Yarmouk, after diversion (node 12) of 0.0/48.0 MCM/yr to Maqarin Reservoir. The Yarmouk River contributes to the Jordan River/Yarmouk Triangle (node 4) at least 261.4/25.0 MCM/yr. Projection of inflows to the EGMC, node 5, are described later in this section.

(b) Northern Riftside Basin - Throughout the area, flood flows are small, being less than 20% of the total resource. Rainfall is high only on the escarpment ridge and, therefore, the direct surface runoff is almost entirely contained within the six main Jordan Valley tributaries. Complete flow estimates are to be found in various sources. There is a considerable variation in the estimates for individual tributaries; the data shown were adopted from Harza. [6-5]

Following a feasibility study by the Japan International Cooperation Agency in 1976, it was decided to construct a dam on Wadi Arab with a storage of 10 MCM. Though details are not available, it is understood that the regulated flow from the dam will irrigate the Wadi Arab irrigation project with 28.8 MCM/yr (node 63). After the project, return flows from Irbid to the Wadi Arab will increase the flow to 41.2 MCM/yr.

The existing Wadi Ziglab dam was built in 1963 and has a capacity of 4.4 MCM. The regulated flows were to supply 6.1 MCM/yr to the Ziglab

irrigation scheme (part of the Northeast Ghor Project) and 6.9 MCM/yr to the EGMC. Recent estimates, however, [6-9, 6-10] and present records (see Appendix G) indicate that mean annual flow is only 3.6 MCM/yr (node 61). Wadi Jurum (node 60) would contribute 11.2/11.2 MCM/yr to the Northeast Ghor Irrigation Project. The exact allocation of water from Wadis Arab, Ziglab and Jurum after the project is not known.

The flows of the remaining three wadis (Yabis, Kufrinja, Rajib) are not regulated, but they contribute to irrigation in the Jordan Valley. However, most of the baseflow of Wadi Yabis is used upstream for limited domestic and irrigation supplies. The total flow from these wadis (node 74) is 16.5 MCM/yr, of which 11.1 MCM/yr is contributed to the EGMC but with a declining rate. We have assumed that 16.5/16.5 MCM/yr would be contributed by the wadis to the EGMC system.

(c) Zarqa River Basin - The Zarqa River has been extensively studied; thus, flow estimates are very reliable. We have adopted the Harza estimate of 67.3 MCM/yr (node 87) prior to the addition of return flow from Amman of 47.5 MCM/yr (node 85). For this analysis, it was assumed that the Zarqa River would contribute 11.9/15.5 MCM/yr to the EGMC (node 81) and 55.4/99.3 MCM/yr to the Zarqa Triangle irrigation areas (node 82). The final allocations between the Zarqa Triangle area and the EGMC are subject to adjustments.

(d) Southern Riftside Basin - In this area, rainfall occurs mainly on the escarpment ridge in the north, and 80% of the total runoff comes from springs and other groundwater seepage.

The existing reservoir on the Wadi Shueib has a capacity of 2.3 MCM and is constructed to store flood water which subsequently recharges the ground. Its maximum contribution to irrigation is estimated to equal the baseflows of the wadi, namely 7.9/7.9 MCM/yr.

The Wadi Kafrein Dam was completed in 1968 and provides storage for 4.8 MCM. A recently constructed diversion dam on Wadi Hisban will divert flows in excess of local demand to the Kafrein Reservoir. The contribution to the Valley from the two wadis (nodes 101, 102) is 19.3/19.3 MCM/yr.

(e) East Ghor Main Canal - The EGMC would receive 128.9/279.1 MCM/yr from the Yarmouk River (node 5) as well as water from the side wadis as previously described. The 128.9 MCM/yr value represents the present record of inflow (see Appendix G), and the 279.1 MCM/yr represents project requirements after implementation of Stage II.

The projected annual flows in the EGMC at km=0 (node 5), km=24 (node 6), km=60 (node 7), km 78 (node 8), and km 96 (node 9) are given in Figure 6-2.

(f) Jordan River/Dead Sea - There are conflicting annual estimates for the Jordan River flows. The National Water Master Plan of Jordan (1977) indicates average flows at King Hussein Bridge of 1013.5 MCM/yr, but a more recent study indicates a maximum of 980 MCM/yr. Given the overall system operation for baseline conditions and allowing a 20% irrigation return flow (node 103), it is estimated that the Jordan River flows into the Dead Sea (node 104) would be 1000.0/795.5 MCM/yr.

The present Dead Sea elevation is -392.9 m. Given that the annual rainfall on the surface of the Sea is 80 mm [6-11] and that the average annual inflow from all surface and underground sources other than the Jordan River is 350 MCM, and using the area and volume curves for the Dead Sea shown in Appendix G, it is projected that as a result of operation of the EGMC system the Dead Sea elevation would be -392.9/ -403.1 m.

6.2.3.2.1.2 Impacts on Flows Due to the Project

The surface water resource quantity projections (flows, storages, Dead Sea elevation) induced by the Stage II development are discussed in Section 4.8 (overall system operation) and are summarized in Figure 6-2.

The differences between the flows with and without the project are the impacts on surface water resources in the area. These differences are presented in terms of volume in the fourth column in Figure 6-2 and are discussed briefly in the following paragraphs. Positive values indicate an increase of water flows or water surplus as compared to the corresponding baseline value. Negative values indicate a decrease of the water flows, a water deficit (i.e., water shortage) or lowering of the Dead Sea surface elevation. The assumptions made for the analysis are discussed in detail in Appendix G and can be identified in Figure 6-2 and the associate schematic presentation of the area. The analysis was performed for the operational phase of the Stage II development and does not include impacts occurring during construction.

Given the assumptions used in the analysis, the surface water resources which will primarily be impacted are:

(a) the Yarmouk River downstream of the EGMC diversion (node 4; 261.4/25.0 MCM/yr),
(b) the Wadi Raqqad upstream from the Yarmouk River confluence (node 31; 73.3/25.3 MCM/yr),
(c) the Jordan River flow (node 104; 1000.0/795.5 MCM/yr), and
(d) the Dead Sea elevation (node 105; -392.9/-403.1 m).

The M&I supplies to Irbid (node 22) increase from 0.0 to 24.7 MCM/yr after allowance of 5% losses for conveyance and treatment plant. For Amman (node 86), the supply increases from 0.0 to 95.0 MCM/yr. (Note: The word "allocation" is used to indicate the volume of water withdrawn from the Maqarin Reservoir or the EGMC. The word "supply" is used to indicate the volume available for distribution after conveyance and treatment losses.)

The impact on water allocated for irrigation is not readily identifiable via a single node. At present, 24,706 ha are under irrigation (stage I projects, land currently under irrigation supplied by the EGMC, and lands supplies by wells and side wadis). Under the "C-1" plan, the total

area irrigated will increase to 32,397 ha. However, the Maqarin Reservoir will provide a regulated supply to the EGMC, as opposed to the existing unregulated flow of the Yarmouk River. Lands irrigated under the "C-1" plan will, therefore, have a more dependable year-round supply, permitting an increase in the number of crops planted each year.

6.2.3.2.2 Surface Water Quality

6.2.3.2.2.1 Present Quality

Water quality data for the region are very limited. Many of the data are old and there is no consistent methodology or format. There has been only limited water quality monitoring with the result that the data which do exist may not be optimum in terms of site selection and data sampled. Comments in this section must therefore be somewhat qualitative in nature. However, enough data do exist to make certain specific points. In general, total dissolved solids (TDS) content and pH are presented as the indicators of water quality as they are the parameters most frequently available. In the absence of specific pollutants, the major constituents may be taken as a proportion of TDS, as shown in Table 6-1.

The present quality of water in the major water bodies is summarized in Table 6-2 and is described in the following sub-sections.

6.2.3.2.2.1.1 Yarmouk River

The upper Yarmouk River in the neighborhood of the proposed Maqarin Dam TDS of about 300 parts per million (ppm) during the high flow period of the year and approximately 500 ppm TDS during the summer or low flow period. The pH ranges from 7 to 8, and the water generally meets the World Health Organization's (WHO) standards recommended for drinking water sources shown in Table 6-3. Farther downstream, the Yarmouk flow is augmented by that of Wadi Raqqad. Despite this added flow of good quality water, the salt content in the region of Adasiye increases somewhat, ranging from 400 to 800 ppm TDS and with

Table 6-1

Average Proportions of Inorganic Constituents in Surface Waters of Jordan as % of TDS

Water Body	TDS (by Definition)	Na^+	Ca^{++}	Mg^{++}	Cl	CO_3^{--}	HCO_3^{--}	SO_4^{--}
Jordan River	100	15-20	7-8	4-6	30-50	∿10	13-27	8-10
Yarmouk River	100	∿10	∿8	∿4	10-20	∿3	∿40	10-30
Wadis	100	3-5	12-16	5-8	7-11	4-5	50-60	1-5

Source: "Jordan Valley Irrigation Project Stage II Feasibility Study," Harza Overseas Engineering Company, 1978; "Yarmouk-Jordan Valley Project Master Plan," Harza Overseas Engineering Company, 1955; and personal file of Mr. Mohammed Hanali, 1974.

Table 6-2

General Surface Water Quality

	Water Body	TDS Range ppm	pH Range
A	Upper Yarmouk	300-500	7-8
	Lower Yarmouk	400-800	7.6-8.4
B	Tiberius Outflow	∿850	7.5-8.2
	Jordan Near Zarqa	∿1100	∿8
	Jordan at Khbridie	1000-2100	7.6-8.1
	Jordan at Dead Sea	∿2000	7.5
	Northern Wadis	350-650	7.4-8.5
	Southern Wadis	400-770	7.8-8.3
	Lower Zarqa & KTR	850-1050	7.4-8.2
	EGMC	220-900[1]	8.0-8.2

[1] Range of 12 monthly data points.

Source: "Jordan Valley Irrigation Project Stage II Feasibility Study," Harza Overseas Engineering Company, 1978; "Yarmouk-Jordan Valley Master Plan," Harza Overseas Engineering Company, 1955; "The Dangers of Eutrophication in the Waters of King Talal Dam Reservoir," E. Salimeh, University of Jordan, December 1978; "Environmental Assessment on Amman Water and Sewage Project," Stanley Consultants, July 1978; "Studies in the Geochemistry of the Jordan River--Dead Sea System, A. Nissenbaum, doctoral dissertation, University of California at Los Angeles, 1969; and personal file of Mr. Mohammed Hanali, 1974; "Domestic Water Project, North Jordan," Stanley Consultants/Boyle Engineering Corporation, August 1979.

Table 6-3

Relevant Criteria for Drinking Water[1]

Constituent	World Health Organization (1971) Highest Desirable	World Health Organization (1971) Maximum Permissible	U.S. EPA Maximum Recommended Levels Primary[2]	U.S. EPA Maximum Recommended Levels Secondary[3]
Chloride	200	600	--	250
Copper	0.05	1.5	--	1
Iron	0.1	1.0	--	0.3
Lead	--	0.1[4]	0.05	--
Magnesium	30	150	--	--
Manganese	0.05	0.5	--	0.05
Mercury	--	0.001[4]	0.002	--
Nitrate (as N)	--	10[4]	10	--
Sulfate	200	400	--	250
TDS	500	1500	--	500
Zinc	5	15	--	5
pH	7.0-8.5	6.5-9.2	--	6.5-8.5
Color Units	5	50	--	15
Turbidity Units	5	25	1	--
Foaming Agents	0.2	1.0	--	0.5
Corrosivity	--	--	--	Non corrosive
Odor	Unobject.	Unobject.	--	3 threshold odor number

[1] All concentrations are in ppm or mg/l except for the last two constituents.

[2] 40 CFR 142 (43 FR 5373, February 8, 1978) Interim Regulations, Partial List

[3] 40 CFR 143 (44 FR 42195, July 19, 1979) Final Regulations

[4] Upper Limits

a pH ranging from 7.6 to 8.4. This reduction in quality may be due in part to surface water runoff, especially where there is agricultural activity, but it is likely that much of it is due to the presence of saline springs in or near the river bed which become more prevalent the farther down stream one proceeds. Good turbidity data are not available for the Yarmouk River, but the literature indicates that only a very small sediment load is carried.

6.2.3.2.2.1.2 The Jordan River

The Jordan River, as it leaves Lake Tiberias, has a TDS level of approximately 850 ppm and a pH ranging from 7.5 to 8.2. As it proceeds southward towards the Dead Sea, it gradually increases in solids content as a result of evaporation and the influx of saline surface and groundwaters. At the King Hussein Bridge a few kilometers above the Dead Sea, the range in TDS is from 1000 to 2100 ppm depending upon the season. As a result of this high level of solids, the Jordan River is not used for irrigation purposes to any significant degree.

6.2.3.2.2.1.3 The Northern Wadis

The Wadis Arab, Ziglab, Jurum, Yabis, Kufrinja, and Rajib flow generally east to west from the plateau region towards the Jordan River north of the Zarqa River. TDS range from 350 ppm in the wet season to 650 ppm in the dry. The pH range is approximately 7.4 to 8.5. Flow in the wadis is quite episodic, depending upon the season, with the exception of Wadi Ziglab which has been dammed to create a reservoir. This reservoir appears to have an as yet unidentified water quality problem. During several visits[1], there was no visual evidence of floating or rooted vegetation or periphytic algae, or of snails and fish. However there were no detailed water chemistries available at the reservoir which might help to confirm or explain such a phenomenon.

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[1]Observations of visiting Arthur D. Little, Inc., project team, March 1979.

Most of the water in the wadis is from surface drainage as a result of rainfall, but there is doubtless some contribution from groundwater or springs which are observed in many of the wadi areas. As the wadis approach the Jordan River itself (west of the canal) in the southern Valley area, they become more saline due to the much more intense agricultural activity and attendant irrigation drainage waters. The wadis may become contaminated by sewage effluent from villages and settlements, although no data are available to confirm this.

6.2.3.2.2.1.4 Southern Wadis

The Wadis Shueib, Kafrein, and Hisban are located south of the Zarqa River. These wadis are somewhat higher in TDS than the northern wadis due to higher solubility of the soils in the southern region. TDS ranges from 400 to approximately 770 ppm, and the pH ranges from 7.8 to 8.3. There are reservoirs and dams on the Wadis Shueib and Kafrein, but no water chemistry data for these bodies were found.

6.2.3.2.2.1.5 Zarqa River and King Talal Reservoir

Since the King Talal Dam has been built, the water quality has steadily deteriorated. Present TDS in the lower Zarqa River and the King Talal Reservoir range from 850 to 1050 ppm and pH ranges from 7.4 to 8.2. The King Talal Reservoir is highly eutrophic and rapidly getting worse. Total phosphorus levels and nitrate levels are high, exceeding those recommended by WHO for drinking water supplies. Dissolved oxygen levels are depleted as well. This is largely a result of uncontrolled drainage of septic and industrial wastes from the Zarqa-Amman region. Heavy metal content of the waters is high, and in some seasons, hydrogen sulfide may be generated from the sediments in the reservoir. These sediments are rapidly causing the reservoir to fill, and its active life may be limited to some 20 years. Upstream of the King Talal Reservoir, the Zarqa River and its contributing wadis are heavily polluted with industrial effluents and septage. The industrial waste streams may contain high levels of phosphates, iron, copper, nickel, lead, nitrate, cadmium, and bacteria. Although many of these metals may be trapped in the sediments in the King

Talal Reservoir, there remains the danger of the release of chemicals from bacteriological activity. The sewage system in the region does not service the entire residential or industrial population and pumped sewage sludges are not always conveyed to the treatment plant for disposal. (Note: The above description applied in April 1979 after three years of low precipitation. Subsequently, heavy winter rains filled the reservoir and the water quality is reported to have improved significantly.)

6.2.3.2.2.1.6 The East Ghor Main Canal

Water quality data for the EGMC have not been regularly observed and compiled although data have been located which include a year's monthly readings of water quality near the proposed intake for the city of Amman. (Table 6-4A) Readings obtained up to 60 km upstream of this point exhibited no significant trends or changes in the water parameters listed in Table 6-3. The data reported in Table 6-4B are more recent measurements taken in late June and mid-July of 1979, at the proposed intake structure site (Location A) and 1 km upstream of A at the Deir Alla bridge (Location B). The samples also indicated a high concentration of organics, including coliform bacteria and algae. Domestic and agricultural pollution is thought to be partly responsible for these high readings. Conventional water treatment at the intake structure is planned. Restrictions regarding the use of the water in the EGMC by the local residents will be implemented before the start of the water treatment program in order to minimize casual contamination. Conventional water treatment can do little for the high concentrations (at or above the highest desirable World Health Organization criteria) of TDS and nitrates presently in the canal water.

6.2.3.2.2.2 Projected Quality

In discussing the future quality of surface waters as a result of the proposed project, it is still necessary to speak in qualitative terms. However, it is useful to anticipate these changes also in terms of worst case and best case possibilities. Worst case is defined as including no upgrading of the sewage collection and treatment facilities in Zarqa,

Table 6-4A

Water Quality of East Ghor Main Canal[1]
At Deir 'Alla Intake Area

Constituents	Year 1977[2]						Year 1978[2]				
	JUN	JUL	AUG	SEP	OCT	NOV	JAN	FEB	MAR	APR	MAY
EC x 10^3, Mmohs/cm	1.40	1.35	0.80	0.76	0.76	0.77	0.70	0.50	0.34	0.76	1.00
TDS, mg/l	896	864	512	486	486	493	448	320	218	486	640
pH	8.1	8.0	8.0	8.0	8.1	8.1	8.1	8.1	8.1	8.0	8.2
Ca, mg/l	40	121	50	48	40	50	40	30	28	52	73
Mg, mg/l	80	46	35	32	18	33	29	15	9	32	39
Na, mg/l	120	106	60	60	83	51	74	51	28	55	69
Cl, mg/l	248	316	92	106	92	106	82	60	21	85	142
SO_4, mg/l	142	84	70	34	29	26	96	24	43	62	89
CO_3, mg/l	5	5	6	5	12	3	6	12	15	6	6
HCO_3, mg/l	226	220	229	229	214	229	189	140	107	226	229

[1]Ministry of Agriculture, Department of Research and Extension, Soils and Irrigation Section.

[2]The dry period when irrigation demand is high occurs in June, July and August. The rainy season is December, January and February.

Source: Domestic Water Project North Jordan. Stanley Consultants and Boyle Engineering Corporation, August 1979.

Table 6-4B

Analyses of Raw Water from East Ghor Main Canal
At Deir 'Alla Intake Area

Physical and Chemical Properties[1]	Location A June, 1979	Location A June, 1979	Location A July, 1979	Location B July, 1979
Electrical Conductivity (EC)[2]	890	960	868	890
Total Dissolved Solids (TDS)	451.0	554.0	505.0	504.7
Hydrogen Ion Concentration (pH)[3]	8.3	8.2	8.3	8.3
Calcium (Ca)	48.1	46.1	34.0	36.3
Magnesium (Mg)	34.6	35.9	33.5	30.5
Sodium (Na)	70.0	--	92.0	94.0
Chloride (Cl)	105.0	128.7	130.5	102.6
Sulfate (SO_4)	77.4	65.0	81.3	74.5
Carbonate (CO_3)	nil	nil	nil	nil
Bicarbonate (HCO_3)	257.0	256.0	363.9	262.3
Nitrate (NO_3)	26.0	5.0	4.0	3.0
Ammonia (NH_3)	0.20	0.26	0.20	0.12
Phosphate (P_2O_5)	nil	--	trace	nil
Iron (Fe)	--	--	0.08	0.05
Potassium (K)	--	--	4.6	4.8
Total Hardness (as $CaCO_3$)	--	--	221.0	216.0
Total Alkalinity (as $CaCO_3$)	--	--	216.3	215.0
Odor	nil	nil	nil	nil
Color[4]	--	--	2.5	2.5
Temperature[5]	--	--	28.0	28.5

[1] All properties are in milligrams per liter, unless otherwise noted.

[2] EC measurements are in micromhos/cm at 25°C.

[3] pH measurement is the logarithm of the reciprocal of the hydrogen ion activity--in moles per liter.

[4] Color is measured on the filtrate using standard platinum-cobalt procedure.

[5] Temperature is in degrees Celsius.

Note: Above analyses for physical and chemical properties were performed by the Royal Scientific Society.

Table 6-4B (continued)

Biological Properties

Location A

July 12	Water samples were turbid with soil particles and green algae, colony types. Fungi and plant remains were present.
July 15	Water samples exhibited high content of organics and gelatinous masses, blue greens, diatoms (40 μ in length and 6 μ in width).

Location B

July 12	Water samples were turbid with soil particles, plant refuse, fungi, green algae (30 μ). High organic content.

Note: Above analyses for biological properties were performed by the Univerity of Jordan, Department of Biology.

Microbiological Properties

Location A

July 12

Total coliform	>16,000/100 ml
Fecal E. coli contamination	+
Fecal Streptococci	+

Location B

July 12

Total coliform	>16,000/100 ml
Fecal E. coli contamination	+
Fecal Streptococci	+

Note: Above analyses for microbiological properties were performed by the Ministry for Public Health.

Table 6-4B (continued)

Trace Inorganics and Heavy Metals	Location A July, 1979	Location B July, 1979
Arsenic (As)	Not Determined	
Antimony (Sb)	0.0	0.0
Barium (Ba)	0.0	0.0
Boron (B)	0.0	0.0
Chromium (Cr)	0.0	0.0
Copper (Cu)	0.0	0.0
Floride (F)	Not Determined	
Lead (Pb)	0.0	0.0
Manganese (Mn)	0.0	0.0
Mercury (Hg)	0.0	0.0
Molybdenum (Mo)	0.0	0.0
Silver (Ag)	0.0	0.0
Tin - Stannous (Sn)	0.0	0.0
Zinc (Zn)	0.0	0.0

Note: All trace inorganics and heavy metals measurements are in milligrams per liter.

Source: Domestic Water Project North Jordan. Stanley Consultants and Boyle Engineering Corporation, August 1979.

Amman, Jerash, and the other villages in the region, and the continued uncontrolled dumping of industrial waste. The best case implies that the sewage and wastewater treatment problems associated with the cities and towns and which have contributed to the deterioration of the King Talal Reservoir are properly attended to. It also implies that the Maqarin Dam and the diversion dam at Adasiye will perform their intended functions, i.e., permit a controlled and fairly steady flow through the EGMC, avoiding the present seasonal fluctuations. Table 6-4C indicates some water quality impacts which are frequently associated with the construction and operation of dams. Table 6-5 summarizes in a general form the impacts detailed below.

6.2.3.2.2.2.1 The Yarmouk River

If proper sewage and waste treatment facilities are not implemented quickly in the region of Irbid and other areas which drain into the upper Yarmouk, there exists a very real danger of contamination of the Maqarin Reservoir.[1] Under the revised "C-1" plan, it is expected that all of Irbid's wastewater will return to Wadi Arab rather than partially to the Yarmouk River. As a result, the risk of contamination of the Maqarin Reservoir are significantly decreased.

There will be an inevitable increase in suspended and dissolved solids during the construction period and for sometime thereafter as the waters equilibrate with the newly exposed mineral surfaces, particularly due to the general lack of vegetation along the reservoir slopes and due to excessive grazing in the catchment area. Salinity of the Yarmouk River could also be increased if the construction activity in the region of the Maqarin Dam should open up major saline aquifers which are known to exist generally in the region.

In the lower Yarmouk at Adasiye, a best case TDS level might be predicted to be in the order of 400 ppm with very little seasonal fluctuations. A worse case is more difficult to predict but it could easily be twice that, i.e., 800 ppm.

[1]Personal discussion, Dr. Sufyan Tell, Irbid Regional Planning Council.

Table 6-4C

Water Quality Impacts Frequently Associated with Dams

1. <u>During Construction</u>

- Increase in suspended soilids and turbidity (temporary and local) and associated downstream siltation.

- Some change in basic water chemistry due to exposure of fresh (unoxidized) mineral surfaces. Increase in TDS.

2. <u>During Operation</u>

- Change in seasonal chemistry of water due to delayed passage in reservoir.

- Increase in dissolution of freshly exposed minerals, especially in the early years (may fall back later) (e.g., increase in Na, K, Ca, N, P, SO_4, BOD).

- Temperature changes; <u>top layer</u> in reservoir is warmer (thus will hold less oxygen) and, if adequate nutrients are available - as seems likely, will support algae blooms in certain seasons. May have temperature stratification if mixing is slow. <u>Bottom layer</u> will be cooler, contain less oxygen (no fresh O_2 brought in and existing O_2 used up in decay of deposited algae) and may even become anaerobic. Can develop toxic concentration of H_2S, CH_4, and certain metals; pH may be low.

- Higher rate of evaporation from reservoir and seepage of water through saline deposits will cause an increase in TDS.

- Quality of water discharged from reservoir (or withdrawn for municipal supply) will depend on where (top vs. bottom) water comes from. Both areas, as described above, have problems. (Algae can affect taste and clog water treatment plants.)

- Water discharged over a spillway and/or plunging into a deep pool can become supersaturated with N_2 with deleterious effects on aquatic life.

- Rate of discharge will control, to some extent, levels of SS and turbidity downstream. Lack of periodic high discharge rates (floods) will allow build up of sediments (and pollutant contained in them) in downstream areas. Trapping of normal sediments behind dam alters natural equilibrium of sediments in river. Downstream erosion may result.

Source: Arthur D. Little, Inc.

Table 6-5

Summary of Possible Water Quality Impacts

Principal Actions of (or resulting from) the Project	Surface Waters: Waters Impacted	Surface Waters: Water Quality Parameters of Possible Concern	Groundwaters
1. Maqarin Dam and Power Plant			
a) Construction (c)	Yarmouk, Jordan, EGMC	SS, turbidity	Minor impacts; principally increase in levels around reservoir
b) Operation (o)	Yarmouk, Jordan, EGMC, Dead Sea	TDS, DO, Temp., toxic chems., algal growth, N_2 supersaturation, sediments	
2. Diversion Dam at Adasiye (c)	Yarmouk, EGMC	SS, turbidity	Negligible
3. Extension of EGMC (c)	Local wadis	SS, turbidity	Negligible
4. Settlements along EGMC (o)	Local wadis, Jordan	Bacteria, BOD, DO, SS; (will depend on method of waste disposal and other practices)	Some deterioration due to seepage of human wastes
5. Amman water supply (c+o) from EGMC	Municipal Supply	Will depend upon materials of construction (other parameters as listed in 1-4 above)	Beneficial impact if less groundwater used for water supply
6. Discharge of Amman waste-waters to Zarqa (o)	Zarqa, King Talal R., Lower EGMC	Bacteria, BOD, SS, DO (will depend on degree of treatment). Possible improvement (lowering) in TDS.	Possible positive impact if more wastes sent to sewer and less to septic systems which leach to ground

Table 6-5 (Continued)

Principal Actions of (or resulting from) the Project	Waters Impacted	Water Quality Parameters of Possible Concern	Groundwaters
7. Irbid water supply (c+o) from Maqarin Reservoir	Municipal Supply	Will depend on materials of construction (other parameters as listed in 1 above)	Negligible (positive impact if less groundwater used for water supply)
8. Induced growth in population, industry, new construction, etc.	All	Related to human and industrial waste disposal and water use. May be severe.	Related to human and industrial waste disposal and water use. May be severe.

Source: Arthur D. Little, Inc.

6.2.3.2.2.2.2 The Jordan River

The Jordan River, at its confluence with the Yarmouk, is already sufficiently saline, about 850 ppm, that activities on the upper Yarmouk will not significantly affect its quality other than reducing total flow. Although there will be some modest increase in turbidity and TDS, the water is already of such a low quality that it is not utilized for agricultural purposes. While the proposed project may alter some agricultural activities in the Jordan watershed, it will probably not increase them substantially beyond levels which would occur without the project.

6.2.3.2.2.2.3 Northern Wadis

The worst case effect upon the northern wadis will be a possibility of increased pollution from population or agricultural sources as a result of the increased number of settlements or agricultural activity in the wadi region. A best case would be no change in quality.

6.2.3.2.2.2.4 Southern Wadis

The project will have little or no influence on the quality of water in the southern wadis except that the increased flow in the southern part of the EGMC may give more flexibility in the control of flows from the dams on the Wadis Shueib and Kafrein which may indirectly affect their water quality. Of more general interest may be the appearance of overflow water from the end of the EGMC as a new surface flow in that region. It may flow either as surface water to the wadis and thus to the Jordan River or may percolate down to the groundwaters. No data were available which would help predict these eventualities.

6.2.3.2.2.2.5 Zarqa River and King Talal Reservoir

It is proposed that the principal water supply for the Amman region come from the EGMC at a point upstream of the Zarqa River. In the absence of vastly improved waste facilities, an increase in the supply of water to the Amman region can lead only to a worsening of the water quality in the King Talal Reservoir and Zarqa River, due in part to increased

population and industrial activity. With proper waste facilities, however, this project could lead to substantial improvement of the Zarqa River and King Talal Reservoir water supplies due to the increased flows, as roughly half the water diverted to Amman from the canal is expected to make its way by surface and groundwaters back to the Reservoir.

6.2.3.2.2.2.6 EGMC

It can be predicted that if the best case conditions prevail, the Maqarin Dam project will serve its intended purpose, and the quality of water in the EGMC will improve by the elimination of exceptionally low flow periods such as may have led to the high dry season TDS values referred to earlier. The WHO-recommended TDS level for drinking water is 500 ppm, and it should be possible to meet this value under optimum conditions. However, if worst case conditions prevail due to the absence of proper sewage control, the enhanced intrusion of saline groundwaters in the Yarmouk Valley, and increased runoff from agricultural land use, much higher solids contents are possible. While it is doubtful the WHO maximum permissible level for drinking water (1500 ppm TDS) would be exceeded, specific contaminants such as nitrate, iron, phosphate as well as bacteriological levels might easily be exceeded. Additionally, operation of the dam will clarify the water in the EGMC by reducing the amount of suspended solids. This bonus is counter-balanced by increased biological activity resulting from greater penetration of sunlight into the water. It should be especially noted that conventional municipal water supply treatment processes are not appropriate for removal of TDS or specific ions such as nitrate.

6.2.3.3 Groundwater Resources

6.2.3.3.1 Water Quantity

The discussion of the groundwater quantity is limited in the following sections to the information required in order to describe groundwater flows that will be affected by the Stage II development. The regions referred to are the same general water resources regions described in Section 6.2.3.1.

6.2.3.3.1.1 Yarmouk River Basin

An extensive phreatic[1] aquifer occurs over much of the area, comprising the basalts, the Amman and Wadi Sir limestones, and the younger Belga rocks. Groundwater flow occurs from the recharge areas, namely the Aljun mound which lies to the southwest of the area and the Jebel Druze recharge mound in Syria to the east of the area. A groundwater divide extends between the mounds dividing waters which flow northwards to the Yarmouk and southwards to the Jordan Valley, Zarqa River, and Wadi Dhuleil. The depth to water ranges from 12 m at Ain El Mahasi near the Yarmouk River, to nearly 300 m at Qumenn near Irbid. There is no quantitative information available on groundwater recharge to the Yarmouk River. [6-10]

Return flows from the M&I supply to Irbid are expected to reach the Wadi Arab at a rate of 12.4 MCM/yr.

6.2.3.3.1.2 Northern Riftside Basin

The principal aquifers are the Amman-Wadi Sir formation and the Hummar formation. The water either appears as springs on the lower slopes of the escarpment or flows through the sub-surface to the Jordan Valley. To the north of Wadi Ziglab the system is overlain by a considerable thickness of confining beds.

Groundwater flows in the region are not expected to be impacted by the Stage II development. No new groundwater recharge of the system will take place. Water withdrawn for drinking purposes in the villages accounts for less than 2.0 MCM/yr. This water is withdrawn from springs or wells next to the wadis, and it is assumed to come from streamflows that recharge the aquifers.

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[1]A phreatic aquifer is groundwater occuring in a zone of saturation having a water table as distinguished from artesian or confined water.

6.2.3.3.1.3 Zarqa River Basin

Two main aquifers exist in the area. The first (upper shallow aquifer) lies within the Amman and Wadi Sir geologic formations and the second (lower aquifer) in the Hummar formation. The hydrogeology of these aquifers is well known. Natural recharge to the upper aquifers is well known. Natural recharge to the upper aquifers is estimated at about 20 MCM/yr. In addition, 28 MCM/yr infiltrates from sewage effluents. [6-12] The natural recharge to the lower aquifer is estimated to be 10 MCM/yr. [6-10]

The main natural discharge area for the two aquifers is near Sukhne in the Zarqa River, where the mean annual groundwater discharge under natural conditions was estimated to be 9.5 MCM/yr as baseflow and 9.0 MCM/yr as subsurface flow. [6-12]

The Stage II development will result in increased groundwater return flows to the Zarqa River because of the M&I water supply to Amman. It is estimated (node 85) that additional 47.5 MCM/yr will return to the King Talal Reservoir. This quantity represents 70 percent of the present flow of the Zarqa River.

6.2.3.3.1.4 Southern Riftside Basin

The principal aquifers in the area are the Hummar and the Kurnub-Zarqa system with water levels varying from 61 to 150 m below ground level. These aquifers are not expected to be impacted by the Stage II development.

6.2.3.3.1.5 Jordan Valley

The potential aquifers of the Jordan Valley consist of bases of sand, gravel, and gypsiferous marls. The gravel usually increases towards the borders of the Valley. The depth to water varies greatly. Many of the aquifers are under artesian pressure. In several areas, the water is at or immediately below ground level and in other cases, the water is perched and held up by impervious clay. In general, the depth to the

groundwater table ranges from 25 to 150 m. Groundwater in the Valley flows towards the Jordan River.

The groundwater recharge of Northern Riftside Basin of the Jordan Valley is estimated [6-10] to be 62.2 MCM/yr and the discharge to Jordan River to be 52.3 MCM/yr. No estimate exists for the Southern Riftside Basin. The return flows from the EGMC because of the irrigation are estimated (node 103) to total 53.9/70.7 MCM/yr.

6.2.3.3.2 Water Quality

6.2.3.3.2.1 Present Quality

Groundwaters in Jordan are best described by referring to general groundwater regions as outlined in the National Master Plan of Jordan. These are the Yarmouk Valley (Region 1), the Jordan Valley (Region 2), the Northern Riftside (Region 3), which extends as far south as the Zarqa River, the Southern Riftside (Region 4), extending south from the Zarqa River and the Zarqa/Amman Region (Region 5).

6.2.3.3.2.1.1 The Yarmouk Region

Water quality is generally quite good, staying in the range 500-1000 ppm TDS near the upper river and below 500 ppm in the neighborhood of the city of Irbid. The lower Yarmouk Valley in the region of Adasiye has lower quality groundwater due to the presence of saline springs. In the neighborhood of Irbid, pollution problems resulting from lack of proper sewage treatment are now seriously threatening the groundwater and subsequently the Yarmouk River itself.

6.2.3.3.2.1.2 The Jordan Valley

The groundwater from much of the other regions makes its way to the Jordan Valley and appears in numerous springs and in the Jordan River itself. These springs typically have TDS levels ranging from 1500 to 2500 ppm; some may be as low as 1000 and as high as 3000 ppm or more in extreme cases.

6.2.3.3.2.1.3 The Northern Riftside

The wells and springs in the area of Wadi Arab presently are of poor quality and not suitable for irrigation or drinking purposes. However, there are numerous wells and springs in the region between Wadi Arab and the Zarqa River which are used for various purposes at the local level. They have not been assayed for water quality.

6.2.3.3.2.1.4 The Southern Riftside

The wells and springs in the Southern Riftside are like those of the wadis and are generally more saline than those to the north due to the higher saline content of the soils. They are used on a local ad hoc basis for various purposes, but no data were available concerning their quality.

6.2.3.3.2.1.5 Zarqa/Amman Region

This region, which has the highest population in Jordan, is served by an upper and a lower aquifer. The upper aquifer water has become seriously degraded in recent years by pollution from human and industrial waste. Nitrate and bacteriological pollution are special problems; in 50% of the wells analyzed nitrate concentration exceed the permissible WHO limits (10 ppm). [6-13, 6-14] Total solids and chloride are also at or above permissible levels. A steady deterioration can be shown to have occurred over the past ten years and to be still progressing. The lower aquifer is still of relatively good quality, but it may soon degrade from seepage from the upper aquifer. These aquifers are also being overdrawn with the result that the water tables are falling.

6.2.3.3.2.2 Projected Quality

6.2.3.3.2.2.1 The Yarmouk Valley

The groundwater in the Yarmouk Valley is not expected to have its quality significantly altered by the proposed project. It is far more sensitive to the presence or absence of proper waste treatment facilities in and around Irbid.

6.2.3.3.2.2.2 Jordan Valley

Increased agricultural activity in areas served by the proposed project will lead to further degradation of the groundwater in the Jordan Valley due to increased use of fertilizers and pesticides. However, many springs in the area are already so high in TDS that they are not useful for agricultural or other purposes. There should be no significant consequences so long as drainage is satisfactory to prevent a saline buildup in the irrigated lands.

6.2.3.3.2.2.3 Northern Riftside

Groundwater in the Northern Riftside area will be vulnerable to pollution from increased activity in the watershed area. There may also be groundwater pollution as a result of the increased water usage in Irbid and those surrounding towns. Some of the villages in the EGMC area may be supplied with drinking water from springs in the Northern Riftside area. If so, a monitoring program should be initiated to ensure that there is no present or future problem with water quality.

6.2.3.3.2.2.4 Southern Riftside

Increased agricultural activity will lead to degradation of groundwaters in the drainage area between the EGMC and the Jordan River itself. Otherwise the groundwater is not expected to show any change or to be slightly improved in quality.

6.2.3.3.2.2.5 Zarqa/Amman

Groundwater in this region may be improved by the influx of project waters to the area, provided that proper sewage and waste facilities are instituted and correctly utilized. Water levels may be replenished and water quality improved as a result of natural recharge. However, if the waste treatment facilities are not given high priority, the groundwater can only continue to deteriorate as a results of increased population as well as increased industrial activity.

6.3 BIOTIC ENVIRONMENT

6.3.1 Introduction

The stage II program, focus of this assessment, is designed to improve water delivery to the Valley and improve water use efficiency, while allowing for some electric power generation. Increased allotments are now to be designated for M&I use in the uplands, altering the project description to some degree. Nonetheless, stage II represents an incremental portion of an ongoing program. Impacts on the biotic environment also represent an extension of ongoing processes, making it very important to identify direct, indirect, and incremental impacts associated with this program. Thus, impacts described below are of two types:

- those directly attributable to project actions in stage II and
- those that are indirect, or represent additional, incremental changes in an ongoing development process.

As discussed briefly in Chapter 3, relatively little information is available on existing biological communities, and this applies especially to the project areas designated for stage II activities. Under the best of circumstances, scenarios can be developed for "worst" and "best" case assumptions to describe the range of impacts that might be expected from a proposed project. Since the available data in this case will not permit the use of scenarios, the approach chosen here is one of applying generic impacts known to be associated with this type of development process, as observed in Jordan and elsewhere. The result makes it possible to point out where problems are expected, without any quantification of potential effects.

The areas directly affected by actions under stage II include the Yarmouk River and Valley and the Jordan River Valley.

The Yarmouk River and Valley are located in the Mediterranean plant-geographical region. [6-15] The indigenous floodplain vegetation has

largely been replaced by agronomic species with remnant stands of riparian brush and trees still in existence. The steep slopes on either side of the river do support some low-growing vegetation (at least in the spring) and evidence of erosion is obvious. Rock outcroppings that support little vegetation are present over large areas. The river, milky in appearance in March 1979, reportedly supports at least carp and Tilapia spp.

The northern Jordan Valley, part of the Irano-Turanian region, is almost entirely in agricultural use. Some areas of the southern Jordan Valley (below the existing EGMC), which are included in the Sahara-Sindian plant-geographical region, are under agricultural use with irrigation from spring or well water. This portion of the Valley is generally more arid, with a greater percentage of saline soils than in the north. Natural vegetation in this area of the Valley appeared sparse during a brief March 1979 visit. The potential direct and associated incremental effects on biota that could result from stage II and overall development pressure are discussed individually below.

6.3.2 Terrestrial Biota

6.3.2.1 Impact Potential Directly Associated with Proposed Stage II Actions

The most significant impact directly associated with stage II actions would be the loss of habitat due to Maqarin Dam construction and reservoir establishment (see Table 6-6). Although there are no reports of endangered flora or fauna from this location, this cannot be considered a conclusory statement, due to the lack of survey data on the area. It is worth noting that the U.S. Fish and Wildlife Service has added two Jordanian species to the Endangered Species list: Gazella subgutturosa marcia (sand gazelle), and Gazella dorcas saudiya (Saudi Arabian gazelle).[1] Mechanized hunting from motor vehicles has been cited as the cause of

[1]U.S. Federal Register, 44 FR 37124, June 25, 1980. See also Appendix C for listing of other mammals in Jordan that may be considered threatened by other conservation authorities.

Table 6-6

Direct Impacts Associated with Proposed Stage II Project

Dam Construction	Habitat loss (Yarmouk River and portion of catchment) • Remnant Mediterranean habitat • Riverine habitat • Downstream habitat alteration or loss Habitat gain (reservoir) • Increased fish habitat for some species • Increased disease vector habitat • Increased eutrophication potential
Dam Construction/Operation Access Roads and Water Depth Fluctuation	Disturbance of vegetation and increased erosion potential Possible mitigation of increased disease vector habitat
New Lands Irrigation Project	Incremental arid habitat loss (southern Jordan Valley)

Source: Arthur D. Little, Inc.

the reduced numbers of both of these species, and habitat reduction due to overgrazing is considered a contribution. The Jordan and Yarmouk Valleys are not listed as known range for these species. No field survey was made during this study to confirm this fact.

Very few, if any, large mammals are likely to still inhabit the Yarmouk Valley area, although several wild boar were reportedly killed in the vicinity of the dam site in 1978. [6-16] Passerine birds, both migratory and resident, which exist in the Yarmouk Valley, will be affected by this habitat loss. Water fowl species will be less impacted by the creation of the reservoir. Reservoir construction may create the potential for increased utilization of this area by migratory water fowl, although the species composition may change somewhat. More specific identification of these impacts is not possible without survey data.

Habitat losses for birds, small mammals, and invertebrates adapted to arid environments, would result from increased agricultural production in the southern Jordan Valley due to the extension of the EGMC. It is noted, however, that irrigated agriculture already exists in significant amounts in this region.

6.3.2.2 Impact Potential that is Indirect or Represents an Increment in an Ongoing Development Process

The fact that stage II represents a portion of an ongoing program makes it difficult to disassociate impacts due solely to the actions of this program from the overall development process. In particular, increasing demands on limited land and water resources (in part, due to population increases), in addition to increases in agricultural lands, can increase stress on all biological systems. These factors could ultimately have economic and sociological implications. In this respect, Jordan is similar to other developing countries in arid regions. Several examples of the more significant alterations in the terrestrial biotic regime are described below:

- Increased Grazing Pressure

  Jordan has a large population of livestock: 927,000 head of cattle, sheep, and goats were reported in 1974. [6-17] Historically, animals were moved from place to place, and grazed areas were allowed to revegetate before animals were returned to them. Increasing human (and thus animal) populations and competition with agricultural land uses have put increasing pressure on available graze land.

  Thus, vegetation is commonly overgrazed. Through selective pressure, livestock alters the plant associations present, favoring the survival of less palatable species (e.g., thorny bushes). This lowers the animal carrying capacity of a piece of land because of the prevalence of undigestible food sources. Over time, grazing land will decline in quality unless an opportunity for natural succession is allowed. [6-18] To the extent that Stage II actions represent losses in grazing land in the Yarmouk Valley and southern Jordan Valley, the proposed project represents a direct contribution to this process.

  The effects of uncontrolled grazing can ultimately be very severe. It contributes to the spread of deserts into previously utilizable areas, which is a prevalent trend today in arid regions of the world. [6-19] Because of the relative lack of resiliency in arid ecosystems, reestablishment of removed vegetation is a slow process. [6-15] Many arid species are perennials which often need several years or longer to reach reproductive maturity. Early growth stages are especially vulnerable to disturbance because of the lack of root development. In addition, overgrazing promotes soil erosion which has deleterious effects on water quality and on future ability of soil to support economically important (and other) plants.

- Erosion Problems

  These represent a corollary to the problems associated with overgrazing and the general lack of extensive tree cover in Jordan. The King Talal Reservoir, with a predicted half life of 20-25 years if nothing is done about siltation [6-20], represents a worst case example. Here, 95% of the land in the catchment area is affected by sheet erosion due to a history of grazing, cultivation, and lumbering.

  According to the Stage II Feasibility Study [6-5], siltation problems are not expected to be this severe. However, it was noted during sites visits in 1979 that the slopes of the Yarmouk Valley are heavily grazed and trees are almost totally absent. The question raised here is to what degree will reduction in grazing land (reservoir filling) and other land use changes result in increases in grazing pressure and subsequent erosion. Similar overgrazing was observed at at least one wadi reservoir (Kufrein Dam) in the March 1979 visit.

- Reforestation (also Afforestation)

  Programs of reforestation have been ongoing for several decades. The impediments to their success are important to note, considering the importance of tree coverage to controlling erosion.

  Trees requiring relatively low amounts of water, such as *Pinus halepensis*, can be planted in Jordan's higher rainfall regions. However, in highly eroded, low moisture

retention capacity soils where rainfall is also low [6-21], some supplemental irrigation will likely be required for successful establishment of even low water requiring species. Trees of economic value, such as the olive, have also been planted. But unless sufficient water is available, crop production can be seriously curtailed [6-21], causing a reduction in economic returns.

Two additional problems also exist. In spite of some policing, young seedlings are often grazed by domestic herds or cut for firewood. In fact, an olive tree planting program, based on the involvement of individual landowners, was developed to offset these problems.

- Increased Pest and Plant Disease Potential

  The susceptibility of high-density agricultural systems to pests is well known and is certainly not unique in Jordan. The agricultural extension arm of the Ministry of Agriculture is addressing some of its efforts toward research on disease-resistant crops, and several important observations relevant to the agricultural development in the Jordan Valley are worth highlighting.

  Successful completion of Stage II is designed to allow year-round irrigation. This certainly affords the potential for increases in agricultural pests, especially due to the prolongation of the growing season, increased food abundance due to successive plantings, or changes in the arid microclimate due to overhead irrigation. [6-22]

Productivity may, in turn, be maintained by the increased use of pesticides, with the well-documented potential for increased pest resistance representing a recurrent problem. Long-term economic gains could be affected as well.

- Effects of Soil and Irrigation Water Quality

  The effects of increased salinity, in both irrigation water and irrigated soil in arid environments, is also well documented. [6-19, 6-23] Potential problems associated with salinity increases in Jordan would be considered an indirect effect of the general increase in irrigated agriculture. The economic significance of such problems is covered in Section 6.4.1.4.2. Further, the moderate-to-high levels of total dissolved solids in various irrigation waters, reported in Section 6.2.3.2.2 from a limited data base, indicate potential problems.

  This is noted here because a number of crops are sensitive to increased salinity: oranges, tomatoes and lentils, all grown in the Jordan Valley, are examples. Sensitivity can be a function of both the total osmotic potential of the soil/plant system and of specific ion toxicity. [6-24] A far better understanding of water quality changes over various seasons (especially in dry years) is needed to understand the impact potential.

  Similarly, as the King Talal Reservoir fills and is used for irrigation in the Valley, the water quality of this source should be better understood. The few data that are available (Section 6.2.3.2.2) indicate that levels of chlorides and some heavy metals may be elevated. Some crops are sensitive to these ions, while others can accumulate them, thereby introducing them into the food chain. The alkaline pH of this water would tend to reduce

the availability of many heavy metals in the soil, although the increased use of sprinkler irrigation may make some more available through leaf absorption. It is not possible to assess the degree of potential problems caused from use of water from this reservoir without a better understanding of its water quality.

- Effects of Increased Traffic

  Whether or not increased population in the Jordan Valley will cause decreases in air quality and subsequently effect plant productivity, will depend largely on the effect of air inversions on increases in vehicular traffic exhaust (and any other emissions). It is only noted that SO_2, CO, and NOX emissions can be, in sufficient concentrations, deleterious to crops. Lead and hydrocarbons can accumulate on plant surfaces and become introduced into the human food chain in addition to affecting human health through their presence in the air.

6.3.3 Aquatic Biota

6.3.3.1 Impact Potential Directly Associated with Stage II Actions

As described for the terrestrial biota above, the most significant impact directly associated with Stage II actions would be habitat losses caused by the construction of the Maqarin Dam on the Yarmouk River, the largest tributary to the Jordan River. Generically, major impacts associated with dam construction include:

- Loss of strictly riverine species due to riverine habitat losses,
- Alteration to downstream flows that could lead to loss or reduction in downstream aquatic populations, and
- Increases in the proposed reservoir, in those species present (or introduced) that are adapted to a reservoir environment.

More specifically, the reported presence of Tilapia spp. and carp in the Yarmouk River indicates that the potential does exist for a fishery resource in the proposed reservoir. Total productivity for these fish populations (and other fish species that can also survive) and the lag time for that productivity to become developed, largely depend upon the degree to which spawning habitat remains available,[1] and on how quickly food sources build up.

If the proposed reservoir also become stratified at least seasonally, problems of lowered dissolved oxygen in deeper portions of the reservoir could potentially affect the biotic populations that have developed. The potential for increasing salinity could also have an adverse effect on some species. Interestingly, carp and Tilapia spp. are relatively tolerant of increased salinity.

The creation of reservoirs can result in increased habitat for disease vectors such as Bulinus sp. (snails that can carry shistosomiasis) and anophelene mosquitoes. [6-25, 6-26] The fluctuating water levels projected for this reservoir could potentially (depending upon rate) reduce shoreline habitat for these species. However, it must be added that such projections are largely speculative, considering the uncertainty associated with the characteristics of the proposed reservoir. Further, the long-term potential for eutrophic conditions, and hence floating mats of vegetation, could also provide such habitat in spite of alterations in water levels.

Thus, while it is possible to project the likelihood of change in composition of the aquatic community, the nature of such changes is difficult to project without more definitive information on species present in the existing system.

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[1]For example, shallow, vegetated areas are optimal as carp spawning habitat.

Downstream effects of the proposed Maqarin Reservoir, beyond the temporary increase in siltation from construction activities, are largely dependent on the operation of the facility itself. Specifically, these would include:

- Changes in water levels and consistency of flow in downstream areas of the Yarmouk, and
- The existence of flowless periods.

In other words, loss of habitat in the lower Yarmouk would depend largely on operational procedures and on the degree to which existing biota could survive such changes. Dry stream bed conditions would seriously curtail survival of all but drought-adapted species. The same applies to the construction of the downstream diversion facility for water supply to the EGMC: the impact on even lower portions of the Yarmouk River will depend largely on the amount (depth and flow continuity) of water beyond the diversion structure itself.

Reservoir releases can result in nitrogen gas (N_2) super saturation in downstream waters (see Section 6.2.3.2.2), a situation that can produce gas bubble disease in fish. Information on proposed discharge methods (and the area's temperature regime) indicate such problems appear unlikely at Maqarin. However, proposed design indicates that the potential for low oxygen levels in discharge water could affect aquatic organisms for at least some distance downstream. Releases from the King Talal Reservoir have been recommended for a potential demonstration commercial fish farming enterprise. (See Section 6.4.1.4.4.) To the extent that either of these problems applies to this water source, they should be considered in the design and feasibility of a fish farming enterprise using this water directly.

Construction activities on side wadis, to the extent that they represent additional impoundment of perennial portions of streams containing aquatic communities, would have similar, if smaller impact, on Jordan's biota.

6.3.3.2 Impact Potential that is Indirect or Represents an Increment in an Ongoing Development Process

The present project description now includes increased allocations of Maqarin Reservoir water to Amman and Irbid for M&I purposes. The new plan leaves King Talal Reservoir water entirely for Jordan Valley irrigation purposes, with no withdrawal for Amman. While water impact issues in general are the subject of other sections of this chapter (Sections 6.2.3.2.2 and 6.3.4), there is a very close relationship between water quality and aquatic and terrestrial biota.

There is very little general information on water quality in Jordan. Considering the fact that water is used for growing and washing crops, drinking water (especially by livestock), and as habitat by species that may be included in man's food chain, it is crucial that the implications of all the changes in land use and water use on water quality be understood. Certainly, these changes in water quality would affect indigenous biota as well. For example, increasing use of fertilizers, and more significantly, pesticides, can result in increased concentrations of these materials in water because of runoff. There is much agricultural land use in the catchments of both the Zarqa and the Yarmouk Rivers, but especially the latter. Pesticides are used in these situations, and their toxicity to aquatic organisms and to man is related to their chemical composition and degradation rate. Increasing use of mechanized wide spray application may affect open water transport systems (e.g., the EGMC) which might otherwise not be affected by the pollutants. The potential effect of increased pollutants and salinity in irrigation water was discussed in Section 6.3.2 above.

Two things do decrease the potential negative impacts of this situation.

- First, the alkaline pH of the water in Jordan serves to reduce the availability of many metals to plants (unless concentrations are exceedingly high). The fact that the water of the Zarqa is relatively hard [6-27] would indicate reduced toxicity of most heavy metals to aquatic biota as well.

- Secondly, the increased use of Yarmouk River water to supply Amman will increase return flows to the King Talal Reservoir, thereby diluting levels of dissolved solids as well as concentrations of other constituents. However, if this increase of water for M&I purposes on top of expected population increases also stimulates increased industrial use without water treatment (a situation largely true for existing industry as well), the dilution benefit may well be lost. The resultant problems would be those stated above.

One report on the proposed Maqarin Reservoir suggested use of this new body of water for tourism development. [6-5] Considering the increasing requirements for water of good quality in Jordan, it must be strongly recommended that the potential impact on water quality from the type and intensity of recreational use ultimately planned be investigated prior to implementation of such a program. High-intensity, water contact use, and associated development has the potential for adversely affecting the water quality of a reservoir with respect to municipal supply.

6.3.4 Disease Transmission

The existing environment in the project areas, particularly the East Jordan Valley, is conducive to the transmission of a variety of infectious and parasitic diseases as well as other acute and chronic health problems. The primary vehicle of concern, either for direct transmission of bacterial and viral diseases or for the breeding of intermediate hosts and vectors of parasitic diseases, is water. The most obvious water bodies in the East Jordan Valley are the Jordan River and the EGMC; however, there are also a multitude of secondary and tertiary irrigation canals, dams and reservoirs, water storage tanks, springs, and isolated bodies of standing water in the area. The environment is also conducive to the transmission of parasitic diseases which are

associated with domestic animals and wild desert rodents rather than aquatic breeding sites. In addition, the environment of human activity, particularly agricultural operations, has many features which are detrimental to human health.

The project will impact several aspects of the environment including the quality and quantity of water, insect breeding sites, habitats of small mammals, domestic animal populations, and sewage and garbage disposal; and these impacts may have profound effects on human health. The key impacts of the project on public and environmental health include, but probably are not limited to, the following categories:

- Malaria,
- Schistosomiasis (Bilharziasis),
- Other Parasitic Diseases,
- Water-borne Bacterial and Viral Diseases,
- Acute and Chronic Exposure to Toxic Substances, and
- Motor Vehicle and Occupational Injury.

Detrimental impacts, especially in the previously mentioned categories, will be lessened by specific beneficial aspects of the project or by mitigating factors which exist or are in the process of being developed in Jordan. These factors are discussed in Chapter 8. The following discussion focuses on the key health impacts which could develop as a result of the project.

6.3.4.1 Malaria

Assuming no change in the Malaria Control Program, there are expected to be local epidemics in the project area. The primary project-related factors which will lead to this impact are: (1) increases in the numbers of water bodies suitable for the breeding of anophelene

mosquitoes, (2) increases in the immigration of foreign laborers with malaria infections and the return of Jordanians from malaria-endemic countries, and (3) the proximity of current and planned residential areas to sites suitable for mosquito breeding. An additional factor, which is not directly related to the project, is the spread of DDT resistance in A.sacharovi populations. [6-28]

6.3.4.2 Schistosomiasis (Bilharziasis)

The environment in the project area is suitable for the transmission of schistosomiasis. Preliminary surveys [6-29] have identified a number of habitats which could support colonies of the vector snail, Bulinus truncatus. Given these favorable conditions, it is difficult to explain why Jordan is spared the burden of schistosomiasis while most surrounding countries are struggling with endemic foci. The crucial missing link is the establishment of colonies of vector snails for, if that were to happen, it is highly likely that established colonies would become infected through human urinary excretion of schistosome eggs and that local residents would be infected by the free-swimming cercarial form of the parasite. The threat of schistosomiasis demands concerted efforts to prevent the development of indigenous cycles of transmission. The expenditures, which will be required if the disease ever becomes endemic in the area, will be a severe burden to the national economy. The required costs will include chemotherapy for human infections, molluscicide distribution for natural drainage systems and irrigation systems and facilities such as laundries, baths, bridges, and fences to limit contact with the parasite.

6.3.4.3 Other Parasitic Diseases

Other species of snails such as Physa and Lymnaea have been found in great numbers in the project area. [6-29] Lymnaea species are well known as vectors of fascioliasis in sheep and cattle (F.hepatica and F.gigantica). [6-30] It is believed that the anticipated increased

population in the project area will be at risk for contracting fascioliasis through contact with egg-bearing animal feces. Hydatid disease may also be contracted in this manner. It is possible that development may have a positive impact on the transmission of cutaneous leishmaniasis by displacing the natural rodent reservoirs such as Psammomys obesus. On the other hand, immigrants to the area will be exposed to the vector sandfly (Phlebotomus papatasii), and it is also possible that the reservoir rodents will favor human habitats when displaced by expanding agricultural lands.

6.3.4.4 Water-Borne Bacterial and Viral Diseases

The provision of closed potable water systems in the project area will have a positive impact on the current high incidence of gastroenteric diseases. Increasing the supply of domestic water and associated improvements in personal hygiene will also have a positive impact on diseases such as trachoma which are commonly associated with poverty, crowding, and dry dusty conditions. It will be difficult, however, to control the unauthorized use of irrigation water for domestic purposes and the poorer residents who cannot afford potable water or who do not have closed domestic systems will continue to suffer from these diseases. Even closed systems cannot guarantee health without proper control and maintenance of the system and its source and control of domestic sewage effluents.

6.3.4.5 Acute and Chronic Exposure to Toxic Substances

The chronic effects of the unregulated use of agricultural pesticides in the project area is unknown at this time, but experience in other countries suggests that adverse effects, especially from organophosphorus compounds, must be expected. It is highly likely that the incidence of acute cases resulting from exposure to toxic substances will increase. A more complicated issue is the potential health impact of toxic industrial wastes. Serious impacts may develop, especially

if irrigation water is reused for domestic purposes in the cities. On the other hand, some toxic substances (e.g., DDT and Dieldrin) are currently having a positive impact as integral parts of the malaria control program.

6.3.4.6 Control of Motor Vehicle and Occupational Injury

The anticipated increase in population and the expansion of commercial activity in the project area will result in a substantial increase in injuries. Traffic density could be particularly severe on the roads which connect the East Jordan Valley with the major urban centers. Likewise, occupational injuries will increase as the industrial sector expands in the area.

6.4 HUMAN ENVIRONMENT AND ACTIVITIES

6.4.1 Jordan and Yarmouk Valleys

6.4.1.1 Archaeology and Historic Sites

This discussion of the two main impact areas--the Maqarin Dam and Reservoir, and the "South Valley" area of the East Jordan Valley--is divided into four sub-sections for each area: Existing Archaeological Data Base, Assessment of the Completeness of the Archaeological Data Base, Adverse Impacts of the Proposed Actions, and Beneficial Impacts of the Proposed Actions. More details and technical data appear in Appendix I. Ways of mitigating the adverse impacts are in Chapter 8.

6.4.1.1.1 Maqarin Dam and Reservoir

6.4.1.1.1.1 Existing Archaeological Data Base

In 1978, the JVA and the Jordanian Department of Antiquities commissioned the University of Michigan and the University of Jordan to survey the Maqarin Reservoir area to identify all sites that might be lost due to dam construction or flooding. As a result of this survey [6-31], there are now 32 known sites. They represent a span of occupation from the Lower Paleolithic through the Ottoman Periods (for chronology, see Table 3-5), indicating that this stretch of the Yarmouk Valley has been inhabited almost continuously for the past 100,000 years. The only major period not represented is the Mesolithic because the microlithic tools of the Mesolithic are smaller than the stone tools of other periods and, therefore, more difficult to find on the surface.

Table 6-7 shows the elevation, approximate surface area, and major periods of occupation of each of the 32 sites. Figure 6-3 shows the location of each site according to its ascribed number.

The sites range in size from 3.4 m^2 (Site 30) to 8 ha (Site 2). The types of sites also vary tremendously, from small, flat Paleolithic/Neolithic camp sites with shallow deposits (such as Sites 16 and 31) to a fortified Early Bronze Age town with several meters of deposit (Site 14), and from natural rock shelters (Site 1) and prehistoric ash pits (Site 30) to standing ruins (Sites 6, 21, 26) and tombs (Site 8).

Table 6-7

Archaeological Sites in the Maqarin Dam and Reservoir Area

Site No.	Local Name	Elevation (meters)	Size (meters)	Periods of Occupation
1		100	10 x 5	Material could not be identified
2		70-140	400 x 200	Early Neolithic, Byzantine, Mamluk/Ottoman
3	El Habis	160-200	300 x 200	Byzantine, Paleolithic, Neolithic through Roman
4	Umm Qala's	150-180	200 x 100	Byzantine, Roman
5	Sheikh Faris	170-190	150 x 100	Byzantine
6		90-160	300 x 150	Iron IB-C, Middle Bronze II, Hellenistic, Roman
7	El-Roba	190-210	200 x 150	Early Neolithic
8		275	tombs	Roman?
9		180-350	240 x 100	Roman
10	El-Madkhanah	135-180	200 x 100	Roman
11	El-Madkhanah	130-170	200 x 200	Early Neolithic, Roman, Middle Bronze IIB-C
12	Abu Taha	130	14 x ?	Early Bronze IVB - Middle Bronze I
13		115-130	100 x 100	Roman
14	Tell Jamid	132	300 x 150	Early Bronze I-III
15	Ez-Zawr	85	100 x 50	Roman
16		100-150	150 x 150	Upper Paleolithic
17	Et-Tahuna	100	100 x 100	Byzantine
18		75-90	250 x 200	Lower Paleolithic, Middle Paleolithic, Early Neolithic
19	El Baidar	170-200	200 x 200	Late Bronze
20		150-170	100 x 50	Middle Paleolithic through Early Bronze
21	Umm El-Hasinat	150	100 x 50	Early Bronze, Middle Bronze II, Byzantine
22		300	200 x 100	Roman
23	El-Burj	70	30 x 30	Middle Bronze IIB-C
24		73	5 x 4	Early Neolithic, Paleolithic
25		70	100 x 100	Lower-Middle Paleolithic
26		40	500 x 100	Early Neolithic
27	Tabaqat Nasrah	30-65	400 x 100	Early Neolithic
28	Tell Qurs	150-180	140 x 90	Early Bronze, Roman
29		80-85	100 x 100	Early Bronze
30		75		Neloithic/Chalcolithic ash pit
31		300	200 x 200	Paleolithic, Neolithic
32	Maqarin Ledge	80-100	? x ?	Middle Paleolithic, Neolithic

(If there is a single dominant period on a multi-period site, the name of that period is underlined. See Table 3-5 for chronology of periods.)

Source: T.M. Kerestes, et al. "An Archaeological Survey of Three Reservoir Areas in Northern Jordan, 1978," Annual of the Department of Antiquities of Jordan.

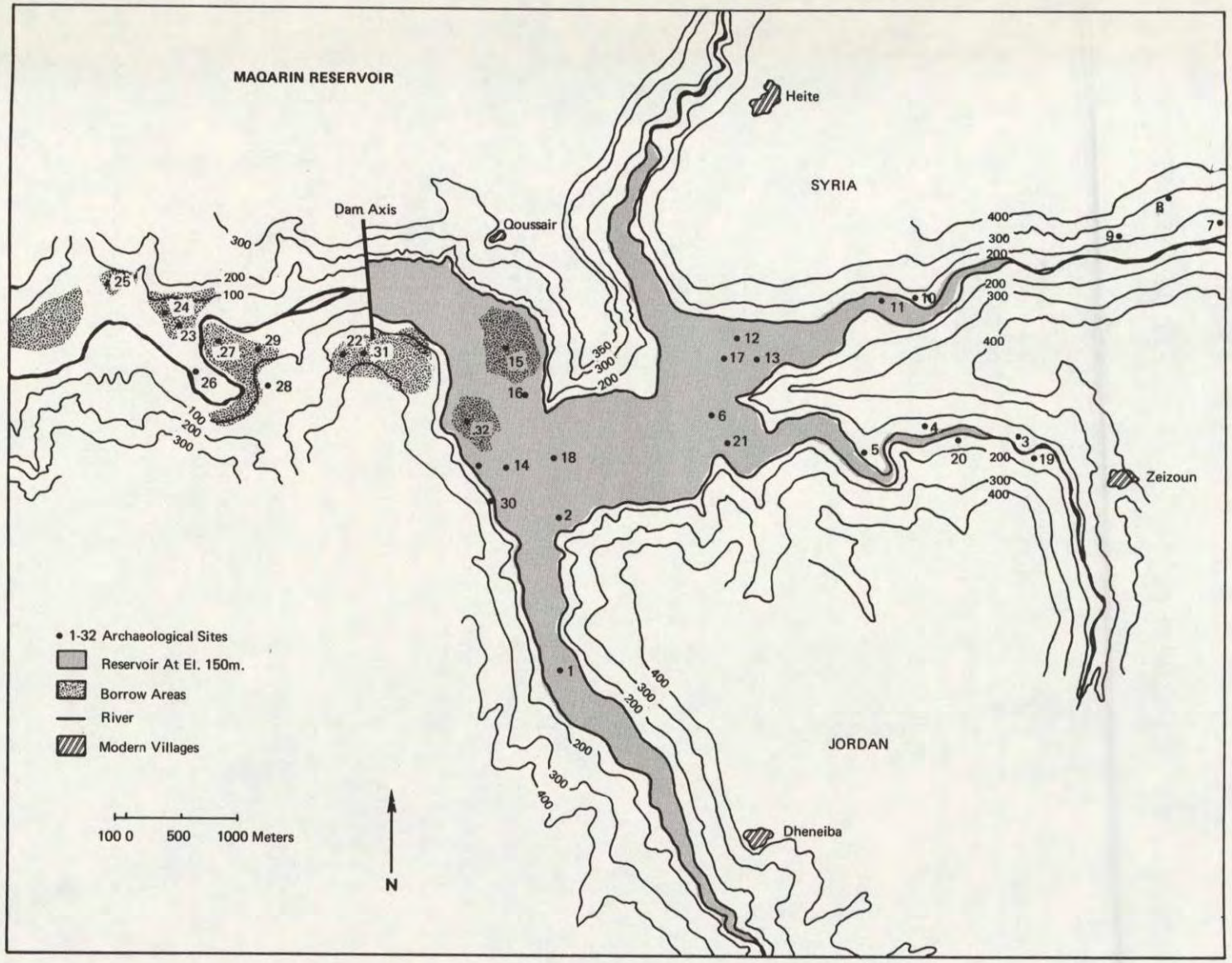


Figure 6-3 Threatened Archaeological Sites Within Maqarin Reservoir

Source: T.M. Kerestes, et al. "An Archaeological Survey of Three Reservoir Areas in Northern Jordan, 1978," Annual of the Department of Antiquities of Jordan.

Table 6-8 divides the sites according to the occupation periods represented on each. The periods with the most extensive occupation in the Maqarin Reservoir area are the Roman Period, represented on 11 different sites, and the Early Neolithic, represented on nine different sites.

6.4.1.1.1.2 Assessment of the Completeness of the Archaeological Data Base

The 1978 survey's methodology was excellent, as evidenced by the 28 new sites discovered. The entire impact area was systematically walked over, using survey techniques designed to discover a maximum number of sites. No more sites of importance are likely to be found, and the archaeological data base for assessing impacts is complete.

6.4.1.1.1.3 Adverse Impacts

Of the 32 known sites in the Maqarin Reservoir area, only four will not be adversely impacted by the proposed dam and reservoir. These are Sites 7, 8, 9, and 28. Sites 7, 8, and 9 are well above the maximum proposed level of the reservoir (170 m), and Site 28 is slightly downstream from the dam site and not threatened by proposed construction "borrow" areas. Ten of the remaining 28 sites are located within proposed construction borrow areas and will be destroyed during dam construction.

The other 18 sites are threatened in three ways.

First, inundation by itself will not necessarily destroy these sites, but it will accelerate the rate of decay and deterioration of certain types of buried artifacts. [6-32]

Second, and much more serious than simple immersion, the level of the reservoir is likely to fluctuate dramatically, because of the changing yearly or seasonal flow of the Yarmouk River. With the maximum level of the reservoir at 170 m, and the minimum at 70 m, all 18 sites within

Table 6-8

Archaeological Sites in the Maqarin Dam and Reservoir Area, by Period

Paleolithic	Early Neolithic	Neolithic	Neolithic/Chalcolithic
3	2	3	30
16	3	20	
18	7		
20	11		
24	18		
25	20		
	24		
	26		
	27		

Chalcolithic	Early Bronze	Early Bronze IVB-Middle Bronze I	Middle Bronze II
3	3	12	3
20	14		6
	20		11
	21		21
	28		23
	29		

Late Bronze	Iron	Hellenistic	Roman
3	3	3	3
19	6	6	4
			6
			8
			9
			10
			11
			13
			15
			22
			28

Byzantine	Mamluk/Ottoman
2	2
3	
4	
5	
17	
21	

Table 6-8 (Continued)

Sites Not Threatened

7	
8	
9	
28	

Sites Located in Proposed Borrow Areas, Threatened Within Two Years by Dam Construction

15	26
22	27
23	29
24	31
25	32

Sites Located Within Reservoir, Threatened Within Six Years by Inundation

1	10	17
2	11	18
3	12	19
4	13	20
5	14	21
6	16	30

Source: T.M. Kerestes, et al. "An Archaeological Survey of Three Reservoir Areas in Northern Jordan, 1978," Annual of the Department of Antiquities of Jordan.

the area of inundation will be subjected to alternating periods of saturation and dryness. One of the most critical requirements for archaeological site preservation is a stable environment. Alternating periods of wetness and dryness will have a serious destructive impact on most of the archaeological materials found on these sites. [6-32]

Third, a dramatically fluctuating reservoir level will also generate currents and waves that will cause erosion. Mud brick architectural remains and the site deposits themselves may be lost through this type of erosion. Erosion may also result from the proposed use of the Maqarin Reservoir as a recreational area. Motor boating or water skiing would generate heavy waves which in turn would be especially destructive.

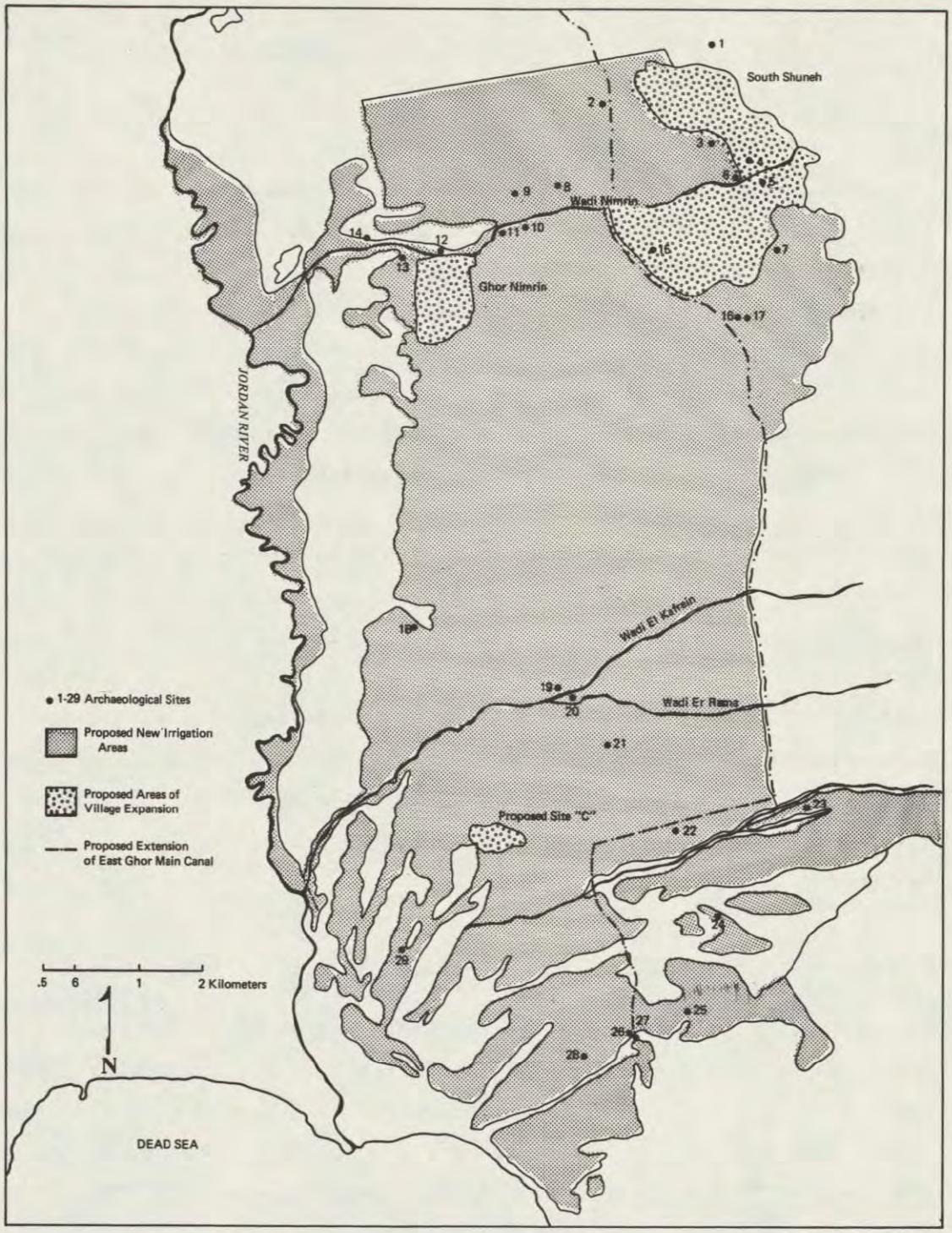
In combination, these three forces would, over the lifetime of the dam, significantly damage or destroy all 18 sites within the reservoir.

6.4.1.1.1.4 Beneficial Impacts

If actions are taken to mitigate the adverse impacts through salvage excavations of threatened sites, a regional archaeological museum could then be built at the edge of the Maqarin Reservoir to display the finds from the salvage excavations. When the reservoir is developed as a recreational area, an archaeological museum would provide a major additional attraction to draw tourists. (See Section 6.4.1.6.2.)

6.4.1.1.2 The East Jordan Valley

The primary impact of the proposed Stage II actions on archaeological sites will be from the irrigation and cultivation of more than 10,000 ha of new lands at the south end of the East Jordan Valley. This area, hereinafter termed "South Valley," consists of a strip of lands six to eight km wide running from a point just north of the town of South Shuneh and the Wadi Nimrin south to the edge of the Dead Sea near Suweima. (See Figure 6-4.) (Note: Under the revised "C-1" plan, the irrigated area is expected to be reduced by about 3600 ha from the area proposed in the Feasibility Study.)



Source: T.M. Kerestes, et al. "An Archaeological Survey of Three Reservoir Areas in Northern Jordan, 1978," Annual of Department of Antiquities of Jordan.

Figure 6-4 Threatened Archaeological Sites Within Proposed New Areas of Irrigation in the Southern End of the Jordan Valley

6.4.1.1.2.1 Existing Archaeological Data Base

At present, there are 224 known archaeological sites in the East Jordan Valley between the Yarmouk River and the Dead Sea. Twenty-nine of these are in the South Valley, and represent the Neolithic through the Ottoman Periods (Table 6-9). In the South Valley, by contrast from the Maqarin Reservoir, the Paleolithic Period is not represented. The absence of occupation in these earliest periods is due to the level of the Dead Sea being substantially higher at various times during the Late Pleistocene, leaving the South Valley submerged.

Many types of sites are represented: long, sprawling Neolithic/Chalcolithic sites with surface remains stretching in a thin line for kilometers along major wadi beds (Sites 9, 10, 11), a large Iron Age mound over 15 m high (Site 5), a quarrying site for flint used in stone tool production (Site 1), an extensive Chalocolithic cemetary with cairn tombs (Site 24), a probable Roman camp with standing ruins (Site 29), and even a walled town of the Early Bronze Age (Site 27). The largest site, and one of the most important in this part of the Near East, is Ghassul (Site 22).

6.4.1.1.2.2 Assessment of the Completeness of the Archaeological Data Base

The archaeological data base for the South Valley is not yet complete. While the wadis and the edges of the Valley have been carefully surveyed, large areas between the wadis, particularly down toward the Jordan River, have not been examined closely. Much of the area between Ghassul and the Dead Sea has been surveyed only superficially or not at all, due to restricted military zones near the Jordan River and a large minefield running southwest from Ghassul. Probably at least 10 sites, some possibly very important, still lie undiscovered.

6.4.1.1.2.3 Adverse Impacts

Five types of potential or existing damage were identified during field reconnaisance.

Table 6-9

The East Jordan Valley: Archaeological Sites in the South Valley Area

Site No.	Local Name	Periods of Occupation
1		Neolithic/Chalcolithic quarry
2	Tulul es-Sukneh	Early Bronze IV-Middle Brinze I, Byzantine
3	el-Hunu	Early Islamic (Umayyad, Abbasid), Late Byzantine
4	er-Rawwaseh	Early Bronze IV-Middle Bronze I, Byzantine Mamluk, Ottoman
5	Tell Nimrin	Iron II, Early Islamic (Umayyad, Abbasid), Mamluk, Ottoman
6	Zoriyyet 'Affash	Byzantine
7	Tell el-Mahmuleh	Byzantine
8	'Affash	Neolithic/Chalcolithic
9	Ghannam	Neolithic/Chalcolithic
10	Ghrubba East	Neolithic/Chalcolithic
11	Ghrubba	Neolithic/Chalcolithic
12	Mokhayyam Ghor Nimrin	Early Islamic (Umayyad, Abbasid)
13	Kilometer 58	Late Roman, Byzantine
14	Tell edh-Dhahab	Early Bronze, Roman, Mamluk
15	Khursa'a	Early Bronze, Byzantine, Mamluk
16	er-Rashidiyyeh	Early Bronze IV-Middle Bronze I, Iron IA, Iron II, Mamluk, Ottoman
17	er-Rashidiyyeh East	Early Islamic, Mamluk
18	Tell el-Kharrar	Roman, Byzantine
19	es-Sadd el-Gharbi	Neolithic/Chalcolithic, Roman
20	Qabr Afandi	Neolithic/Chalcolithic, Early Bronze IV-Middle Bronze I, Byzantine, Early Islamic, Mamluk
21	el-Mawwaj	Byzantine
22	Tuleilat Ghassul	Neolithic/Chalcolithic
23	Wadi el-Malih	Neolithic/Chalcolithic
24	Ghassul Southeast	Neolithic/Chalcolithic cemetary
25	'Azeimeh Reservoir	Mamluk
26	Mweis North	Early Bronze, Roman, Byzantine
27	Mweis	Early Bronze
28	Maqbaret Sweima	Mamluk, Byzantine, Early Islamic
29	Sweima Camp	Roman, Byzantine

(If there is a single dominant period on a multi-period site, that period is underlined. See Table 3-5 for chronology of periods.)

Source: M. Ibrahim, et al. "The East Jordan Valley Survey, 1975," Bulletin of the American Schools of Oriental Research.

The most serious would be the ploughing and leveling associated with the proposed expansion of cultivation. Of the 29 known sites (Table 6-10), all but one (Site 1) are threatened by the expansion of canal-irrigated lands. Given what has already happened to sites in developed areas of the North and Middle Valley, unless these are in some way protected, all 28 sites in the South Valley will eventually be seriously damaged, and in some cases destroyed, by the proposed Stage II actions.

Four (Sites 4, 5, 6, and 15) are also threatened by the expansion of village development in South Shuneh. Moreover, any further widening of the main road through South Shuneh will cause additional damage to Tell Nimrin (Site 5), the largest and most important site after Ghassul.

Another major adverse impact will come from constructing the 14.5 km extension of the EGMC. As now planned, the extension will cut through or very close to four sites (Sites 2, 22, 26, 27), including Ghassul, the most important in the South Valley.

The Jordanian army, too, is damaging sites. During our field reconnaissance, we found army trenches cut into Sites 11, 16, and 22.

Finally, an indirect adverse impact of the proposed actions might be an increase in site looting. An increase in valley population or an increase in the numbers of low-paid farm laborers may accelerate site robbing. Larger numbers of tourists, too, will create a ready demand for stolen antiquities. Unfortunately, fencing sites to protect them may only exacerbate the problem, for a fence would draw attention to sites whose existence had not previously been widely known.

6.4.1.1.2.4 Beneficial Impacts

Present studies show that the total number of hectares originally planned for irrigation in the East Jordan Valley will be reduced by about 3600 ha. Almost certainly difficulties will arise in

Table 6-10

The East Jordan Valley: Archaeological Sites in the South Valley Area, by Type of Impact

Sites Not Threatened

1

Sites Threatened by Expansion of South Shuneh

4 (fencing)[1]
5 (salvage excavations and fencing)
6 (fencing)
15 (fencing)

Sites Threatened by Expansion of Cultivated Areas

3 (fencing)
7 (fencing, but low priority)
8 (fencing)
9 (fencing)
10 (fencing)
11 (fencing)
12 (fencing)
13 (fencing)
14 (fencing)
16 (fencing)
17 (fencing, but low priority)
18 (fencing)
19 (fencing)
20 (fencing)
23 (fencing)
24 (fencing)
25 (fencing)
28 (fencing)
29 (fencing)

Sites Threatened by Construction of East Ghor Main Canal Extension

2 (reroute the canal to avoid; fencing)
22 (reroute the canal to avoid; fencing; or major salvage excavation)
26 (reroute the canal to avoid; fencing)
27 (reroute the canal to avoid; fencing; or major salvage excavation)

---

[1]Parentheses indicate recommended mitigation.

Source: Arthur D. Little, Inc.

selecting which 3600 ha not to irrigate. The proposed mitigating action of fencing off archaeological sites to protect them might serve the double purpose of providing land that can be taken out of cultivation for a positive, beneficial purpose.

A second beneficial impact could be the development of archaeological sites in the South Valley, and in other parts of the East Jordan Valley, as tourist attractions. (See Section 6.4.1.6.2.) Archaeological sites in Jordan constitute a non-renewable resource. They are the primary resource for the country's present and future tourist industry.

6.4.1.1.3 Other Areas of Impact

Other proposed actions--such as the construction of small diversion canals on the Wadis Yabis, Kufrinja, and Rajib and the construction of a concrete diversion dam below the existing intake to the EGMC--will affect only relatively small ground areas. At present there are no known sites within these proposed construction areas. The proposed changeover to a sprinkler system in the central and northern parts of the East Jordan Valley should not have a significant impact on archaeological sites. However, the types of site destruction from ploughing and leveling anticipated for the South Valley are already occurring at an alarming rate in other developed areas of the Valley, and the fencing program suggested for the South Valley really ought to be applied to the whole Valley from the Yarmouk River to the Dead Sea.

6.4.1.2 People/Lifestyles

6.4.1.2.1 Anthropology

The arable land of the East Jordan Valley between Lake Tiberias and the Dead Sea known as the Ghor was in recent times only sparsely populated. In the 1940's the British declared, "to a large extent the Ghor has been abandoned and is now the resort of fauna of Palestine rather than man." [6-33] Nevertheless, the extreme north of the Ghor held most of the irrigated land in Trans-Jordan. The rest of the Ghor was inhabited by Bedouin tribes. [6-34]

Although much of the Ghor was fertile, it remained undeveloped because villages in the Valley were not defensible and, in the south, lacked water for irrigation. After World War I, the British took control of the region and imposed security by suppressing the Bedouin tribes. The British also began abolishing the old system of communal land ownership within villages used by the Ottomans. Land was surveyed, was registered in the names of individuals, and thereafter could be bought and sold. As part of the registration, Bedouin tribes received large tracts of uncultivated land simply by claiming it. In this way tribal groups (or their leaders) became large landlords, most of the Ghor being divided between the L'Ighzawi in the north and the Adwan in the south.

In 1947, there were only 19 small settlements in the whole length of the Valley. With the exception in Adasiye of a village of Bahais, who were refugees from Iran, the villages were all composed of tribal Arabs, mostly Sunni Muslim with a minority of Christians, who share a similar cultural background.

After 1948, refugees from Palestine transformed the Valley's social and economic geography. The number of settlements in the Ghor increased. [6-35] This growth was interrupted for a time by the 1967 war and its aftermath that turned the Ghor into a battleground.

Many of the East Bankers were recently settled nomads for whom agriculture was a new business. By contrast, the newcomers had been skilled farmers for generations, and organized their villages on different principles. A study of two old Trans-Jordanian villages showed that all settlers were from one tribe, so that everyone in the village was related by blood; tribal solidarity expressed itself through support of fellow tribesmen in disputes, through friendships within the clan rather than outside it, and most importantly, through endogamous marriage patterns. By comparison, the refugee camps were formed

from a much broader base and tended to have a wider social network. [6-35] Another study emphasized that, in addition to having differences in outlooks and skills, the newcomers were immigrants in an area where insider/outsider distinctions are quite strong; their preference for living and dealing with other newcomers is typical of most immigrant groups. [6-36]

These cultural and social differences give individual villages distinct characteristics depending on the origin of their settlers and the degree of importance either group holds in the village. Both groups tend to have large families and close ties to kinsmen, but trying to integrate new settlers in a village of tribal origin that is a social unit is quite a different problem from adding new elements to a village established on a more eclectic basis.

In addition to the two major groups in the Valley, there are also Pakistanis, Egyptians, and Koreans. The Pakistanis are agricultural laborers and sharecroppers. Many came as individuals, but today in the south a number of tent communities are made up of Pakistani families. Because they often do not speak Arabic, are not part of any village, and work for lower wages than Jordanians, local residents regard Pakistanis with contempt; also they are generally ignored in terms of social planning. The Egyptians are recruited in Egypt and flown to Jordan to meet seasonal peak labor demands; they show little interest in settling in Jordan, but intend to profit from the relatively high wages in Jordan and then return to their own villages. Koreans are now working on large construction projects, but are housed in camps and will depart when their contracts end.

The project is not expected to bring any new ethnic groups to the Valley, but a major question about how many Egyptian laborers will continue to come has not yet been answered.

6.4.1.2.2 Socioeconomic Structure

Socioeconomic structure in the East Jordan Valley is based on land ownership and tenure patterns within the agricultural economy. In striking contrast with the rest of Jordan, sharecropping is the most common type of land tenure; moreover, statistics show that the percentage of land being sharecropped has been increasing. (See Table 6-11A.) This has led to a highly stratified social system with landlords at the top, followed by small farmer owners, sharecroppers, with wage laborers at the bottom.

Large landowners form the traditional elite of the Valley population. Many benefited from liberal land grants by the British, and others invested in land when it was cheap. Exact data are not available on ethnic origin of the landowners, but the most widespread belief among Valley residents is that they are mostly of East Bank origin. Absentee landlords are found predominantly in the north where they make up almost half of the landlord class. They generally have more land than owner-operators. Absentee landlords decline in number as one moves south, but the size of holdings grows much larger (Table 6-11B). This reflects the results of JVA's land redistribution conducted in the north. Land was purchased by the government and given to landless farmers, increasing the number of owner-operators and reducing large holdings, but without changing the basic social structure of the region. This occurred in part because many large landowners, not foreseeing how the EGMC would increase the value of their holdings, willingly sold their excess land to the government or refugees. [6-35] Today, landlords are fully aware that even wasteland is potentially valuable. Further land redistribution has not yet been completed. The extension of the EGMC into the new lands will heighten this problem because the southern ghors are most dependent on sharecropping on large holdings.

Table 6-11

Socioeconomic Structure of the East Jordan Valley, 1973

A. Form of Tenancy

	Owner-Operated	Share-Cropped	Cash	Mixed
Jordan (national)	56.3%	11%	0.5%	32.0%
Ghor (1961)	32.5%	39%	1.8%	26.7%
Ghor (1973)	35.9%	47%	2.7%	14.2%

B. Landlord Types

	Absentee		Non-Farmer	Mixed (Owner Rents Excess)		Other
North Ghor	48.5%	55%	14.7%	11.8%	90	25%
Middle Ghor	32.4%	61%	15.5%	5.6%	254	46%
South Ghor	22.2%	100%	14.8%	44.4%	554	14%
		owns more than 30 dunums			average size of land in dunums	

C. Sharecroppers By Origin

	From Valley	Palestine (includes Israeli-Occupied Territory	East Bank
North Ghor	35.6%	57.6%	6.8%
Middle Ghor	46.4%	46.3%	7.3%
South Ghor	26.4%	64.1%	9.4%
Total	37.5%	54.8%	7.7%

D. Ownership Status of Tenants

	Tenant & Owner	Tenant Only
North Ghor	13.7%	86.3%
Middle Ghor	17.1%	82.9%
South Ghor	1.9%	98.1%

Source: Hazelton, Agro-Economic Aspects of Tenancy in the East Jordan Valley, 1975, Amman, Royal Scientific Society.

Owner-operated farms covered 36% of the Valley's arable land in 1973. [6-37] They benefited from land redistribution, credit schemes, and cooperatives. Our interviews found this group the most satisfied by JVA's projects. Controlling only one-third of the land, they do not bridge the wide economic gap between the large landowners and sharecroppers.

Sharecroppers worked 58% of the farmland in 1973 and have shown continued expansion since. [6-37] The expansion of agriculture has resulted not only from EGMC water, but also from an increased supply of sharecroppers. In contrast to most parts of the world, sharecropping in the Valley is highly efficient, as explained below in Section 6.4.1.3.

In part, this is because a large pool of relatively skilled newcomers was available to fuel agricultural expansion. Many of these newcomers, former landowners themselves, found themselves in an economically inferior position because of international politics. They did not come out of a long tradition of feudal dependence, but were innovative and upwardly mobile. They are generally considered to be superior farmers in comparison with East Bank sharecroppers, many of whom are new to agriculture. Their importance can be seen in a breakdown of the sharecropper population by origin (Table 6-11C). In the south. Refugee sharecroppers of Palestinian origin make up almost two-thirds of that population. These sharecroppers are almost entirely landless, with a small percentage owning some land in the north and middle ghors, but with the south having the highest percentage of landless farmers (Table 6-11D). In the southern new lands, the project will have its greatest impact. Problems of tenant farmers, therefore, will be of critical importance to its success.

Agricultural wage laborers hold the lowest economic position. Laborers are often foreigners, Egyptian and Pakistani, who work for lower wages than do Jordanians. Because sharecroppers enjoy both higher social status and important social ties in the Valley, they find competing

with foreign labor demeaning. If the agricultural system changes more toward wage labor, a labor shortage could follow that would make the Valley's development increasingly dependent on foreign labor for jobs which Jordanians will reject.

Increased agricultural productivity is creating a new non-agricultural class of people, such as small traders, teachers, government workers, and truck drivers who are likely to play a growing role in the Valley's society, which has previously been dominated by landlord-tenant relations and tribal affiliation. Little social research has been done on the impact these middle-class groups will have on the Valley.

Land redistribution has had very little effect in changing the socio-economic structure. Moveover, it seems unlikely that the law as presently written and implemented will change the basic social structure in the new land area, as explained below in Section 6.4.1.3.

The foundation of agricultural development will still be sharecropping. At present, land redistribution has benefited only small owners, except for the first redistribution in the north. Although sound economic arguments can be made that the sharecropping system is efficient, questions of equity and expectations arise. Indeed, the very success of redistribution in the north seems to have heightened expectations in the south, which are beyond JVA's control, and made the program there more difficult. If little or no land is to go to landless sharecroppers, many sharecroppers may feel unsatisfied if they are under the impression that the new water will automatically bring them land. No matter how fairly the law is written on paper, sharecroppers who are denied land for whatever reasons are likely to interpret the government's actions as discriminating against newcomers, who comprise two-thirds of the sharecroppers. Since land redistribution always carries political overtones, the outcomes likely to result from present policies should be analyzed carefully.

6.4.1.2.3 Population and Labor Force

6.4.1.2.3.1 Economic Conditions in the Valley

6.4.1.2.3.1.1 Population Growth and Distribution

Population has fluctuated widely over the last 30 years due to political events. Prior to 1948, the population of the Valley was only about 13,000 persons most of them living in North Shuneh and South Shuneh. With the political events of 1948 to 1952, a number of new settlements were set up by Palestinian refugees. In the early 1950's the total population in those settlements was about 30,000, but this number swelled to about 60,000 with the production of the irrigated land made possible by the construction of the EGMC and has been estimated to have been about 90,000 just prior to the 1967 war. A 1973 survey [6-38] recorded 64,012 people residing in the Valley; preliminary results of the 1979 census population indicate 80,000. Thus the Valley, which contains only 3.5% of the East Bank's total population, has been growing more slowly than that of other areas.

Valley residents are concentrated in 78 villages and municipalities running from the Yarmouk River in the North to the Dead Sea in the South. Villages vary in size from about 300 to 4000 persons; municipal status is granted only to incorporated areas of over 5000 residents. Four municipalities contain over one third of the Valley population; the largest in 1973 was North Shuneh with about 7700.

The East Jordan Valley is divided into three main sub-areas. These are used throughout the report. They are:

1. The Northern area - from Yarmouk River in the north to Wadi Qarin (south of Wadi Yabis) in the south.
2. The Central area - from Wadi Qarin in the north to south of Karamah village in the south.
3. The Southern area - from south of Karamah village in the north to the Dead Sea in the south.

In 1973, 85% of the Valley's population had located in the Northern and Central portion of the Valley in which lands partially irrigated by

water from a combination of the EGMC and wadis supported a larger population.

6.4.1.2.3.1.2 Population and Labor Force Characteristics

6.4.1.2.3.1.2.1 Population Characteristics

The Valley's population characteristics differ only slightly from those of the country as a whole, but the characteristics of its predominantly agrarian labor force differ significantly. Although fertility rates are somewhat lower in the Valley than the combined areas of the East Bank, the age structure is still marked by a very high ratio (50%) of persons 15 years or under.

Adult literacy rates in the Valley are about half those of the national rate. As indicated in Section 3.4.3.3.1, Jordan's adult literacy rate is one of the highest in the Mideast: almost two-thirds of Jordan's adults are literate. In contrast, only one-third of Valley adults are literate. Literacy rates increase rapidly with younger age groups, and given the national policy of universal education, the literacy rate of the Valley will parallel that of the East Bank in another generation. This will occur independently of the proposed project. Although the literacy rate of the Valley is low compared to that of the country, it is still high for the rural sector of a developing country. As indicated in Section 3.4.3.3.2, the level of modernization in Jordan's rural areas as measured by other social indices is high.

6.4.1.2.3.1.2.2 Labor Force Characteristics

The Valley differs significantly from the East Bank in labor force participation, female participation in the labor force, and percent engaged in agriculture, as shown in Table 6-12. Although the Valley comprises only 3.5 percent of the East Bank's total population, it comprises roughly 5.5 percent of the country's labor force.

Table 6-12

East Bank and Valley Labor Force Characteristics

(Percent)

	East Bank	East Jordan Valley
Population Participating in Labor Force	20	30
Female Labor Force Participation	4[1]	18
Participation in Agriculture	19	82

[1] Unofficial estimates of the 1979 female labor force participation are about 12%.

Source: Social and Economic Survey of the East Jordan Valley, Department of Statistics, 1973, and Multi-purpose Household Survey.

The greater labor force participation of the Valley vis-à-vis the East Bank is due primarily to females. Female labor comprises one-third of the Valley's Jordanian labor force. In 1973 over 96% of these women worked in agriculture. The role of women is discussed more fully in Section 6.4.1.2.4. Service occupations in the Valley accounted for only 12% of the employed population.

Agriculture in the Valley is practiced primarily on units of from 10 to 100 dunums, as indicated in an Arthur D. Little, Inc. survey of over 30 farmers. Ten dunums is usually considered an inefficient economic unit, and units of this size are discouraged under JVA's land distribution program. The typical Valley farm unit is farmed by an owner or sharecropper with the assistance of family and temporary paid laborer. In over 30 farming units surveyed, only one employed Jordanian males. Temporary paid labor was split between female and foreign labor. Foreign labor is predominantly Egyptian. Given a staggered planting and harvesting schedule, foreign labor moves from village to village. Land operators said Egyptians left the Valley only in June and July. Interviews indicated that female labor is not itinerant; women work in the same or nearby village in which they live. Unpaid family female laborers tend to be wives or daughters of sharecroppers. Women who work as temporary paid laborers tend to be either widows of the 1948 or 1967 wars, not yet married or wives of poor, landless men.

In contrast to Jordan as a whole, sharecropping rather than owner-operation is the dominant form of Valley tenancy.

According to the 1973 survey of the Valley, the the labor force was 19,495, of which 15,734 were engaged in agriculture. This survey covered only Jordanians living in the Valley, and did not include the foreign labor which makes a substantial contribution to the labor force. According to the 1975 agricultural census, 38,600 persons were engaged in agriculture within the Valley. Over half of these were occasional or seasonal workers as is shown in Table 6-13. Based upon the survey

Table 6-13

Number of Agricultural Workers in
The East Jordan Valley--1975

Permanent Workers	Male	Female	Total	Percent of Total Workers
Paid	1,272	135	1,407	
Unpaid	7.615	4,615	12,230	
			(13,637)	35.3
Temporary Workers				
Paid	3,855	540	4,395	
Unpaid	160	380	540	
			(4,935	12.8
Occasional Workers				
Paid	15,240	4,290	19,530	
Unpaid	160	336	496	51.9
			(20,026)	
	28,302	10,296	38,598	100.0

Source: Department of Statistics, Agricultural Census, 1975.

and field work conducted by other research teams, it can be assumed that most paid male temporary workers and nearly all paid occasional workers are foreigners. Although classified as non-permanent workers, they can find employment almost year round because of shifting crop planting and harvesting. Valley farmers reported that the Egyptians work in the Valley all year except June and July.

Permanent labor for both males and females is largely unpaid, indicating that they are predominantly husband-wife landowner or sharecropper teams. Temporary labor comprises a relatively small percentage of the total labor force. In summary, the present agricultural labor force is characterized by landowners or sharecroppers who hire on a temporary or occasional basis large numbers of women and foreigners to fill peak labor demands which occur during planting and harvesting.

6.4.1.2.3.2 Project Impacts

The future size and characteristics of the Valley's population will depend primarily upon the nature of agricultural labor procurement. Current labor supply is matched against future labor requirements in Table 6-14.

According to the table the number of jobs in Valley at full development will range from 27,300 to 31,700. Worker requirements will depend upon the diversion of water to M&I use and the rate of agricultural mechanization. Harza labor requirements are lower than those of the JVA because they assume higher levels of agricultural mechanization. Both JVA and Harza estimates are based upon full-time, permanent agricultural labor which does not now exist in the Valley and which may not be consistent with socio-economic trends. These assumptions and countervailing forces are displayed in Table 6-15.

The net job increase resulting from the proposed project is in the range of 3500 to 8100 jobs. These jobs are shown in Table 6-16. Most new jobs will be farm operations and non-farm jobs in commerce, services and

Table 6-14

Present Supply and Estimated Future Valley Labor Requirements
(persons)

	Present Labor Supply	JVA Requirements		Harza Requirements	
		36,000 ha Irrigated	32,400 ha Irrigated	36,000 ha Irrigated	32,400 ha Irrigated
Farm Operator (Permanent unpaid male workers)	7,615[2]	12,000	10,800	9,660	8,690
Unpaid Family Laborers	5,651[3]	9,000[4]	8,100	7,245	6,520
Agricultural Laborers (full-time)	1,407	7,200	6,480	7,465	6,720
Non-Agricultural Workers	3,800	7,000	6,300	6,000	5,400
Full-Time Valley Workers	18,473	35,200	31,680	30,370	27,330
Agricultural Laborers (part-time)	23,925				
	42,398				

[1]Estimated labor requirements for 32,400 ha is based on direct ratio of requirements for 36,000 ha.

[2]Only permanent unpaid male workers are considered to be general farmers. Although female ownership of land can be found in the Valley, it is atypical.

[3]Assumes unpaid labor is family labor.

[4]Assumes family labor requirement is equivalent to 25% of full farm operator/year per holding. Family labor is assumed to work one-third time.

Source: Arthur D. Little, Inc., estimates based upon Department of Statistics, Agricultural Census, 1975; Social and Economic Survey of the East Jordan Valley, 1973; Harza Report, Feasibility Study, Stage II, January 1978, Appendix G - Agricultural Development.

Table 6-15

Labor Force Assumptions
And Countervailing Trends

Assumption	Countervailing Trends
Harza does not recommend share-cropping on the basis that new holdings will not support both a landowner and a share-cropper.	Land reform programs have not had a substantial impact to date on land holding patterns. No new landowners are expected to be created with the extension of irrigation to the southern portion of the Valley.
Unpaid female family labor will continue to make a substantial contribution to the agricultural labor force.	As female education rises, participation in agriculture declines. As incomes rise even illiterate women do not work in the fields for reasons of status.
Non-farm operator agricultural labor will become permanent over time.	Permanent paid agricultural workers currently comprise less than 4% of all agricultural workers. Agricultural wage rates are less than the Jordanian minimum wage and Valley labor has for the most part sought opportunity elsewhere leaving foreigners to make up the labor force.
Young people will seek agricultural occupations including that of a share-cropper.	Societal and personal expectations may be in conflict with the need to provide adequate agricultural labor force. Arthur D. Little's survey of over 60 Valley households, not even a single parent aspired for a son to become a farmer or a daughter to marry one. Moreover, these parents view the education now provided to all Valley children as preparation not for farming but such service occupations as teaching, nursing or government work.

Source: Arthur D. Little, Inc.

Table 6-16

Net Job Increase Resulting
From the Proposed Project
(persons)

	Low Estimate	High Estimate
	Harza Estimate with 32,400 ha Under Irrigation	JVA Estimate with 32,400 ha Under Irrigation
Farm Operator	1,075	3,185
Unpaid Family Labor[1]	869	2,449
Paid Agricultural Workers	0	0
Commercial Service and Administrative	1,600	2,500
	3,544	8,134

[1]Family labor works only one-third time.

Source: Arthur D. Little, Inc., estimates.

administration. There is no net increase in paid agricultural workers. Harza and JVA project about 5000 full-time equivalent agricultural laborers will be required. Arthur D. Little, Inc., estimates assume that the current labor supply of over 24,000 paid non-permanent workers will more than meet future labor requirements. Moreover, it is assumed that the supply of agricultural workers is very elastic. If additional labor is required, it can be supplied by foreign labor sources.

At present, temporary and occasional labor is about 25% female and 75% male; the latter is assumed to be predominantly foreign. Overtime requirements for foreign labor may increase as female labor participation declines. Although educated women are more likely to participate in the labor force than non-educated or poorly educated women, the 1973 Valley survey indicated that women who have a low level of education and therefore find it difficult to obtain jobs outside of agricultural activity refrain from working as temporary paid laborers unless they are forced to do so because they are widows, single, or are members of a very low-income family. This was confirmed in interviews with Valley women. Women throughout the Valley expressed interest in skill development and occupations other than agriculture. Moreover, many of the wives of even small landowners indicated that they did not work in the fields. In contrast the wives of sharecroppers tended to work alongside their husbands. As incomes in the Valley rise it can be expected that increased social status will inhibit widespread female participation in the agriculture labor force.

A continued supply of foreign labor may not be compatible with JVA and Harza assumptions, but there seems to be no ready source of Jordanian male labor to fill the agricultural labor requirement. Agricultural wage rates do not compare favorably with other occupational wage rates, although many sharecroppers work for more than one farm and thereby obtain incomes competitive with other fields. In the Arthur D. Little, Inc., field survey conducted in the spring of 1979, farm operators were

paying male laborers 2 JD per day. In contrast, construction workers were earning two to three times this amount four years ago and probably considerably more at present. [6-39] Male workers abroad, of course, earn substantially more than 4 to 6 JD per day. Farm operators said the availability of cheap foreign labor depressed Jordanian male labor rates.

Given an extremely low unemployment rate within the country and the low agricultural wage, it is unlikely that Jordanian men now employed in other occupations in Jordan and abroad would voluntarily return to the Valley to be paid one-half or one-third of what they are now earning.

Given the increase in service and administrative jobs, the skill and educational requirements of the Valley labor force will increase. Based upon current trends, it is likely that a high number of these jobs will be filled by Valley children now attending school. Movement into service occupations such as teachers, nurses and doctors is consistent with parental expectations provided in the Arthur D. Little, Inc. survey. A substantial number of male and female teachers interviewed were from the same or a neighboring village in which they were raised. Hence, the Valley program will provide employment opportunities for these young people.

The proposed project will not however have a substantial impact on the country's high urbanization rate. Service and administrative jobs created may hold some young people in the Valley, but the number of jobs created will not be sufficient to have a substantial impact on the rural exodus to upland cities.

Net job increases associated with the project will result in population increases of from 10,700 to 24,700. These population estimates assume that one-half of the new project-related jobs will be filled by current Valley residents. Population estimates are based upon a family size of 6.1 and assume only one wage worker per household unit.[1] The low estimate is consideraly lower than JVA and Harza estimates. If over the next generation female participation in non-agricultural employment substantially increases resulting in two paid workers per household, population increases will be less than those shown in Table 6-17.

The proposed project will distribute the Valley's population more evenly. As new lands are irrigated and new villages are built in the South Valley, its population will rise from 16% to 34% of total Valley population. In the North Valley, already partially irrigated, population will grow only modestly, and by 1990 constitute only a little over 25% of the Valley's total. The size of most villages will increase by one- to two-thirds and become eligible to apply for municipal status; however, a special governorate or regional council may be established for the Valley and change the powers ordinarily granted to village councils and municipalities.

6.4.1.2.4 Role of Women in the Valley's Development

6.4.1.2.4.1 Existing Conditions

Women play a critical role in the Valley's economy and development. They constitute one third of its labor force and are essential to planting and harvesting its vegetable crops. Women work both as family members and as paid laborers. Female participation in the agricultural labor force is correlated with poverty. Arthur D. Little, Inc., interviews with more than 40 Valley females showed that paid women laborers were predominantly widows, single, or members of very poor families by village standards.

[1]Unpaid family labor is not assumed to result in the creation of a household unit.

Table 6-17

Future Valley Population--1990
(persons)

	Low Estimate	High Estimate
1979 Estimated Population	80,000	80,000
Natural Population Given An Increase of 2%/year	19,500	19,500
Project-Related Population[1]	10,700[2]	24,700
Total	110,200	124,200

[1]Assumes one-half of non-agricultural jobs will be filled by current Valley residents. Family labor does not result in Valley population increase. Project population based upon family size of 6.1 Under low estimate, 1035 project-related jobs created; under high estimate, 6000 jobs created.

[2]Estimate based upon labor requirements for 32,400 ha irrigated.

Source: Arthur D. Little, Inc., estimates.

The low economic status is reinforced by the wage structure which pays women at only half the rates of males, including foreign males; for four hours of work a female is paid JD 1 or roughly $3.40, while a male doing the same work for four hours receives JD 2 or $6.80. This discrepancy is justified by such comments as: "men work harder than women," and "men's work is harder than that of women." Assuming that a woman is the only wage earner in her household, as happens often when children attend school, her annual income, including some overtime, would probably total about $680. If she supports a family of three, herself plus two children, their per capita income is only $226, considerably lower than Jordan's national average of $610.

In addition, rural women care for each family's domestic animals--cows, goats, and chickens. However, the most onerous responsibility of most rural women, of both high and low income is carrying the family's domestic water, typically about ½ to 1½ miles each day from a public well or tap or the EGMC to their homes. The piping of water is almost non-existent in the Valley, although planned for all houses.

Nearly all women interviewed stated their desire to limit their family's size. However, their efforts have been hampered to date by lack of clinics and clinic female staff. Psychological and bureaucratic factors also hamper women in limiting family size, a requirement if the benefits of development programs are not to be cancelled by rapid population growth. According to the former Head of the Department of Women's Affairs within the Ministry of Labor, women lack financial security. Even women agricultural workers cannot attain financial security because they are not covered by the social security system which is available only to agricultural workers who work with machines. Handling of machines and equipment is considered man's work. Hence, a woman's only financial security is to bear additional children who will eventually become wage earners. Current economic opportunities in the Valley are limited. Although agricultural work is available, for reasons of social status women prefer not to work in the fields except with their

families. Moreover, the work available to females is repetitive and unchallenging. The more challenging tasks of decision-making, marketing, and equipment handling are considered man's work. Training in such tasks is not offered to women, and neither the JVA, the JVFA, or the Ministry of Agriculture seems to have plans to train women to take advantage of increased technology or mechanization.

Although these East Jordan Valley women are energetic and vital, they expressed boredom with their lives. The level of modernization in rural Jordan is high as measured by exposure to the outside world, urban-rural linkages, and attitudes toward change. The constricting lives of rural women is manifested throughout the Third World by the migration of young women to urban centers at an even higher rate than that of young men. It is likely that an out-migration of educated Valley women will occur over the next generation. Both mothers and daughters interviewed aspire to achieve high educational levels and to qualify for occupations such as teachers and nurses.

6.4.1.2.4.2 Impact of Proposed Project on Women's Role

Stage II impacts on women will be moderate. As the result of piped water and exclusion of domestic animals from new housing areas, their domestic burden will be lightened. Economic opportunities will continue as family and temporary paid laborers in agricultural production; but there is no indication either that women will be paid equally with men or that their wages will substantially increase. While more service jobs will become available through health and social programs, Valley women will be unable to compete successfully for these positions because of their limited educations.

Greater communication with urban areas made possible by the spread of electricity, radios and television are likely to increase the frustrations of rural women as they compare their lives, perhaps unrealistically, with opportunities for self-development outside the Valley. Community

center programs may mitigate the restlessness of Valley women to some extent. These programs planned by the Ministries of Labor and Education will include nutrition, child care, sewing, and in some cases adult literacy. While they may fill social needs of rural women, they will not enable women either to improve their skills or increase their participation in Valley development programs. Indeed, increased mechanization will likely reduce demand for unskilled agricultural labor provided by women and thus the economic contribution they are making today.

6.4.1.3 Village Development

6.4.1.3.1 Existing Conditions

The villages in the East Jordan Valley consist of a series of small to medium sized settlements of mud huts (of one and two rooms), small cement-block structures (mostly "hand made" by the indigenous population), and occasional tents. These settlements are scattered along the Dead Sea-Yarmouk Road, on the hillsides sloping up from the Ghor lands, or on patches of land among the planted fields in the Valley. The villages range in size from about 300 people up to 10,000-12,000 (as of the 1978 official survey). In the early 1970's there were some 50 to 60 recognizable settlements along the 100 km long valley from the Yarmouk River in the north to the northern edge of the Dead Sea in the south.

As of 1973, the settlements were collectively estimated to have about 65,000 people and in 1978, 80,000 mostly in farm families. (See Section 6.4.1.2.3.)

The settlements, which are most often occupied by families from the same or related tribes, began to take on some identity during the 1950's. Most settlements had a "name" that was known to the local inhabitants. Very often settlements that looked to be physically related were two or more separately named villages, depending on the tribal occupancy.

For the most part these settlements were established on land that was owned either by the government, by Jordanian tribes that had been traditional occupants and/or occasionally by the "traditional" families of Jordan--many of whom were merchants and other professional people who lived in the major urban centers in the upland areas--Amman, Salt, Jerash and Irbid.

In the early 1970's the living amenities in most of the settlements were minimal. There was no common supply of electricity, nor easily accessible potable water. There were few paved streets and no basic sanitary facilities. Most school and health facilties were of minimal standards, usually a few rooms in a cement block structure with little equipment and inadequate staffing. Neither the school facilities nor the programs were conducive to providing basic educational skills for the school-aged population--which is roughly half of the total population. There were few, if any, community or administrative facilities, or facilities and programs for either curative or preventive health.

The houses were basically small, one- or two-room structures of mud or cement block construction with small windows. The structures were designed to protect the inhabitants from the sweltering heat. The structures were often surrounded by walls to provide enclosed outside space used to keep the family's animals and store possessions. Many of the shelters were tents. The family life of the village tended to take place outside the shelters in early morning and late afternoon and inside during the heat of the midday sun and at night.

Domestic water usually had to be transported by the women from common village rainwater cisterns, from stations along the main road where trucked water could be purchased, from springs, or from the irrigation canal (unauthorized). Domestic garbage was usually disposed of by small animals, goats, donkeys, and chickens which habitually live in or adjacent to the family living areas. Human wastes were disposed of in holes dug in front of the house and animal wastes in the usual way.

The vast majority of the people living in the settlements worked the farm land--the men tending fields and cultivating, the women and children in planting and harvesting. School hours have been traditionally set up to allow children to help in the fields when necessary.

6.4.1.3.2 The Village Development Plan

6.4.1.3.2.1 Objectives

In 1971, inspired by the call in Jordan's Three Year Plan for improvement in the living conditions in the villages plus the plans for expanding the irrigation system and increasing agricultural production in the Valley, an extensive process was undertaken to analyze village conditions and develop a program for their improvement. Aided by a 1973 survey of the Valley population [6-38] and by information about the expansion of agricultural land as a result of new irrigation processes, the town planning firm of Planning and Development Collaborative International (PADCO) prepared a separate site plan for each of the 36 villages; however, JVA is now concentrating its efforts on only 32 villages.

Since these site plans set the basis for the major capital facilities investments and the development system for the villages, it is important to analyze the basic conclusions and recommendations of the Plan in order to judge the impacts on the human environment of the improvement programs being carried out in the Valley. The following are the key structural elements and principles of these village plans:

- The driving force behind the plans is the demand for manpower needed to operate the agricultural economy, assuming that land reform and more irrigation will cause a modest growth in farm households and a substantial increase in non-farm but agriculturally related households. It was also assumed that the average household size would increase from its 1973 level of 5.7 to a level of 6.1 persons, more like the

national average in the years ahead. These factors created an estimated design population of about 150,000, or about 80,000 to 90,000 increase over the 1973 levels.

- A major objective of the plans was to prevent village development on good agricultural land. A second related objective was to cluster village development in areas where enough population could be housed to justify reasonable levels of convenient community facilities and services.

- There were three basic principles that governed the siting of villages: first, to provide convenient access to the fields, the main highway and secondary roads; second, to provide convenient access to water and other utilities; and third, to avoid areas that would present difficult building and service problems -- slopes of hills and wadis, for example.

This resulted in a program for the development of "villages" along the 100 km length of the Valley. In some cases two or three of the smaller contiguous villages were combined into one to increase the population that could be served. In others, existing small or badly located village settlements were not included in the plan since serving them would be difficult, require high investment per capita, or would encroach on agricultural land.

6.4.1.3.2.2 Village Types

The villages are of four basic types:

1) Larger villages with well-established commercial and administrative functions.

There are four of these "villages,"[1] three in the northern part of the Valley and one in the south. In addition to having larger populations -- about 8000 - 12,000 currently, these villages are characterized by a higher proportion of relatively substantial houses and commercial buildings than the smaller villages, even though the preponderance of housing is mud brick and cement block houses. About 40% of the Valley's current population live in these villages, which have collectively about 20% of the vacant buildable land included in the village boundaries. Two of these villages have been established entities for a long period of time. Much of the land in them is privately owned. Two others developed quickly on government owned land after the outbreaks in 1948 and 1967.

2) Medium Sized Villages

There are 15 villages[2] ranging in size from between 1000 to 4000 persons, most of whom moved in after 1948. These villages consist primarily of mud brick and some cement block housing and are built on land owned by the government (in the Katar, or land not suitable for irrigation). Collectively,

[1]North Shuneh, Mashara, Kreiymeh, and South Shuneh.

[2]Karama was once a village of size and importance of the first category of villages, but was virtually destroyed by Israeli raids in the late 1960's and has not yet grown back to its previous size.

these settlements contain about 40% of the Valley current population and about 42% of the village land available for expansion.. Five of these villages are located in the north, seven in the central Valley, and three in the south.

3) Small "Bedouin" Villages

There are five villages, all in the north and central parts of the Valley, which were not settled primarily by newcomers but by people coming from the Jordanian uplands. These villages are usually quite small--three of the five have less than 500 people, and two others have about 2000. The land these villages occupy has been owned by the occupying tribes for some years. At present, these villages contain only 7% of the Valley's population and only 5% of the new land that can be used for village expansion.

4) New Villages

There are seven sites,[1] five of them in the south, which have been designated as areas where new villages can be built on suitable land. At least three and probably four are earmarked for the relocation of people who now live in settlements in agricultural land or have not been designated for future improvement. About 35% of all the new land available in villages are in these settlement areas, 80% of which are in the south.

[1]There are two or three other sites that could be added to this category, if needed.

These four categories of villages account for between 85% to 90% of the Valley's current population. The rest of the 10% to 15% is scattered in smaller villages in the agricultural area, in individual farm houses and tents, or in settlements not "recognized" as villages.

The geographical distribution of these villages is important. Twelve of the villages are in the north--the 50 km section of the Valley that has been under irrigation for quite some time and is thus more "settled" than the central and southern areas. Three of the four larger villages, five of the fifteen medium villages,[1] three of the five small villages, and only one of the new sites is located in the north. The existing settlements are spread relatively evenly at 5 to 7 km distance along the northern section of the Valley.

The central area consists of ten villages; seven of which are medium villages, two small villages, and one new site, all clustered within a 10 km section of the Valley known as the Zarqa Triangle--a flat valley where the Zarqa River joins the Jordan Valley. The Zarqa Triangle contains much newly irrigated agricultural land brought into existence by the development of irrigation related to the King Talal Dam. In the six years since the census of 1973, collectively these villages have grown in population by about 30%. As a result, a new municipality[2] has been incorporated from the three villages that form the center of the Zarqa Triangle region.

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[1]Note that a number of these are village areas consisting of more than one settlement.

[2]Deir 'Alla--which includes Eddbab and Swahla as well--was recognized as a new municipality recently; it is also headquarters of Deir 'Alla Sub-district in Balqa Governorate.

The southern valley consists of two quite different segments. The first is the area about 40 km long which has lands not yet under irrigation but will be irrigated by the extensions to the EGMC. In this area there are only two new village sites, and one larger existing refugee village (Karama), along with some smaller settlements not designated for improvement. The two new sites are designed to absorb the population of these undesignated settlements.

In the 15 km stretch between South Shuneh and the Dead Sea, there are six villages arranged not only along the north-south road but along the two major east-west roads in the area as well. South Shuneh is a major center, two of the other villages are refugee settlements, and three are new sites. Part of this area has been irrigated by local dam projects rather than the EGMC. The four populated villages in the south have collectively grown by over 30% since 1973. Most significantly, the southern villages contain over half of all the village land available for new development.

6.4.1.3.2.3 Village Plans

For each of the villages, the site plan:

- Established the boundaries of the village;
- Laid out a network of streets and other public ways;
- Established sites for educational, health, commercial, religious, government, and other facilities;
- Established plots for home sites of a standard 12 m x 24 m size which include areas with buildings already constructed in most instances; and
- Identified unbuildable areas.

Within each of the village boundaries, a variety of different patterns are found regarding the amount of land already occupied, the location of the occupied land relative to the vacant land, the "tightness" or "looseness" of the existing settlements in the areas already occupied, and the quality and type of topography of the vacant area.

6.4.1.3.2.4 Reallocation of Village Land

The site plans have now been prepared for all of the villages, and in the villages in which development activities are taking place, they have been used as the basis for siting of facilities and the allocation of land for housing. The significant feature of the site plans is that they are the basis for reallocation of village lands for housing and other purposes. Article 23 of the Jordan Valley Development Law[1] establishes the formula through which village land, all of which is expropriated to the JVA by the law, is redistributed. In part, it provides that:

- The (Jordan Valley) Authority shall have the power to improve and develop to the extent it sees fit the lands expropriated for housing purposes located within town and village boundaries approved by the Authority. The Authority shall divide those lands into housing plots the minimum area of which is not to be less than 250 m^2, and the maximum not to exceed 300 m^2. (The President of the Authority, with Board approval may exceed the upper limit of housing plots if the public interest so requires.)
- The following lands within town and village boundaries are expropriated without compensation:
  - -- No part of any holder's expropriated land whose area does not exceed 288 m^2.
  - -- All the land in excess of 288 m^2 from holders whose expropriated land does not exceed 384 m^2.
  - -- 25% of the area in excess of 384 m^2 from holders whose expropriated land area is larger than 384 m^2.
- The Authority shall allocate housing plots to the holders whose land it expropriated on the following basis:
  - -- One housing plot for holders whose expropriated land does not exceed 288 m^2 (after the deduction for excess land taken without compensation).

[1]Temporary Law No. (18) for the Year 1977 - May 16, 1977 - Official Gazette #2700.

-- For holders with larger parcels, the number of housing plots a holder is able to put into 288 m^2 segements on the land remaining after the free taking.

- For holders who have excess land after multiplying the housing lot size by the number of his family members (i.e., for a holder with six family members for example, this would be 1728 m^2), the following allocation applies:
  -- Housing plots equal to the number of his family members if his net land in square meters is less than double the number resulting from multiplying the lot size by number of family members. (A holder with six family members and 2000 m^2 could have six housing plots on 1788 m^2, for example.)
  -- Housing plots equal to twice the number of his family members if his net holdings are between two and three times the number of his family members. (The holder with six family members and 4000 m^2, for example, could have 12 housing plots or 3456 m^2.)
  -- Housing plots equal to three times the number of his family members if his net holdings are between three and four times the number of his family members. (The holder with six family members and 6000 m^2 could have 18 housing plots on 5184 m^2.)
  -- Housing plots equal to four times the number of his family members if his net holdings are more than four times the number of family members. (The holder with six family members and 12,000 m^2 would have 24 housing plots on 6912 m^2.)

The purpose of the reallocation formula is much the same as that applied to agricultural land in the Valley--the village land that is "improved" through government action is to be allocated first to current holders (owners) of village land on the basis of size of current holdings (i.e., a measure of commitment to the Valley's agricultural development) and to

present and future need--for passing on land to the next generations in proportion to the size of the current owner's holdings. Owners with a housing lot below the minimum size will not be able to improve his land--build a new house--without acquiring a standard parcel. Owners with large holdings that are in excess of family "needs" will have excess land expropriated with compensation to be determined by a Committee established by the JVA.

6.4.1.3.3 The Village Development Program

In 1975, the JVA began executing the village site plans, prepared with the help of loans from U.S. AID. The implementation program consists of six parts, discussed below.

6.4.1.3.3.1 The Replatting[1] and Allocation of Land Within the Village Boundaries

Based on the village plans, surveys and property maps showing street, public places, and building lots are being drawn for each of the designated villages.[2] Once these property maps are drawn, building parcels will be allocated to holders of land in accordance with the formula outlined in the law of 1977. Houses which exist on properly sized and allocated lots will then be able to receive direct water and electric power from the facilities being constructed in the mapped streets. The replatting also provides the basis for locating streets, which are then graded and topped with a temporary surface. Holders of land entitled to building lots will be able to build or rebuild houses on these lots in accordance with a

[1]Platting is laying out of lots on the ground by determining the location of property lines and boundaries.

[2]This process is also being applied to two or three settlements that were not originally included in the JVA plan, but have been subsequently recognized.

building code which sets construction and facility standards for each house.[1] When the village plans were originally accepted by JVA, a ban was placed on all reconstruction activities that did not conform to the plan. At present, only two villages have gone through the complete replatting and land allocation process. Since the replatting program applies to those parts of the designated villages which are already built up with houses of various sizes, shapes, and conditions as well as to vacant areas, this process is expected to be long and complicated. Since the objective of the replatting program is to provide a system for the orderly provisions of utilities to each site, as well as to allocate lots of serviceable size to villagers, flexibility is being applied in the actual plot design and allocation.

6.4.1.3.3.2 Housing Program

While the major tenet of the Development Plan is for villages to provide their own standard housing on allocated plots, a decision was made in 1975 to provide some housing under JVA auspices both because of the delay that was going to be experienced in replatting and because individual villages were having difficulty in constructing new houses with their own financial and technical resources. The current housing program has three components:

1) The provision of 300 units of three-bedroom 90 m^2 housing in five villages to house the teachers, health technicians, utilities, and other government workers needed to operate the existing and new infrastructure in the Valley. These units will be leased by JVA to appropriate ministries which will assign appropriate staff to the facilities.

[1]While this code sets fairly rigid standards for construction and utilities provision, existing or new houses that do not meet these standards have been allowed to take advantage of new water and electrical services.

2) The construction of 2100 units of two-bedroom 60 m^2 housing in 21 villages with 50 to 150 units in new village lands to provide new housing for "eligible candidates" (see below). While both the 60 m^2 and 90 m^2 housing were planned for the 12mx24m plots, it was decided in the later stages of the construction program for the 2100 units to provide a housing unit only on every second plot, thus doubling the effective lot area per house.

3) A mortgage loan program through which a pool of $4 million was established to provide low cost mortgages so that "eligible candidates" could either purchase houses built under the 2100 unit program or build their own houses. Those eligible for the program include, as first priority, those persons whose skills are regarded as critical to the success of the overall development effort, i.e., agricultural workers, farmers who own land but left the Valley for various reasons, and individuals assigned to the Valley to staff new irrigation and social support services. As a second priority, current Valley residents now living in substandard housing are also eligible. To implement this policy, 70% of the $4 million loan funds is to be made available to farm workers, sharecroppers, tenant farmers, owners of a single farm unit (three ha) or less, or employed persons earning JD 70 per month or less. The remaining 30% of the funds are to be allocated to other eligible candidates, expected to be school teachers, health technicians, and other professionals and service workers required to operate facilities in the Valley. All borrowers are required to own the lot on which the house is built--i.e., to have been allocated a lot by JVA. The maximum loan allowed is JD 2500 (the 2100 unit houses cost about JD 3000 per unit), and applicants are required to make a down payment of 30%, plus an application fee of JD 50 plus a JD 10 payment each

month until the house is ready. In addition to house purchase, a loan may be secured under this program for improving an existing home, provided the applicant agrees to provide a percolation pit if no sanitary facilities are available in the home.

As of April 1979, most of the 300 units have been constructed, but not yet occupied pending allocation to various ministries, about half of the 2100 units have been in construction but none yet completed, and over 2500 applications for mortgage funds received but no funds yet allocated pending review of eligibility and credit worthiness by JVA and the Housing Bank, respectively.

6.4.1.3.3.3 Education

A very high priority has been put on the construction of schools in the Village Development Program. With just about half the population of the Valley consisting of children of school age, and with a high level of illiteracy, improved education has been considered one of the most important aspects of improving living conditions in the Valley. To this end the Development Plan called for adequate classrooms to be provided in each of the designated villages according to the population capacity estimated for each. A review of the school facility situation in 1975 revealed that there existed 273 standard classrooms in only 17 of the 36 designated villages -- at 35 students per room, this would provide capacity for just under 10,000 students, while the number of potential students was at least double this amount. The plan calls for each designated village to have at least one boys' and one girls' elementary school, except in the very smallest villages where capacity would be available in the schools of nearby villages. Preparatory schools (the equivalent of junior high schools where attendance is obligatory) were to be combined with secondary schools (high schools-- attendance not obligatory) where possible, except in villages where no secondary schools are planned. This meant that 10 of the larger villages would be selected for location of secondary schools. As a result, a

Phase I program was designed to construct 26 schools with a total capacity of 392 rooms, 300 of them classrooms and the rest offices, libraries, laboratories, craft and exercise rooms in 14 different villages. As of April 1979, construction of most of these new schools has been completed, many were in full operation, and some were awaiting the arrival of laboratory, physical education, and other equipment including in the Phase I program. In the Phase II program now being planned, an additional 23 new schools will be built in 14 villages.

The staffing of the schools is the responsibility of the Ministry of Education which takes over the school buildings once constructed by JVA. Teachers are assigned by the Ministry which apparently has no problems in providing adequate teaching staff for Valley schools, particularly since new housing is now becoming available for teachers. About 128 new teachers--men and women--were recruited in the last year to staff the new schools as they opened.

6.4.1.3.3.4 Health

The health conditions in the Valley have long been considered one of the major environmental problems. Compared with other areas of Jordan, the health facilities and services in the Valley have been below par. Enteric diseases such as diarrhea are common, and one of the consequences of increased irrigation has been a larger supply of water that is easily contaminated, thus perpetuating the opportunity for water-borne diseases. While plans are underway for provision of potable water in a completely independent system, the new water supply system is not yet in operation in most villages, and it is common practice for drinking water to be taken from irrigation ditches and other polluted sources.

Before the Village Development Plan was put into operation, only 10 of the Valley settlements had public health facilities and services of any type. The Village Development Plan calls for the provision of health facilities and services which can provide preventive and nutritional

programs in addition to curative medicine services. Three types of health care facilities are envisioned:

- Type "A" centers which will provide a broad range of medical services, including emergency care and laboratory facilities and will eventually have "field hospital" status. More extensive full-service care will continue to be provided in the larger upland towns of Salt and Irbid. There are four of these planned either in the larger or the centrally located villages, and three are under construction in the Phase I program. Maternal and child health care are expected to provide the major demand for these facilities.
- Type "B" centers are facilities oriented toward the provision of outpatient and pharmacy services, which are also expected to be used for maternal and child health cases. Seven of these centers are planned, four of which are under construction in the Phase I program, mainly in the larger villages without a type "A" facility.
- Type "C" centers are basically designed for preventive and first aid services. Seven of these facilities are planned, three of which are being constructed under Phase I.

At present, there are only 52 medical practitioners in the Valley; six of these are physicians and the majority of the remainder are practical nurses and trainees. With the completion of the Phase I and Phase II facilities, staff requirements are expected to double to close to 100, including 10 physicians and 49 nurses. While in education there appears to be an adequate production of teachers in Jordan through national training programs and facilities to staff planned facilities, this situation does not apply to the medical professions, and some staffing difficulties may be experienced. At present, the construction of Phase I health facilities is nearing completion. None was in operation as of April 1979 pending receipt of equipment and decisions on staffing.

6.4.1.3.3.5 Domestic Water Supply and Wastewater Disposal

6.4.1.3.3.5.1 Domestic Water Supply

At present, North Shuneh and South Shuneh are the only two villages in the Jordan Valley with municipally owned and operated potable water supply systems. North Shuneh uses Wadi Arab water without chlorination, while South Shuneh uses well water which is occasionally chlorinated (depending upon whether the chlorinators are working.) The water service is subsidized in these two villages. The present consumption is 50 liters/capita/day at a unit price of approximately 20 fils/m^3. [6-40] The other villages in the Valley do not have municipal potable water systems. The villagers use water from nearby springs, wadis, EGMC and/or from water delivery trucks. Consumption has been estimated to be in the range of 20-40 l/c/day. [6-40]

As part of the Village Development Program, chlorinated water from various springs and wells will be supplied for drinking purposes. The domestic water program is being implemented in three sections:

1) In the south, four villages are to be supplied from wells in one of the upland valleys--the program consists of the installation of pumps at well sites, installation of mains, construction of five storage reservoirs, installation of the distribution system to individual properties, and the installation of water meters. This project was begun in 1977 and has experienced a number of delays. As of April 1979, domestic water was not available to these four villages being served under this project.

2) In the middle of the Valley, fifteen villages are to be supplied from two wells in upland valleys; one has been used since 1973, and the other will be put into operation when the house distribution network is complete. This project will consist of a distribution system and water meters, in addition to pumps at the well sites. A contract for this

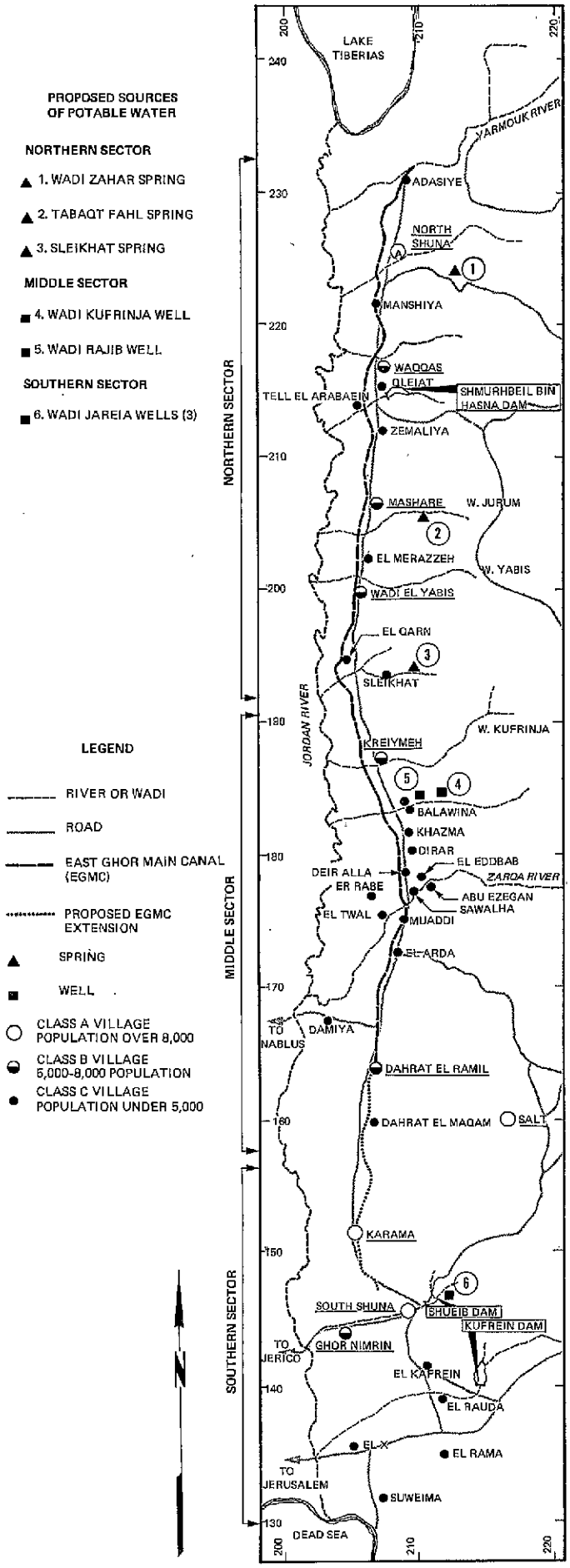
work was issued in 1978 and as of April 1979, the work was still under construction.

3) In the north, 11 villages are to be supplied from upland sources that are now under construction (one village--North Shuneh--has had its own local water supply system for quite some time). As of April 1979, no new domestic water was available to these villages.

New buildings constructed under JVA authority (schools, health centers, government housing, etc.) will receive trucked water until the system is operational. Users of new domestic water will be charged for its use at rates not yet determined. The proposed sources of water, reservoir sizes, and locations are shown in Figure 6-5. The reservoirs will be built of concrete, and the supply lines of ductile iron and/or asbestos cement. PVC pipes will be used for the distribution network.

The major design criteria used for the domestic water systems are summarized in Table 6-18. One of the design criteria provides that the minimum pressure in the distribution network be equivalent to 20 m higher than the highest plot on the settlement. Thus, the maximum pressure in the network will be at least in the 40 m range (assuming a 20 m drop in the main header and the highest plot on the settlement). For such pressures, given the construction practices, the assumed design losses of 5% in 1977 and 15% in 2007 are optimistic. Conservative estimates of 15% in 1977 and 25% in 2007 would have been more appropriate.

The construction activities in the southern vallay have been substantially completed, while those in the central valley are currently underway. Construction in the northern sector has been initiated. There will be a minor impact resulting from these construction activities. In particular, the installation of supply lines in the vicinity of the North-South road, will create temporary traffic inconveniences in the valley. However, the overall impact from these construction activities



PROPOSED SOURCE ALLOCATIONS

Village	Potable Water Source	Reservoir Size (m^3)	
1. ADASIYE	1	–	NORTHERN SECTOR VILLAGES
2. NORTH SHUNA	1	600	
3. MANSHIYA	1	–	
4. WAQQAS	1	400	
5. QLEIAT	1	–	
6. TELL EL ARABAEIN	1	–	
7. ZEMALIYA	1	–	
8. MASHARE	2	600	
9. EL MERAZZEH	2	–	
10. WADI EL YABIS	2	400	
11. EL QARN	2	–	
12. SLEIKHAT	3	200	
13. KREIYMEH	4&5	–	MIDDLE SECTOR VILLAGES ONE 1000 m^3 MAIN RESERVOIR AT THE WELLS
14. BALAWINA	4&5	–	
15. KHAZMA	4&5	–	
16. DIRAR	4&5	–	
17. DEIR ALLA	4&5	–	
18. EL EDDBAB	4&5	–	
19. ER RABE	4&5	–	
20. ABU EZEGAN	4&5	–	
21. SAWALHA	4&5	–	
22. EL TWAL	4&5	–	
23. MUADDI	4&5	–	
24. EL ARDA	4&5	–	
25. DAMIYA	4&5	–	
26. DAHARAT EL RAMIL	4&5	500	
27. DAHARAT EL MAQAM	4&5	–	
28. KARAMA	-6	500	SOUTHERN SECTOR VILLAGES ONE 2000 m^3 MAIN RESERVOIR AT THE WELLS
29. SOUTH SHUNA	-6	500	
30. GHOR NIMRIN	6	–	
31. EL KAFREIN	6	500	
32. EL RAUDA	6	500	
33. EL X	?	?	
34. EL RAMA	6	–	
35. SUWEIMA	6	–	

Source: Arthur D. Little, Inc.

Figure 6-5 Proposed Water Supply System--
Jordan Valley Village Development Program

Table 6-18

Summary of Major Design Criteria
Proposed Potable Water Supply System
Village Development Program

1. Population

	1973 Census	Design Population	Notes
Northern Sector	29,053	49,200	(a)
Middle Sector	24,520	62,200	(b)
Southern Sector	10,146	35,000	(b)
Total Valley	63,719	146,400	(c)

	1977	1987	1997	2007	Notes
2. Per Capita Consumption					(d)
Liters/day	80	90	100	110	
3. Peaking Factors					(d, e)
Hourly	1.65	1.60	1.50	1.45	
Daily	1.50	1.45	1.35	1.30	
Monthly	1.35	1.33	1.28	1.25	
4. Water Losses					(d)
%	5	9	13	15	

5. Minimum Pressure Value: 20 m higher than the highest plot in the village.

(a) "Domestic Water Supply Project - Jordan Valley Northern Sector," Final Design Report. Prepared by VBB, March 1978.

(b) "Jordan-Village Development," AID Capital Assistance Paper No. AID-DLC/p-2111, July 8, 1975.

(c) The total design population has been quoted by various sources as being in the 140,000-150,000 range.

(d) The values are from the VBB report mentioned under Note (a) above. VBB also used these values for the Southern Sector project. It was assumed that these values were also used in the design of the Middle Sector project.

(e) Peaking factor compared to average daily consumption.

will be much less compared to the impact resulting from the construction of housing units in the villages.

The domestic water supply systems are an integral part of the Village Development Program. The following issues should be properly resolved in order to ensure that long-term benefits are indeed derived from the proposed program.

- Since water connections will be provided only to those housing units which conform to the development plan, it is likely that others will continue to use water from the present sources of poor quality. Thus, the associated health problems from such water usage will continue for the period until the program is substantially completed in the entire Valley. In this respect, it would have been more appropriate to install community standpipes for population which would remain outside of the Development Plan for longer periods.
- The cost of potable water is another important factor which requires further clarification. The cost of water was estimated to be in the 160-330 fils/m^3 in an earlier study [6-40], compared to the present charge of 20 fils/m^3 in North and South Shuneh. The low charge is attributed to the system being old and ineffective, and the charge is expected to go up by stages after the new system is constructed. For a population unaccustomed to water charges, high costs may result in potential problems of illegal usage and late payments of monthly bills. On the other hand, if subsidies were to be provided, which JVA does not now intend, the equitable allocation of the subsidies among the various villages would also need careful evaluation.
- It is the intention of the JVA to turn over the operation and maintenance responsibilities of the water supply systems to the local municipal agencies to be set up in the Valley. This will necessitate that proper operator training programs be initiated at an early stage. In particular, strong emphasis should be placed on operation and maintenance procedures for pumps, chlorinators and control equipment. Other aspects such

as periodic monitoring of raw water quality, leak detection tests, meter reading and calibration, etc., should also be included in the training program. The objective should be to minimize financial, technical, and administrative problems currently faced by other water agencies in Jordan. (See Reference 6-41 which describes these current problems).

6.4.1.3.3.5.2 Wastewater Disposal

Currently, domestic wastewater in the Valley is disposed predominantly in individual percolation pits. There are no reported data on wastewater characterization in the Valley. Based on the estimated water consumption (50 and 110 l/c/day in 1977 and 2007, respectively) and consumption factors of 0.4 and 0.7 (Table 3-13), the sewage flow is estimated to be 20 and 77 l/c/day in 1977 and 2007, respectively. As a comparison, the sewage flow in an average home in the United States is in the range of 280 l/c/day. [6-42] It can be reasonably assumed that the sewage composition in the Valley will be somewhat similar to that encountered in Amman; i.e., the sewage will be characterized by high values of BOD and suspended solids (Table 3-14).

The domestic wastewater will be disposed in individual percolation pits serving one or a group of housing units, while septic tanks will be used for institutional buildings such as schools and hospitals. Percolation rates ranging between 5.5 to 29 cm/hr have been measured at the various village sites. [6-43] The percolation pits are 3-4 m^2 in cross section, 2-3 m deep, and have concrete block walls. At the bottom, the pits are lined or open depending upon the geological conditions at the specific village. In general, such a pit will serve 5 to 25 persons, depending upon whether the pit is connected to one large house or three or four small houses. Consequently, the influent flow for each pit will vary between 160-800 l/day in the early 1980's to 400-2000 l/day around the year 2000.

During field investigation, it was noted that the manholes on the percolation pits were not fitted with rubber gaskets, thus resulting in excessive inflow during rainfall conditions, especially in low-lying areas. It is recommended that the manoles be equipped with rubber gaskets.

The choice of percolation pits (versus central packaged treatment plants) was made based on economic considerations. It is believed that the pits will be effective in disposing the domestic wastewater during the early years of the Village Development Program. However, the question of sludge pumping has not yet been properly resolved. In particular, it will be necessary to make trucks available to the villages so that sludge can be pumped out and hauled away for adequate disposal.

Over the longer period, as the Village Development Program gets fully implemented, the resulting high population density will result in increased wastewater flows and will give rise to the inevitable pollution of groundwaters. The time frame during which the groundwater pollution will become pronounced and the extent to which it affects potable water sources and agricultural activities in the Valley cannot be determined without further investigations. If other areas in Jordan such as Amman and Irbid are any examples, it would appear that this groundwater pollution could become a major concern within the next 10 to 15 years.

6.4.1.3.3.6 Electricity

Since 1974 the plan for bringing electricity to the Valley from generating stations in the uplands areas has been in progress. Three high-voltage lines (33 kV) have been completed from uplands power sources to the Valley. Each of these three feeder lines is connected to a high-tension line running the 100 km length of the Valley. This line will feed a low voltage (220 V) network that will consist of 54 transformers and a distribution system feeding 31 villages. In 1978, 14 villages in the south and central portions of the Valley were receiving electricity from this system. Work is continuing on the distribution network to bring electricity to the remaining villages.

6.4.1.3.4 Program Impacts

6.4.1.3.4.1 The Current Status of Program Impacts

In the spring of 1979, the basic impacts of the Village Development Program are just beginning to be felt. The electricity supplied from upland sources was made available to the Valley only in 1978. Of the 26 schools scheduled for construction in Phase I, only 12 to 14 have been opened and are now in full utilization. While six of eight of the Phase I medical facilities have been constructed, none are yet in operation. Most of the Phase I government worker housing units and about half of the 2100 units of low-cost housing are nearing completion, but in April 1979 none was occupied. The domestic water supply system has not been completed. Only two of the villages have gone through the replatting process.

Over the next year, however, the full effects of the basic improvements to village infrastructure and living conditions should come to the fore. At present, there are positive signs that living conditions in the villages are beginning to improve; but this can be attributed as much to the improvement in incomes of farmers and others involved in the Valley's improving economy as to the effects of the Village Development Program itself. Television aerials are beginning to appear on many of the Valley's homes; a number of new houses have been built, some in designated villages with permits from JVA, others outside the villages without permits; stores selling modern appliances and equipment (including Japanese motorcycles) have opened in the commercial centers of the larger villages, and more cars and trucks are appearing in the village streets and on the Yarmouk-Dead Sea Road.

While there are visual signs of a new affluence in the Valley, there will be some difficulties in trying to quantify and measure these changes. For example, the 1973 census of the Valley population did not collect any information on household or family income. While the 1978 census, just now being tabulated, did obtain such information, it will not be possible to measure directly the amount of income increase that occurred during the period when the Village Development Program was being planned and initially implemented, because of the absence of this key information on the 1973 baseline conditions.

6.4.1.3.4.2 Summary of Program Impacts

The Village Development Program will result in substantial increase and upgrading of community facilities. A summary of facilities is presented in Table 6-19. As a result of the program, the 1138 classrooms in 49 schools will be constructed. Health facilities, which are currently in very short supply in the Valley, will be substantially increased.

Five older clinics and 10 health stations will be replaced by two hospitals, 10 clinics and 19 health stations.

6.4.1.3.4.3 Impacts on Village Housing and Living Quarters

The impacts of the Village Development Program on the existing housing and living conditions in the designated villages should be positive, even though these impacts are too few to measure at present. The first major change has come about through the provision of electricity which is now available from a central source to all designated villages. A significant number of existing houses have been connected to this central source, and occupants are now able to use electric lights, appliances, and radio and television on a regular basis. (Prior to this, the villagers had to rely on locally provided gasoline driven generators for electricity.) While the plan originally called for the provision of water and electricity only to those housing units that were located on a "standard" 12m x 24m lot, electricity is now being provided to residents on application even though the replatting has not been finished in most of the villages. Residents are charged for electrical usage on the same basis as residents of other parts of the Kingdom.

Until the potable water supply system is put into full operation, the very important improvements expected from this system will not be felt. Until that time, villagers will still have to depend on their traditional sources of water -- the quality of which is not high and its use still limited. Because of the importance of potable water to the health of the villagers, this program should continue to receive high priority for implementation as soon as possible, along with measures to educate

Table 6-19

Village Development Program

Schools

	Old Classrooms	Proposed Additional Classrooms
4 large villages	130	329
18 medium villages	282	528
5 small villages	59	60
5 new villages	30	221
32	501	1,138

Health Facilities

	Old Facilities		Proposed		
	CL	STA	HOS	CL	STA
4 large villages	2	2	2	2	-
18 medium villages	3	5	-	5	12
5 small villages	-	1	-	-	5
5 new villages	-	2	-	3	2
32	5	10	2	10	19

HOS - Hospital - A

CL - Clinic - B

STA - Health Station - C

Source: PADCO, "Settlement Planning and Housing Recommendations for the East Ghor Valley," November 1973.

villagers in the proper use of water not only for drinking but for personal hygiene and other domestic purposes as well. It would be well to include water conservation education in the program, for the chances of over use or misuse of the new, important, but scarce commodity may be quite high initially.

The availability of domestic water will automatically mean that the wastewater disposal system will have to receive higher priority attention than it has currently. While the original plan for sewage disposal called for reliance on individual septic tanks as the major element in the waste disposal system, the emphasis is now shifting to the provision of communal tanks which can be controlled and maintained by public authorities more easily. For many of the larger villages, however, collection and treatment facilities might be worth considering over the long run, particularly since they offer the possibility for recycling and reusing wastewater--an urgent objective in this particular environment. In any case, it appears that the whole question of wastewater collection and disposal will have to be moved to a higher priority in the Phase II village development effort.

Part of the problem with moving the provision of domestic water and the handling of wastewater in the villages to a higher priority for early completion has to do with the program for the mapping and reallocating of village land. The most sensible and desirable sequence for improving village conditions through provision of new infrastructure is to have all the land replatted, streets laid out, and standard lots distributed to owners prior to the provision of utilities. Because of the size of and the numerous difficulties in the replatting process, JVA is providing the utilities before replatting is fully completed. While this makes it difficult to achieve the kind of order in the development process that would be desirable, it does make for quicker delivery of utilities to villagers.

Overall improvement in the quality of housing in the villages will probably take the longest time to achieve for two important reasons; first, the quantity of existing housing is such that it will not be possible to quickly provide new modern units to all or even a large portion of the villagers; second, the level of investment required to create an entirely new inventory of standard units would overtax the resources not only of the villagers but also of public agencies providing or subsidizing houses as well. As a result, the strategy is to encourage villagers to make investments in new or rehabilitated housing at their own pace, when their resources are at a level that they can afford to obtain a low cost loan or make another arrangement for improving their property. When the Village Development Program began, it was expected that a substantial number of villagers would begin to build new or improve their existing homes on their own. However, for a number of reasons, including the fact that there are virtually no contractors who can build housing to the new modern standards now required in the building code adopted by JVA, very few applications for building permits for new housing were received. It was in order to provide new housing in the absence of any significant private efforts that JVA and USAID decided on the program to build 2100 new units under contract to JVA for subsequent sale to villagers and other eligible candidates.

Again the full effect of the 2100-unit program has yet to be felt, since none of the 1000 units currently under construction has yet been occupied. While the standards of layout and construction of these units are, in some respects, an improvement over the quality of the majority of the existing housing in the villages, they are not overly generous in terms of interior and exterior space. The units have been designed for construction costs of JD 3000 ($10,000) per unit. They have been built in groups of 50 to 100 units, many on the standard 12m x 24m lots, which gives the physical appearance of substantial crowding and high density, although the standards are more generous than much of the existing housing in the Valley's

villages. The units that have been built on double-sized lots[1] (a unit on every other lot) appear to have a much better quality in terms of space and visual impact than the other units. As a result, JVA will be building the remainder of the 2100 units on this double lot principle.

While the visual appearance of the new housing is not outstanding, the demand for units is high. As of April 1979, there were about 2500 applications for the first 1000 units. An analysis of applications for the new housing units in five of the southern villages[2] prepared for Arthur D. Little, Inc., by JVA indicates that of 1012 applications received as of April 4, 1979, 456 were from people eligible for the new units. (See Section 6.4.1.3.3.2, item 3.) Of the eligible candidates, 316 were from people who were not now resident in the Valley but who were eligible as a result of their occupational status or ownership of land in the Valley, and 140 were current residents of the Valley. While there are no specific figures available in summary form, it appeared from a brief visual inspection of the application lists that a majority of the applicants (including the eligibles) did not list their profession as farming. The large number of ineligible applicants were apparently people from the upland cities who were seeking second homes in the Valley. As of April 1979, no one had yet been selected to receive the new units from among the eligibles.

It remains to be seen how these units will work functionally once they are occupied. One problem may arise from the policy of JVA not to allow occupants of the new units to keep animals on the premises. Animals (chickens, goats, and sheep in particular) are an integral part of

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[1]The owner will own the standard 12m x 24m lot. The vacant lot will belong to JVA until such time as the adjacent owner is willing and able to purchase the vacant lot for expansion.

[2]Randa, Kafrein, South Shunel-Sakneh, Karama, and Zahret el Ramil.

farmers' daily lives and culture. The most common observations about the new housing provided by those interviewed in the Arthur D. Little, Inc., field survey, however, concerned the size of the rooms (too small) and the fact that the ceilings were considered to be too low (thus making the rooms too hot). While the objective is to provide modern sanitary conditions in the villages, the problem of handling the cultural traditions, particularly of farming households, needs more careful attention.

6.4.1.3.4.4 Impacts on Community Services

In the community service area, there have already been important positive impacts in education. The provision of new schools has not only provided the large school-aged population of the Valley with modern facilities and equipment but also has raised the morale of both the students and teachers. As a result, more students have been accommodated, better teaching conditions are evident, including the ability to broaden curricula for both boys and girls. Discussions with a number of school teachers in the Valley during April 1979 indicated that conditions in education in the Valley had markedly improved with the provision of the new schools and equipment. While it will be some years before the effect of the rise in literacy can be measured with any accuracy, it is evident that the educational component of the Village Development Program is its major success.

In the health area, the improvements in services that will be made possible as a result of construction of new health care facilities have not yet been accomplished, since the new facilities have not been equipped and staffed. When the facilities are put into operation, there is every reason to believe that there will be substantial improvements in the quality of health services available to residents. The one problem that may arise in the program is developing a good staff for the new facilities. The Ministry of Health, as opposed to the Ministry of Education, has had only relatively few of its staff working in the Valley, and their ability to recruit and locate qualified professionals for these new facilities may

pose some problems. Despite this potential difficulty, the provision of the new health facilities should give Valley residents--particularly women and children--the kinds of preventive and curative programs that had been present only minimally in the recent past.

6.4.1.3.4.5 Impacts on Local Commerce and Industry

Significant improvements in the commercial and industrial sector of the Village Development Program are already apparent. As a result of the increased wealth brought about through irrigation of farm land, there is already evidence that the volume of commercial activities in the villages--particularly the larger ones--is increasing. This results not only in new jobs for Valley residents but also better access to goods and services provided by privately owned and operated businesses. There are a number of new stores that have come into existence, particularly in North and South Shuneh (including a motorcycle sales store). A construction industry is beginning to emerge--specifically a few plants making cement blocks and pipes--although there is a long way to go before a construction industry is developed capable of undertaking the quality and quantity of work implied by the Village Development Program.

In the area of marketing of agricultural products, major new central markets are being build by JVA in three locations to consolidate and control the marketing activities now conducted informally along the main highway. One of these markets in the central section will be completed before the end of 1979.

With the exception of the new central markets, the strategy for commercial and industrial development in the Valley is to encourage private initiative and investment to undertake new activities. JVA must grant building permits for any new commercial and industrial buildings, but, other than this regulatory function, there is no active program for promotion of industrial and commercial development. Depending on the trends in development that result from the village and agricultural programs, the Valley may find

itself with either a good balance of commercial and industrial activities vis-à-vis its population, or be underserved or overserved in certain commercial and industrial categories. Based on the experience of other regional development efforts of this kind, it would be desirable for the people responsible for Valley development, particularly the JVA, to develop a system for monitoring the development of industrial and commercial activities, to compare this development with demographic shifts and changes occurring in the Valley, to determine potential service deficiencies or new commercial or industrial growth opportunities and needs resulting from this, and to take appropriate steps to encourage or support commercial and industrial activities as a result. Two needs may be apparent in the near future that may not be met with strictly private initiative. First, the aforementioned construction and home improvement, while much needed, may not develop without some sort of public assistance. Second, commercial and industrial activities are needed to appeal to the new generation of better-educated residents, who might tend to leave the Valley unless attractive entrepreneurial, professional, and technical opportunities are available.

6.4.1.3.4.6 Impacts on Clientele Served

One of the most important facets of the Village Development Program is that, by design, it will bring benefits primarily in the form of improved living conditions to the residents, present or future, of the designated villages. Except for education and health services, which are available to residents of the Valley regardless of where they live, the other major benefits will be available only to those who live in the 34 planned villages--some 85% to 90% of the estimated 1978 population. The remaining 10% to 15% of the current population will either have to do without new benefits, including legal improvements to existing housing in non-designated areas, or to move into designated villages. While, in concept, there will be lots available in existing and new villages for current village non-residents, any families desiring to move will have to give up their investment in their existing home--which presumably will not have any basic value--and relocate in a village.

The actual mechanics of this process have not yet been worked out or put into practice because of the status of the land replatting program. Thus, it is difficult to predict exactly how non-villagers will be able to take advantage of the benefits. Where a new village is designed to replace an old one, there will be a priority scheme developed to allocate new lots in the designated village. But for those who are not in these replacement villages, but scattered in the agricultural lands, there is no particular program or process designed at present.

A significant portion of the population living outside the designated villages are either migratory Bedouin families who spend a substantial portion of their time working as farm laborers, or laborers imported from Egypt or Pakistan to work the fields. Many live in tents of varying qualities. While farm owners have the overall responsibility for housing their imported labor, it appears that no particular provision has been made for their housing in the Village Development Program. If the pattern of using imported labor for field work continues (this is quite likely with continued improvement in incomes and opportunities of permanent Valley residents), provision will have to be made for these temporary workers, if an over population of farm land or unserved land is to be avoided.

6.4.1.3.4.7 Impacts on Service Delivery Institutions

In the Jordanian institutional structure, there are two major sources for the provision of public services to communities--the Ministries of the national government which play the major role, and local governments. The Village Development Program is having very important impacts on both these sets of institutions. For the ministries responsible for education, health, welfare, recreation, transportation, water supply, electricity, communications and other nation-wide services, the development of the Valley has meant accelerated demands and priorities for new services. For those ministries that were involved in the initial planning

for the Valley or which (like education) were well established in the Valley prior to the planning, the ability to assign priority and implement programs in the Valley does not pose unusual problems. For those ministries that were only peripherally involved in the initial planning (like Labor and Social Welfare and Health), the problems of organizing priorities and implementing programs appears to pose some difficulties. The fact that JVA is a unique organization in the national government structure, having Ministerial level authority over the development of the Valley, but having no assigned community service functions other than the provision of basic infrastructure facilities in the Valley, has created a situation in which ministries must adjust their actions to initiatives actually developed by JVA. In some instances, this has caused problems of communications among some ministries and JVA, which can be overcome with more careful attention to mutual needs and priorities.

In regard to local government, the operation of JVA has clearly overshadowed the functioning of existing municipal governments in the Valley. Prior to the creation of the Village Development Program, the four major municipal governments and the other local councils and mukhtars had to arrange for the provision of what municipal services were available in the villages on their own. In the Jordanian structure, these local governments are responsible for the provision of such municipal services as water, garbage collection and disposal, street construction and maintenance, provision and maintenance of public spaces and facilities, including schools, health centers, town halls, and others. With the Village Development Program, virtually all the power to implement the provision of new infrastructure and control the land was vested in JVA. In most instances, this situation has been welcomed by both village officials and residents alike, for they recognize that the level of resources now available would never have been available to them on an individual basis. However, now that the implementation of the infrastructure projects in Phase I is nearing completion, the local governments--which have partially atrophied in the last few years with JVA's presence--are not in a position to assume their traditional responsi-

bilities for operating municipal services now possible with new JVA infrastructure.

This situation is well recognized by JVA which is in the process of developing a plan to create a single municipal council for all the villages in the Valley. The council would be responsible for making policy decisions on such matters as service levels and charges for municipal services.

There would be a municipal service organization reporting to and responsible to this council which would have the responsibility for the actual operation and maintenance functions.

6.4.1.4 Agricultural/Agri-Related Business

6.4.1.4.1 Cropping Patterns and Agricultural Production

In the East Jordan Valley lies 65% of Jordan's irrigated land. It produces most of the country's vegetables and non-olive tree crops, and considerably more than half of the total production value of Jordan's agricultural sector.

Of the Valley's 60,548 ha, about 42,000 ha are arable and 36,000 irrigable under present (Feasibility Study) assumptions. The EGMC currently irrigates some 11,900 ha, and on-farm wells, an additional 2100 ha. A pressure water distribution system serving about 9400 additional ha is under construction; its source will be the Zarqa River and several side wadis. (Several irrigation systems already drawing water from the side wadis are included in the overall pressure system for the 9400 ha.) Although the exact amount varies from report to report, approximately 11,300 ha were to have been brought under irrigation as part of Stage II. These combined projects (existing, under construction, and proposed) would have irrigated all 36,000 ha of the Valley's irrigable land. The decision to divert water from irrigation to M&I uses will reduce Stage II irrigation hectarage from 36,000 to 32,400. Table 6-20 summarizes the irrigation/land breakdown for the Valley.

Table 6-20

Irrigated Land Breakdown, East Jordan Valley
(Hectares)

Total Arable Land, East Jordan Valley	41,147
Farmland to be Identified Later	5,147
Total Irrigable Area (Feasibility Study)	36,000
Reduction due to Increased M&I Allocations	3,603
Total Irrigable Area ("C-1" Plan)	32,397
Stage I - Independent Water Sources	5,570
Stage I - Zarqa River	5,077
Total Stage I	10,647
Stage II - Land Currently Supplied by EGMC	11,927
Stage II - Land Currently Supplied by Wells	2,132
Stage II - New Land to be Supplied by EGMC	3,671
Stage II - New Land to be Supplied by Amman Return Flow	4,020
Total Stage II ("C-1" Plan)	21,750
Total Stage I and Stage II	32,397

Source: Arthur D. Little, Inc.

Table 6-21 shows the cropping patterns with and without the Stage II development based on recent studies undertaken by the World Bank appraisal mission. Two values are shown for each condition; the number of ha during year one of the analysis period, and the number of ha during years 10 to 50. Between years one and 10, the number of ha for each crop generally have a uniform transition between the two values. The total irrigated area for Stage II lands as shown in Table 6-21 is 19,546 ha, as compared to 21,750 ha proposed in the "C-1" plan.

The data in Table 6-21 show a shift in the types of crops to be grown over the years with the project. Wheat would be phased out, and much of the newly available land would be used for melons, oranges and grapes.

Production is expected to nearly triple as a result of the Maqarin Dam. Some of this increase will result from additional irrigated hectarage possible because of the project. The remaining increase will come from (1) higher yields resulting from more timely water applications permitting better utilization of other projection inputs, and (2) more intense cropping patterns, i.e., moving from an average of 1.06 harvested crops per hectare to 1.28 crops annually.[1] (Some sources for the Valley already indicate a 1.14 cropping intensity for recent years. If this is the case and Stage II intensity will still only be 1.28, then the benefits of the project will be less than indicated by Harza.)

In the Yarmouk Valley, an estimated 20 to 30 irrigated hectares of vegetables will be lost due to inundation behind the dam. No field surveys have been conducted to establish cropping patterns on this land. Consequently, no production data exist for this area. However, if one assumes a vegetable cropping pattern similar to the East Jordan Valley,

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[1]No detailed weighted average cropping intensity were available to Arthur D. Little, Inc., as part of the "C-1" plan revisions. Thus, 1.28 has been assumed as remaining reasonably correct.

Table 6-21

Jordan Valley Irrigation Project, Stage II
Cropping Patterns

(Number of Ha)

	Without Project		With Project	
Year =	1	10-50	1	10-50
Wheat	1,182	0	1,129	0
Greenbeans	406	303	411	861
Tomatoes	1,853	788	1,832	2,239
Eggplant	963	545	962	1,550
Cucumbers	479	121	467	344
Squash	805	242	788	689
Cauliflower/Cabbage	434	303	438	861
Pepper	450	121	440	344
Onions	119	242	132	689
Potatoes	253	303	265	861
Beans	554	333	555	947
Others	546	182	536	517
Melons	182	606	221	1,722
Oranges	2,385	2,303	2,458	6,545
Bananas	155	121	157	344
Grapes	64	364	89	1,033
Total	10,830	6,877	10,880	19,546[1]

[1]The "C-1" plan involves 21,750 ha.

Source: World Bank, draft appraisal study, 1980.

10 ha of tomatoes (350 tonnes), 5 ha of eggplant (175 tonnes), 3 ha of squash (105 tonnes), 3 ha of cucumbers (105 tonnes), 2 ha of melons (44 tonnes), and 7 ha of other vegetables (175 tonnes) would be lost as a result of the project. The major impact of this loss will be on Syrian rather than Jordanian farmers.

In general, the increase in cropping intensity and irrigated hectarage should have a positive effect on the farmers, the East Jordan Valley, and the country as a whole. The obvious benefits are increased income, employment, and foreign exchange (since a large quantity of the output is to be exported). However, export fruit and vegetable production can be a risky enterprise and is apt to become increasingly so in the future as more countries try to capitalize on the lucrative agricultural trade with the oil-rich nations of the Middle East. Since agricultural production in any of its forms anywhere in the world is a risky undertaking, the East Jordan Valley is not unique. In any event, if the attractiveness of the export market takes a radical negative turn, farmers in the project area can shift to other crops for domestic production. While these crops may not be as financially attractive as fresh fruits and vegetables, they should be adequately profitable to ensure continued production and economic survival in the Valley. Finally, vegetable and fruit prices can vary tremendously on the world market from year to year. Thus, a farmer's debt capacity and ability to repay existing loans may be severely limited in any given year. Unless the credit system can accommodate this, then needed agricultural investments will be slowed and/or foreclosures may be common.

6.4.1.4.2 Soil Chemistry

6.4.1.4.2.1 Introduction

The quality of water used for irrigation in semi-arid or arid regions must be considered due to the ever-present hazard of salinization or alkalization of irrigated soils. For irrigation use, the quality of

water is determined by the concentration and composition of dissolved constituents. Soluble salts may produce harmful effects on plants by increasing the salt content of the soil solution (salinization) and by increasing the degree of saturation of the exchange materials in the soil with exchangeable sodium (alkalization). The latter process may also result in soil conditions that are unfavorable for the entry and movement of water and for tillage.

The implementation of a successful irrigation project involves not only the supplying of irrigation water but also the control of salinity and alkalinity. The quality of the irrigation water, irrigation practices, and drainage conditions are involved in the control of these factors. In the early stages of the project, soils that are initially saline require the removal of the excess salts and may require chemical amendments (e.g., lime) in addition to irrigation water. Soils that are initially non-saline may become unproductive if excess soluble salts or exchangeable sodium are allowed to accumulate because of improper irrigation, soil management practices, or inadequate drainage.

Jordan Valley soils were reclassified according to sprinkler irrigation land classification specifications followed by the U.S. Bureau of Reclamation with certain modification by Harza. [6-5] The Harza reclassification was based on previous studies performed in 1955 and 1969 with some additional field checking. Consideration was given to topography, drainage, and soil depth, texture, water holding capacity, and salinity. Areas requiring reclamation prior to irrigation were delineated. The scope and detail of the Harza reclassification appear to be adequate for the needs of the proposed project. No new data which would warrant any modifications of the Harza reclassification were available for this study.

The findings of the Harza study in terms of the land area assigned to various land classes are summarized in Table 6-22.

Table 6-22

Summary of Land Area Assigned to Land Classes

Land Class	Suitability for Irrigated Agriculture	Area in Hectares
1	Most suitable	11,573
2	Less favorable	5,426
3	Marginally suited	3,180
4	Presently unsuited	4,706
		24,925

Source: Harza Overseas Engineering, Company, "Jordan Valley Irrigation Project, Stage II Feasibility," January 1978.

The lands which are considered arable at present, namely classes 1, 2, and 3, account for a total of 20,219 ha and are distributed throughout the Jordan Valley from the Yarmouk River to the Dead Sea.

As noted in Section 6.2.3.2.1, water quality data for the region are also very limited. However, enough data do exist to make certain specific points with respect to the impact on soils of the use of existing and projected surface water sources for irrigation.

6.4.1.4.2.2 Characteristics Which Determine Irrigation Water Quality

The characteristics of irrigation water that appear to be most important in determining its quality are: (1) total concentration of soluble salts, which can be adequately expressed for purposes of diagnosis and classification in terms of electrical conductivity; and (2) the relative proportion of sodium to other cations. This proportion is usually expressed as the sodium-adsorption ratio, or SAR, which is an empirical quality defined by the equation:

$$SAR = Na^{+} / \sqrt{(Ca^{++} + Mg^{++})/2}$$

where Na^{+}, Ca^{++}, and Mg^{++} represent the concentrations in milliequivalents per liter of the respective ions. Consideration may also need to be given to other water quality characteristics, including the presence of boron or other toxic elements and bicarbonate concentrations, any one of which may change the quality rating. However, since no information was available on these other characteristics, the present discussion is limited to electrical conductivity and sodium-adsorption-ratio.

Irrigation waters may be divided into water-quality classes based on salinity and sodium hazard. [6-44] The significance and interpretation of the quality-class ratings are summarized in Table 6-23.

Table 6-23

Classification of Irrigation Water Based on Salinity and Sodium Hazard

Low-Salinity Water (C_1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.

Medium-Salinity Water (C_2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High-Salinity Water (C_3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Very High-Salinity Water (C_4) is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.

Low-Sodium Water (S_1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stone-fruit trees and avocados may accumulate injurious concentrations of sodium.

Medium-Sodium Water (S_2) will present an appreciable sodium hazard in fine-textured soils having high cation-exchange-capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability.

High-Sodium Water (S_3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management--good drainage, high leaching, and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium, except that amendments may not be feasible with waters of very high salinity.

Very High-Sodium Water (S_4) is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these water feasible.

Source: Richards, L.A., ed., Diagnosis and Improvement of Saline and Alkali Soils, Agriculture Handbood No. 60, USDA, Washington, D.C., 1954.

6.4.1.4.2.3 Present Water Quality with Respect to Irrigation

Detailed water chemistries were available for only three of the water bodies listed in Table 6-2, namely the Jordan River at the King Hussein Bridge and the Upper and Lower Yarmouk River. [6-45] These were the results of chemical analyses performed in 1959-1960, which included classification of water samples taken from these water bodies at different seasons. The results reported were according to the classes described in Table 6-23. These classifications, arranged in decreasing order of frequency, are as follows:

Water Body	Irrigation Water Classification
Jordan River at King Hussein Bridge	C_4S_2, C_3S_1, C_3S_2, C_4S_1
Upper Yarmouk	C_3S_1
Lower Yarmouk (used for EGMC)	C_3S_1, C_2S_1, C_2S_3
Zarqa	No data available (see below)

It is clear from these results that the principal hazard associated with the use of water from these sources for irrigation purposes is that of salinization; there appears to be little danger of the development of harmful levels of exchangeable sodium, although certain sodium-sensitive crops may accumulate injurious concentrations of sodium.

Extrapolation of this 20-year-old data to present conditions for the respective water bodies or other irrigation water sources is dangerous. However, if the TDS content is taken as an indicator of the relative proportions of other constituents as described in Section 6.3.4.3.1, then it may be possible to provide qualitative comments on the quality of these waters for irrigation purposes. The range of TDS reported in Table 6-2 for the Upper and Lower Yarmouk Rivers was between 300 and 800 ppm, which is approximately the same as that for several other of the water bodies listed in Table 6-2 including the Northern and Southern

Wadis and the EGMC. Thus, most of these waters may be expected to be in the classification C_3S_1 if the concentration and composition of the dissolved constituents are similar to those reported in the last results. Similarly, the range of TDS reported in the table for the Jordan River at the King Hussein Bridge is 1000 to 2100. These waters were included in the C_4S_2 classification in the 1959 studies; thus, the other portions of the Jordan River and the Lower Zarqa and King Talal Reservoir have similar ranges of TDS reported in the table may also be expected to be included in the C_4S_2 classification.

Table 6-23 indicates that irrigation waters in the C_4 classification are not suitable for irrigation under ordinary conditions. High-salinity waters (C_3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required, which involves careful selection of irrigation practices and provision for adequate leaching from the root zone. Plants with good salt tolerance should be selected.

6.4.1.4.2.4 Soil Chemistry Impacts

Waters from other surface water bodies, including for example, the Northern and Southern Wadis, the EGMC, and the Yarmouk River, described in Table 6-2, may present a salinity hazard when used for irrigation pruposes. Careful selection of irrigation practices and provision for adequate leaching and drainage will be required.

In general, a water quality base adequate for the development and maintenance of a successful irrigation project is apparently not available. Efforts should be initiated immediately to obtain detailed chemical data on irrigation waters in the proposed project area.

Water quality data on the Zarqa River, in particular, was not available for this study. Given the important role of the Zarqa River as a water source in the overall project, efforts to obtain this data shoud be initiated immediately.

6.4.1.4.3 Land Tenure and Farm Organization

Table 6-24 reflects the survey of land tenancy conditions in the East Jordan Valley in 1961 and 1973. The latter survey ("Social and Economic Survey of the East Jordan Valley, 1973") indicated that 47% of all land farmed was sharecropped, not owner-operated. Nonetheless, over 50% of land owners do farm at least a portion of their land. Numerous landowners with only moderate-sized holdings (less than 50 ha) farm a part of their land and lease the remainder; since a family can farm only 2 to 3 ha at current technologies and cropping patterns without resorting to hired labor, this is not unexpected.

Table 6-25 shows the average size of holdings in the Valley in 1974 and 1978. The data show a dramatic decrease in the number of holdings during that five-year period; the number of small holdings (less than 20 dunums) has increased significantly, especially in the southern Valley. When asked to explain these shifts, several observers of the Valley's agricultural sector could not do so and attributed the variations more to sampling error than to any radical shift in holding patterns occurring within the past five years. No data were readily available which relates tenure patterns to size of holdings. The southern portion of the Valley, on the average, has larger farming units. This is expected if for no other reason than the land redistribution program has not yet been implimented in the south.

Most sharecroppers in the Valley (over 90%) operate on a 50:50 system: sharecropper and landowner each receives 50% of the output, and each pays 50% of the input costs, with the possible exceptions of labor and water. In all cases, family labor is provided at no cost to the landowner, and generally all hired labor is also paid for by the sharecropper (in approximately 80% of the cases). Water cost is either paid for on a 50:50 basis or in about a third of the cases, paid for entirely by the landowner.

Table 6-24

Distribution of Land in the East Jordan Valley
by Type of Tenure--1961 and 1973

Type Tenure	1961	1973
Owner-operated	32.5%	35.9%
Sharecropped	39.0%	47.2%
Cash-Rent	1.8%	2.7%
Mixed	26.7%	14.2%

Source: "Agro-Economic Aspects of Tenancy in the East Jordan Valley, 1973," Royal Scientific Society.

Table 6-25

Holdings Distribution in the East Jordan Valley by Size Group--1974 and 1978

Size Groups (Dunums)	Southern Valley		Northern Valley	
	1974	1978	1974	1978
1-19	20%	42%	28%	34%
20-39	37%	34%	50%	36%
40-99	26%	19%	18%	24%
100-199	10%	4%	3%	5%
>200	7%	1%	1%	1%
	100%	100%	100%	100%
Total Number of Holdings	3,539	2,783	4,334	2,996

Source: "The Agricultural Sample Survey of the Ghors, 1974 and 1978," Department of Statistics.

Decision making within the sharecropping system may be by the sharecropper, by the landowner, or by mutual agreement between the two. Choice of crops, quantity and kind of farm chemicals (fertilizer and pesticides) and sale of produce are those activities in which the landowner is most frequently involved. Planting dates, harvesting dates, and harvesting methods are those decision areas more often left up to the sharecropper. Land preparation decisions include landowners slightly more often than not.

Since Stage II will be governed by the 1977 Jordan Valley Development Law, all lands in the project area will be subject to possible redistribution. Accordingly, the largest holding after redistribution will not exceed 200 dunums (with several exceptions generally related to tree crop operations) and the smallest unit will not be less than 40 dunums. Excess lands will be distributed first to those landowners (farmer and non-farmer) with less than 40 dunums and then to non-landowners who are currently in the Valley farming rented or sharecropped land.

The impact of the irrigation project (i.e., of the law) will be relatively insignificant when compared with the results obtained in the northern Valley during the 1960's following the construction of the initial portions of the EGMC. Under the redistribution program in the north (through 1967), 4007 landowners were reallocated at least a portion of their original land; 1297 landowners were reimbursed for their land, but received no land; and 500 farmers without land (laborers, sharecroppers, etc.) received a unit (30 dunums at that time).

In the south, landowners today, after seeing in the north the possible benefits to be derived from the EGMC's water, have done or are doing one of two things:

- Keeping non-owner-operated land (by contrast in the north, owners who did not foresee the benefits of retaining and renting such land sold it);

- Redistributing "excess" land among family members in order to avoid all or part of the potential redistribution impact on their large holdings.

Thus, proportionally, there is likely to be less land available for redistribution in the south than in the north. In fact, JVA estimates that there will be virtually no land available for redistribution in the south to farmers who do not currently own the land they operate. In other words, excess land is available only for existing landowners who have less than 40 dunums. Almost no landless will receive land in the south under the redistribution program. However, some modification of the size of holdings will occur: (1) there will be some reduction in size of the largest holdings (however, the best land remains with the landowner since he has first choice of which of his previous lands he retains within the legal limits); and (2) all small holdings (i.e., those under 30 or 40 dunums) will be eliminated "officially" (however, two or more small farmers are being permitted to hold jointly a single unit of 40 dunums).

Because of the relative insignificance of true redistribution in the south, or "new lands," Stage II is not expected to have a significant impact on land tenancy arrangements. On currently farmed lands, there may be some shifting of land from sharecropping or renting to owner-operation; this would occur on those owner-operated farms with less than 40 dunums whose owners choose to farm their additional allocation rather than renting the land as may currently be happening with the current owner of the transferred land. In addition, "officially" there may be an increase in mixed tenancy at the expense of owner-operated tenancy since large landowners, who in the past farmed their land with hired labor, now will be "renting" much of their land from other family members. Finally, on the currently uncultivated land which will be brought into production for the first time with the advent of the EGMC extension, it is difficult to ascertain the likely tenancy arrangements. Unless sharecroppers can be attracted into the Valley from other parts of Jordan,

most of this land will probably be farmed by owner-operators who hire imported labor from other countries. It is possible that new sharecroppers may become available from one or more of the following sources: (1) farmers in other parts of Jordan attracted by the opportunity for higher farm incomes, (2) a new influx of newcomers, and (3) foreign farm laborers who decide and are allowed to take up permanent residency in Jordan.

Finally, it should be noted that the field interviews indicated some disillusionment and/or misunderstanding of the redistribution program among farmers. For example, one farmer received additional land but got less than a full unit which he had expected. He did not know why this occurred since he thought the law required the unit to be the smallest landholding. Tenant farmers thought that the program would provide land for those without land who are farmers. They do not see this happening and cannot understand why it does not or are cynical, suggesting that the whole program is ineffective.

In summary, land redistribution associated with the project should not be understood as radical land reform. Radical change was not the intent of the law and definitely not the result. Some redistribution has occurred and will occur. Moreover, it will have some desireable income redistribution effects. However, this redistribution will probably benefit smaller absentee owners who rent their land to tenants as much as smaller owner-operators. (Irrigated farmland in the Valley rents for JD 15 to JD 40 per dunum.)

But lack of radical land reform and continued dominance of sharecropping does not mean that Stage II will benefit only the rich, the absentee owner, or the large landowner. In the short- to medium-term, Stage II should economically benefit practically all farmers. In the long term, many smaller, less progressive or less aggressive tenants will be displaced as farm operators, as explained in Section 6.4.1.4.5 on agricultural labor.

Sharecropping is often cited as a negative element in the development process since, in theory, it can lead to lower input utilization and thus lower output and farmer income; in addition, it can lead to informal slavery from which tenants rarely escape. While abuses do exist in the Valley, the sharecropping system there does not seem to have many of the typical drawbacks found elsewhere. In fact, it has many positive features: risk is shared, investment capital is more readily available, technical advice is often available despite the shortcomings of the extension service, farm incomes are excellent for a small farmer in a developing country, the current standard of living is improving, and tenants do not appear tied irrevocably to landlords by recurring and continually mounting debt. In addition, the use of inputs does not appear so restricted as theory might suggest; in fact, more inputs may be used <u>because</u> of the system. This results for two reasons: (1) farmers do not yet have that fine-tuned perception of their position on the production function curve; (2) since modern technology is still being employed with low-to-medium intensity, each additional unit of input generally reaps considerably greater yield and income. Thus, as long as the government restrains abuses, the sharecropping system and lack of radical land reform need not hinder development of production or create undue social pressures. As farmers become more sophisticated, input levels increase and government services begin and operate effectively, the system might better move to a cash-rent basis for optimal production and returns to farmers. (This is not to say that there will be no social tensions among tent people, and in time among other smaller sharecroppers who will be forced out of farming by mechanization and consolidation.)

Finally, with respect to land distribution in Stage II, an equally troubling issue as distribution equity and procedure is the declining quantity of land which can physically be irrigated. The projected decrease based on one of the operation studies conducted for the World Bank appraisal study shows:

Total Irrigable Area
(hectares)

	Jordan Valley	Project Area	New Lands
1990	31,195	20,548	7,879
2000	28,970	18,323	5,654
2010	25,977	15,330	2,667

Apparently, farmers will be distributed (or redistributed) land at the outset of Stage II. Yet within 20 years, 25% of the land in the project area and, therefore, conceivably 25% of the farmers, will have no water with which to farm this land. If this policy is pursued, the project rather callously dangles hope in front of the farmers for a few years then gradually forces them out of business or drastically reduces their incomes. This may well create a socially volatile situation with far-reaching repercussions. Therefore, considerable thought should be exercised before such a policy is actually carried out. In fact, a revised water and land allocation policy might be well worth considering.

6.4.1.4.4 Non-Irrigation Cultural Practices in Agriculture

Unlike small-scale farming in most developing countries, agricultural practices in the East Jordan Valley are by no means traditional. There is a fair degree of mechanization, and the use of chemical fertilizers and pesticides is widespread. Except for grains, seeds are purchased rather than being plantback. Practically all cultivated land in the Valley is irrigated, with an increasing hectarage using drip systems. The use of plastic tunnels, greenhouses, and mulching is growing rapidly.

Practically all farmers, large and small, are producing for the commercial markets rather than for home consumption. As on Jordanian stated: "The farmers in the Valley may not use the most efficient and advanced agricultural practices. But this is because most of them are new, first-generation farmers, not because they are tradition-bound and, therefore, resistant to change."

At present, practically all land preparation is done by machinery, i.e., tractors with plows and/or harrows. Planting is done by hand, regardless of whether seed or seedlings are being planted. Pesticides (i.e., fungicides and insecticides) are occasionally applied with tractor-borne equipment; however, hand-pumped back-pack sprayers are the most common equipment as well as pump-operated systems using holding tanks (actually 55-gallon drums) and hand-operated sprayers attached to hoses radiating from the holding tanks. Fertilizers are generally applied by hand. Few herbicides are used in the Valley; consequently, most weed control is accomplished either through manual hoeing or hand weeding. Plastic mulching is also being increasingly used to aid weed control as well as to maintain soil temperature. Small grains are usually harvested with combines. Some mechanization has been introduced into potato harvesting; however, to date it has essentially been limited to machine- or animal-drawn plows which bring the potatoes to the surface to be harvested by hand. All other vegetable crops and fruits are harvested by hand.

In 1979 it was estimated that over 600 ha of cucumbers and tomatoes were grown under plastic tunnels.[1] Farmers initially began using these two types of plastic covering to reduce frost damage. The coverings

[1]Plastic tunnels are generally less than 0.5 m in height and are constructed by inserting a semicircular wire in the ground to form a frame over which a plastic (clear polyethelene) covering is placed. They run the length of a row. Plastic houses look the same but use a curved steel pipe frame. They are perhaps 2 to 2.5 m high in the center and look much like plastic quonset huts.

provided protection from frost to the plants and also raised the micro-environment temperatures, thereby allowed earlier planting and harvesting which resulted in higher prices received for output. Furthermore, yields are higher with plastic than with openfield production (double in the case of low tunnels, and as much as 6.5 times with houses). [6-46] Higher yields result from increased plant populations and longer plant life. The use of plastic precludes the use of machinery on the land once the plastic and crops are in place. However, garden tractors and rototillers have been used in the plastic houses for land preparation prior to planting or transplanting. Plastic tunnels and houses are also used widely on the West Bank.

The advent of the Stage II irrigation project will have little direct affect on non-irrigation cultural practices in the Valley. New technologies (inputs, machinery, etc.) are being adopted at a fairly rapid rate and are expected to continue in the future with or without the proposed project.

However, the rate of adoption may be accelerated somewhat by various activities associated with the project. First, the Jordan Valley Farmers Association (JVFA) plans to establish centralized pools of machinery and equipment for hire by members. Initially, this will probably lead to more machine application (as opposed to back-pack application) of pesticides, then more machine-applied fertilizer, eventually machine cultivation or herbicide applications for weed control, and finally machine planting.

It is also possible that with the mechanization of pesticide application, the number of treatments will increase. However, it should be realized that machine application is generally more efficient than hand-pumped sprayers. Thus, better control may be attained at the outset of mechanization without any increase in the number of treatments or quantity

of pesticides used. Nonetheless, it is generally felt today that a more comprehensive pesticide program would be economically beneficial to the farmers in the Valley. Such a program will more likely be adopted more quickly with the mechanization of pesticide application than with the current labor-intensive methods.

A second impetus for more rapid mechanization may result from labor shortages in the Valley caused both by the increase in crop hectares (from approximately 14,000 to 21,750 for Stage II) and the shift from less to more labor-intensive crops (field crops to vegetables). The labor situation is discussed below in more detail in Section 6.4.1.4.5. Stage II should not have an impact on the adoption of plastic coverings in vegetable production on currently farmed lands. The impact of credit and marketing services on cultural practices will be discussed in Section 6.4.3.4.

Besides the possible increase in the level of pesticide usage in the Valley, other possible effects of more rapid mechanization fall into two categories: soil compaction and labor dislocation. The former may occur with increased machinery utilization in the fields especially on higher clay soils. This would create potential drainage and aeration problems that could affect soil saline levels as well as non-salt-related plant growth. In addition, if left uncorrected, compaction could lead to sheet erosion. The labor issue will be discussed in Section 6.4.1.4.6.

It should be realized that it is the intent of Stage II planning to significantly increase the use of machinery. In fact, the hours of tractor usage would increase as much as threefold. While Harza's reports define clearly this move to mechanization, it is considerably less clear about the methods to be employed to convert farmers from labor to machinery-intensive operations.

6.4.1.4.5 Fisheries

6.4.1.4.5.1 Introduction

A feasibility study of fresh water fish farming in Jordan was completed in 1978 by Kelvin Hughes Aquaculture Services [6-47] for the Ministry of Agriculture. Information from that report was used in the discussion below. The complete study should be consulted concerning fisheries development associated with Valley development, as several sites in the Valley and associated with the King Talal Reservoir were recommended for demonstration or commercial ventures.

6.4.1.4.5.2 Historical Background

Interest in fish farming in Jordan is derived, in part, from the fact that sources of fresh fish supply, even for existing populations, are essentially limited to the Jordan River, the Yarmouk River and a 24-km coast at Aqaba. The annual catch for the former two sources is estimated at 100 tonnes. This could be considered representative of maximized productivity from these sources, assuming continued introduction of *Tilapia* fry into Lake Tiberias. The reported landings at Aqaba in 1977 were 44 tonnes of fish, a potentially low estimate that may be due to reporting deficiencies. However, fish imports increased 400% between 1970 and 1977, exceeding 3000 tonnes in 1977. This was many times the existing local resources. Commercial farming efforts to date have not been successful for a number of reasons, including (or especially) the choice of site, small-scale production with consequent marketing problems, and the choice of carp as the species to produce. Carp are relatively unpopular fish in Jordan while *Tilapia* spp. are a locally popular fish.

Two fish farming sites operated by the Ministry of Agriculture were still in existence in 1978. The site at Wadi El Yabis produces common carp fingerlings for sale to farmers, with the excess being utilized to stock reservoirs. Production here is limited by a lack of a reliable water supply from the EGMC. Three ponds of adult carp are also maintained (but not harvested) at Azraq Shisham. A now-defunct fish farm on Wadi

Ziglab utilized water diverted from upstream flows. In addition, a number of pools, irrigation ponds, and experimental ponds have been stocked, as well as Ziglab and King Talal Reservoirs. Kafrein Reservoir may also have been stocked this past year. The latter was at one time designated for fisheries development.

The reservoir on the Wadi Ziglab has been stocked since 1969 with common carp and Tilapia spp. In 1974, use of this fishery resource was rented out by the Ministry of Agriculture to a private company to harvest stocked fish. In less than two years, the reservoir was reportedly fished out. This is of particular interest as it has been recently reported that no fish presently exist in the reservoir, and no algae or snails were found along reservoir margins during two site visits in 1978 and 1979. [6-470 Military and paramilitary personnel reportedly fished this water body with dynamite and poison in the late 1960's. However, the various reports on lack of visible life in this reservoir may well be related to as yet unidentified water quality problems and worthy of further investigation, considering other uses of this water

6.4.1.4.5.3 Freshwater Fish Farming: Development Feasibility

The 1978 feasibility study [6-47],which was based on selected water quality criteria, fish species requirements, costing estimates, and home market studies, formulated a list of conclusions and recommendations for future freshwater fish farming in Jordan:

- More emphasis should be placed on Tilapia spp. rather than than carp, as the former is more popular in Jordan and, hence, more marketable.
- Highly intensive running water systems should be developed rather than pond systems as the former are more conservative of land and consume (computed as a net loss) a fraction of the water consumed by pond farming. Water reuse for irrigation is possible in running water systems, although some treatment would be required for drinking water uses.

- Running water systems require trained, experienced staff and management. For this reason, and to allow development of markets, the growth of a freshwater fish farming industry should be gradual.

Running water systems do require a 100%, fully reliable source of water as well as trained, experienced personnel. Thus, sites must be carefully chosen and approached with the assumption that development of this type of farming will take time.

It was also recommended that demonstration sites be chosen from a list of sites considered to have the greatest potential for the successful initiation of intensive, running water systems. The experience gained could then be applied to other areas at a future date. These included: Wadi Ziglab, Wadi Heidan, East Ghor Main Canal at Adesiye, Hammeh, A Ghor Spring, and the Zarqa River below the King Talal Dam.

For reasons stated elsewhere in their report, it is felt that further examination of water quality in Wadi Ziglab and King Talal Reservoir should precede selection of these locations. The potential for excess or deficit dissolved oxygen and nitrogen in water released from the King Talal Reservoir should also be investigated.

It was noted that Tilapia spp., especially, could be reared in saline spring water (17% to 34% NaCl maximum, depending on species) that could not be used for agricultural purposes. Carp are somewhat more sensitive to high salinity, especially during spawning, although they too can be reared at up to 20% salinity.

Several other approaches to increasing fish production without consuming large quantities of water were also examined in this study. Open stocking of reservoirs (already practiced) cannot produce anywhere near the number of fish per unit area of water that intensive farming can produce. Some form of license sales would be needed to financially support fingerling production. Considering the relatively small size of all impounded waters in Jordan (including the proposed Maqarin Reservoir), it would appear possible that increases in demand for such stocked fish could exceed the productivity limits of these reservoirs. Cage farming, a more intensive open water fish production technology, also would consume no water as cages would be floated in existing reservoirs. In this case, production would be greatest where aeraters are used. Poaching problems, conflicting water uses, and ownership over water rights have been problems in other countries where this is practiced. They may or may not be potential problems in Jordan.

6.4.1.4.6 Agricultural Labor

The 1975 Census of Agriculture reported about 46,000 persons living on or near 6957 farm holdings in the East Jordan Valley.[1] In addition, it reported rather large temporary and casual labor forces, perhaps as many as 25,000 persons. Approximately 30% of farms use family labor only; approximately 60% rely mostly on family labor but supplement it with hired workers, and 10% use hired labor primarily.

[1]Only 6007 farms reported arable land in cultivation.

Table 6-26 presents the 1975 breakdown. Of the 13,392 essentially full-time workers and approximately 25,000 part-time workers, approximately 8000 full-time and 15,000 part-time workers will be in the Stage II project area. This is approximately 2.2 full-time and 4.2 part-time workers per farm at current input and mechanization levels (or 0.6 full-time and 1.1 part-time worker per hectare).

According to the Stage II planning documents, each farm in the Stage II project area would have 1.0 full-time, 0.5 part-time hired worker, and miscellaneous family labor equaling approximately 0.25 of a full-time worker. This would mean 6700 full-time farm operators, 3230 essentially full-time hired laborers each working on more than one farm and probably 7000 to 25,000 part-time family workers.[1] (This assumes 25,353 irrigated hectares shown in the Feasibility Study rather than the 21,750 hectares shown in the "C-1" plan.)

If the typical part-time laborer is assumed to be one-fifth of a full-time worker,[2] then the average Valley farm is currently using 2.62 person-years versus 1.73 person-years for a proposed farm in the "re-organized" project area. This would be a 38% reduction in labor demand per hectare in spite of the shift to more labor-intensive crops, greater cropping intensity, and considerably increased yields, inputs, etc., on the proposed typical project area farm.[3] However, due to hectarage increases and greater cropping intensity, cultivated area requiring labor will increase by 86% in the project area (assuming 21,750 irrigated hectares at a 1.28 cropping intensity, or 100% assuming 25,353 ha).

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[1]The range is this great because it is not known whether in the future the part-time family labor will be provided by one or more family members, which could be as many as eight persons in some families if all available people spend some time in the fields. Changing education and other social factors will tend to influence how many and which family members work part-time on the farm.

[2]This may be overly conservative since many part-time workers may work both at planting and harvesting and, in cases of foreign labor, move from one part of the Valley to another following planting and harvesting seasons.

[3]This includes an adjustment for the difference in size between current and proposed farms.

Table 6-26

Agricultural Labor Force
in the East Jordan Valley--1975

	Permanent	Part-Time Temporary	Part-Time Occasional	Total
Paid (Hired)	1,407	4,395	19,536	25,338
Unpaid (Family)	11,985	536	536	13,061
Total	13,392	4,935	20,072	38,399

Source: "General Results of the Agricultural Census, 1975," Department of Statistics, 1977.

Table 6-27 presents labor estimates under two technology levels and two water availability scenarios. As can be seen from these data, if the project is successful in attaining the desired mechanization level, then no additional on-farm laborers would be required in the project area. (Operators of pooled machinery are not here considered as farm laborers.) In fact, if only 21,750 ha of land can be irrigated in the project area because of reduced water availability, then there may actually be a 15% reduction in farm labor requirements. Unless these persons can find alternative employment (if they are paid workers or dislocated tenant farmers) there will be a possible major economic dislocation for a significant portion of the Valley's population. Some of this impact (but not all) should be mitigated by the growth of non-farm but agriculturally related job opportunities elsewhere in the Valley (e.g., grading and packing facilities, machinery pools, etc.). In addition, since farm incomes should rise, loss of part-time paid work of some family members at the family farm may not cause a net reduction in total family income. However, required skill levels and social status perceptions among Valley residents may not permit a smooth transition to other occupations.

A more likely event in the short run, however, will be a farm labor shortage rather than an excess due to the sudden increase in irrigated area in the south as a result of Stage II. At the extreme, if no increases in mechanization occur, then labor demand will increase by 55% if 21,750 ha are irrigated and by 80% if 25,353 ha are farmed. This would be further intensified by any further move to "plastic cover" production, which is highly labor intensive.

Currently, there appears to be no source in Jordan which could provide, if needed, an additional 6000 to 9000 people willing to work in the agricultural sector (actually more than 6000 to 9000 since this figure represents person-years which equates to 19,000 to 31,000 full- and part-time workers given current employment patterns). Those refugees interested in farming are probably already doing so now.[1] Whereas some

[1]There is an opinion with no data to support it at this time. However, given the potential importance of its implications, the JVA might ascertain if it is correct through sample surveys in the refugee camps.

Table 6-27

Expected On-Farm Labor Demand in the East
Jordan Valley, Stage II Project Area

(Person-Years)

	1979	Full or Originally Planned Water Availability (25,353 ha)	"C-1" Plan Water Availability (21,750 ha)
Current Technology	11,000	19,800	17,000
Proposed Technology[1]	N/A	11,000	9,400

[1] Does not include operators of pooled or for-hire farm equipment, dairy farm employees, marketing and packing personnel, and miscellaneous others. These groups represent an additional 2,400 person years in agricultural production related work, for 21,750 ha; and approximately 2,800 jobs for 25,353 ha.

Source: Arthur D. Little, Inc., estimates.

farmers from elsewhere in Jordan may be attracted to the Valley by the lure of potentially higher income, their family ties, current land ownership, and the inability to own land in the project area will likely prevent this source from providing the necessary manpower. Finally, former farmers or young people from farm families who have emigrated to the city are not likely to return to farming, especially without the possibility of owning land. Thus, it would appear that any significant increase in farm labor demand will require an increased dependence on foreign labor.[1] This could pose social and political implications if not problems not only for the Valley but for the country as a whole.[2]

Some mechanization will occur naturally, without labor shortages or wage increases. However, further significant wage increases or difficulties in obtaining foreign labor would probably hasten mechanization faster than any Stage II programs. Ideally, mechanization will develop at a rate consistent with the availability of labor. However, any quantum and sudden increase in area cultivated (which would result with the completion of the Maqarin Dam) would likely create a labor shortage temporarily. During such a period, farm operators would probably have no alternative but to increase their use of foreign labor. It should be remembered that mechanization will significantly impact all farm activities except harvesting which still must, with a few exceptions, be done by hand. Thus, no matter how successful mechanization, there would still be a significant demand for seasonal labor at harvest.

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[1] If cultural attitudes eventually permit it, the entrance of more Jordanian women into agricultural work could reduce or eliminate any contemplated labor shortage.

[2] Currently, employers are required to provide some sort of housing (presently a room, tent, etc.) for their hired labor. Significant increases in the use of hired labor may put undue pressures on their ability to do so, especially given the design of the village housing projects.

When mechanization becomes the major component of power generation on farms, farm units will be consolidated. This will be an "operational" rather than "owner" consolidation, since the latter is effectively prohibited by the 1977 Jordan Valley Development Law. Optimal use of machinery and equipment generally requires larger contiguous tracts of the same crop than are presently found in the East Jordan Valley. Thus, to justify the purchase of machinery and equipment, farmers will be pressured to farm larger and larger tracts of land. Since approximately 60% of the land is not farmed by its owner, it is likely that the larger and/or more progressive farmers, be they landowners, renters, or sharecroppers, will bid the land away from the smaller, less progressive, and/or less agressive renters/sharecroppers. This may be desirable to many landowners who rent their land, since they could thus interact with one farmer rather than several. Some "operational" consolidation has already occurred. If it continues, it will create a fairly large group of displaced farm operators who much either hire themselves out as farm workers or seek other employment. However, this impact could be blunted at least partially if proposals like the JVFA machinery pool are effectively established and administered for the benefit of all farmers no matter how small.

6.4.1.4.7 Irrigation

Currently the Stage II area contains slightly more than 14,000 irrigated hectares, of which nearly 12,000 are irrigated from the EGMC. The remainder receive water from on-farm wells and side wadis. Most fields use surface irrigation; some use drip irrigation; very few now use sprinkler systems.

In the past three to five years, an increasing number of hectares have been irrigated with drip systems; but to date, no comprehensive survey has ascertained exactly how many. However, in 1978, Steitieh and Abbas [6-46] found that nearly 50 ha were using drip systems (10% of plastic tunnels and 37% of plastic houses). With the growth in the use of plastic houses (to an estimated 600 ha of tunnels and 65 to 70 ha, or a 100% increase in one year) and the increased familiarity with drip, it is probable that the number of ha will have doubled by the end of 1979. In addition, a survey by Hyslop [6-48] indicated that 30% of the tomato farmers in the Valley (nine in a sample of 30) are using drip systems with plastic mulching. These nine farmers were irrigating approximately 150 ha. An unpublished survey of the Faculty of Agriculture, University of Jordan, conducted in 1978-1979 indicated that approximately 1700 ha were presently irrigated by drip systems in the Valley (80% in open fields; the remainder with plastic mulching or tunnels). Consequently, based on these studies, it is possible that over 10% of the irrigated land in the project area is already using drip irrigation. To date, no serious salinity problems have been reported, but salt suildup is beginning to be seen.

Water is currently allocated to farms by opening floodgates for a specified number of seconds which represents a specified volume of water for which the farming operation is then charged. The actual water volume is not measured, just the time the gates are open. Farms generally receive water once per week, although this may vary based on water available in the EGMC and other factors. Apparently, the water is allocated on a surface rather than crop basis,[1] although farmers do vary water usage from crop type to crop type. In the recent past, water charges were 0.003 JD/m^3. Only recently, they were increased to 0.006 JD/m^3, with stepped increased likely in the future until 0.020 JD/m^3 is reached.

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[1]That is, the surface operated rather than the water requirements of the crops being grown.

Harza estimates that an average ha in the project area would use 10,910 m^3 of water annually, assuming current crop intensity, cropping patterns, and irrigation systems (surface, at 55% efficiency).

The soils in the project area are comprised of two broad groups: Non-saline in the area north of the Zarqa River, and saline in the area to the south. The soils are very permeable, and tests show that with proper leaching nearly all soils can be reclaimed for irrigation purposes. The soils are rather low in organics, highly alkaline, low in nitrogen, high in potassium, and average in phosphorous. The salt level in the soil is influenced mostly by upward migration of moisture from lower levels. This is controllable if sufficient water is infiltrated into the soils to provide downward movement of the salts. This is manageable with irrigation as is evidenced by adjacent lands having 2% and 0.2% salt, with the latter having been irrigated and farmed and the former left in an undeveloped state. Essentially, it can be concluded for the project area that if water used for irrigation is low enough in salts to permit its use for farming (which is the case today), then soils will be low enough in salts (if managed properly) to permit agricultural production.

The proposed Stage II irrigation project will bring 7700 ha of unused land under cultivation through land reclamation (clearing, leveling, rock elimination, and leaching) and sprinkler irrigation. In addition, it will convert approximately 14,000 ha of 55%-efficient surface irrigation to 70%-efficient sprinkler irrigation.[1] Under the proposed cropping intensity (1.28 crops per year) and patterns, each ha in the project area would use an average of 10,096 m^3 of water annually

[1]The 70% efficiency is for the overall project given canal evaporation. Farm efficiency of the sprinkler system itself is 75%.

(actually 10,019 at the farm). The sprinkler system will be a two-line system (one wet, one dry) provided to the farmers at a subsidized price of approximately JD 250 per ha[1] (actual cost is JD 550 per ha).

No insurmountable difficulties are foreseen with respect to developing the currently unused lands for irrigated agriculture provided enough water becomes available for both reclamation and eventual production. The reclamation process and recurrent leaching through the years will increase the salt levels in drainage waters. However, this is not expected to pose problems for agriculture, since the drainage waters will seldom reenter the system supplying agricultural water.[2] Erosion may occur in the south on those lands already cleared, and in some cases levelled, if they are not farmed soon; the most probable reason for non-farming will be lack of water resulting from diversion for M&I uses.

The actual quantity of water used under the proposed project will not differ that dramatically from the quantity currently being used on an average irrigated hectare basis (i.e., a reduction from 10,733 m^3 today to 10,096 m^3 with the proposed system, a 5% decrease in water use per hectare). This relatively small reduction in the face of considerably greater system efficiency (55% to 70% results from an associated increase in cropping intensity (from 1.06 to 1.28) which requires additional water utilization.[3] This change in water usage is not expected to pose any problems with respect to salt buildups in the soil. Drainage water will likely have higher levels of farm chemicals, however, as is discussed in detail in the following section.

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[1]Based on conversations with Dr. John Hyslop, U.S. AID, Amman, Jordan. This estimate was derived by dividing the amount of the loan money available for sprinkler equipment by the area for which the equipment was purchased and adding 50% to this amount. No explicit estimates were made for the cost of transport in Jordan, handling, assembly, storage, interest, etc.

[2]Drainage will be into the Jordan River and Dead Sea.

[3]Actual water savings would be greater than 5% if current cropping intensity is already 1.14 (versus 1.06) as some sources indicate.

The irrigation system proposed under Stage II does not consider key factors:

- Disease impact of sprinkler systems on vegetables,
- Move to and potential attractiveness of drip systems,
- Irrigation requirements of farms using plastic coverings, and
- Means by which farmers will be convinced to adopt sprinkler irrigation.

Tomatoes and other vine crops are susceptible to a wide range of fungal and bacterial diseases frequently induced by high humidity and/or free water conditions. Thus, production of these crops is best under conditions of low humidity and controlled water. Already between December and March, humidity levels are periodically severe enough to cause serious disease problems. Under such conditions, sprinkler systems are likely to increase the frequency and severity of those diseases. [6-49] While research may eventually show that those disease problems can technically and, perhaps, economically be controlled through proper management and improved pesticide application techniques, that is not now the case.

Tomatoes are grown on 2500 to 4000 ha annually in the project area. Other vine crops susceptible to humidity and free water induced diseases, such as cucumbers, peppers and eggplants, comprise another 2000 to 3000 ha. Thus, in any given year, there may be 5000 to 7000 ha which would not currently be adaptable to sprinkler irrigation. Given crop rotation patterns, the area unsuited to sprinklers would be even greater over time, perhaps approximately one-half of all the irrigated hectarage in the Valley. Therefore, until the disease problems can be resolved, a large portion of the project area cannot effectively employ the proposed sprinkler system without risking severe potential crop losses.

It should be noted that at the Donors meeting in April 1977, freedom of choice between drip or sprinkler was stipulated. This policy has now been adopted by the JVA.

Drip irrigation is frequently cited as being 30% to 50% more water efficient than sprinkler systems although this savings may be reduced considerably if significant leaching is required. This factor along with the disease problems associated with sprinklers and the adaptability of drip to plastic-cover farming have caused an increasing quantity of land to be irrigated with drip systems. This is in spite of the high cost of drip (approximately three times the cost for a two-line sprinkler system). In other words, to date, drip irrigation has apparently proven economically satisfactory given growing conditions in the Valley. Therefore, unless salt problems prove unmanageable with drip (and they need not be), then it is highly improbable that all Stage II hectarage will be converted to sprinklers as was initially proposed; indeed, already numerous farmers (30% of those interviewed by Hyslop) [6-48] are negative as to the merits of a sprinkler system. Thus, the impacts of the project must be evaluated in light of a mixed irrigation system--possibly drip-and-sprinkler; possibly drip-and-sprinkler-and-surface. All systems are possible since JVA will be delivering water by pressure pipe to the farmer to do with as he feels best.

Without periodic leaching, drip irrigation typically causes salt buildup outside a cone shaped area directly below the drip nipple or nozzle. This poses problems for broadcast crops (e.g., small grains) and could eventually cause problems even with row crops planted directly over the salt-free cone. Consequently, leaching or pre-irrigation is recommended annually, although it is possible in some cases to delay this process for several years. If delayed, the quantity of water required to leach will be greater than if done annually but probably less than the multiple of the annual leaching required times the number of years leaching was not undertaken. Given the necessity of periodically leaching land using drip systems,[1] the increase in efficiency of drip over sprinkler

[1] Even with a sprinkler system, in areas of high salts, leaching, pre-irrigation, or over-irrigation is often required to keep salt levels down. It is assumed that the Harza data reflect any water use for this purpose.

may be only 15% to 30%, rather than the 30% to 50% when the leaching requirement is not considered.

Since leaching will be required at some time with a drip system, the utilizer of such a system must eventually consider employing an alternative irrigation system--either sprinkler or flood--on the same land. This will likely require additional capital investment for equipment or land levelling unless the land is already adaptable to flood. Water availability and economics and terrain considerations will dictate how the farms will approach the need for leaching. Currently, those operations using drip have either not yet been confronted with the need for leaching, or their land is sufficiently level to permit flooding (which may be being done for reasons other than leaching, e.g., to grow a grain crop as part of a crop rotational program).

Stage II planning as described in the Feasibility Study also has not taken into account the irrigation needs on the increasing quantities of land under plastic tunnels and houses (currently 1000 to 1100 ha). While some types of sprinklers can be adapted to some types of crops in plastic houses, the types of sprinklers presently available in the Valley and the crops currently grown in houses there are not compatible. Nor are sprinkler systems as effective as drip systems with plastic tunnels and mulching.

One final technical caution should be made about drip irrigation. When water is applied regularly, the root systems of the irrigated plants tend to become shallow. Consequently, such plants are less tolerant to any interruption in their water, be that interruption caused by technical or institutional reasons.

Managing an irrigation system effectively, whether at the farm level or the project level, is exceedingly complex, especially when a variety of crops with different water requirements using different irrigation systems are grown throughout the year on a variety of saline-susceptible soils. Arbitrary divisions regarding timing and quantity of water release can have disasterous results.

Unfortunately, published Stage II planning documents to date (April 1979) do not describe what organization will be ready after completion of the Maqarin Dam to manage farm water releases for the maximum benefit of all. In addition, there appears to be no effective mechanism currently for evaluating water release options and for ensuring the adoption by farmers of irrigation procedures and systems which will ensure optimal utilization of available water. However, JVA reports that it intends to start soon its intended Water Management Technology Project to meet these pending needs.

For example, currently the project area faces the probable loss of 3600 ha which originally were felt to be irrigable from the proposed Maqarin Dam. The question obviously arises as to which 3600 ha will not be irrigated. Three principal options exist with numerous variations and combinations:

- Complete all proposed canal extensions, develop all proposed lands for cultivation, and simply reduce water allocations to each farm by one-sixth, thereby permitting the farmer to decide which lands to irrigate and at what level.
- Complete all proposed canal extensions, develop all proposed lands for cultivation, and remove from production, no matter where located or who owns them, the 3600 least productive hectares.
- Do not extend the canal for the southernmost proposed 3600 ha.

Each of these options poses a set of unique considerations or impacts regarding equity to farmers, foreign exchange, production, water utilization, and village development. The parameters and ramifications of

this problem are apparent to JVA, which acknowledges its responsibility and reports that it is addressing these important questions.

In addition, with respect to current water management in the Valley, neither the JVA nor others have yet redesigned traditional water allocation procedures such that optimal water utilization will ensue. Given current water prices and availability, there is little incentive for farmers to adopt more efficient irrigation systems. Drip systems which have been adopted have been implemented primarily for reasons other than increasing water efficiency or reducing water cost; for example, they were often adopted as part of new, more productive farming systems such as those associated with plastic coverings. This use has been primarily outside of the EGMC, that is, in gravelly soil supplied from wells.

JVA reports that it will control the future allocation of water by specifying the types of crops and the percentage of land to be allocated to each type of crop. This type of control will be necessary to avoid potential shortages of irrigation water because of poor utilization. Unfortunately, however, while this approach may be efficient for water allocation purposes, it may not adequately address production economics and crop prices of the "acceptable" crops to JVA. As a result, unless JVA selects crops based on analysis of both water and economic considerations, farmers are apt to suffer financially more than is necessary.

6.4.1.4.8 Farm Chemicals

Pesticide application methods are discussed in Section 6.4.1.4.4 and types and quantities in Appendix J. Farmers generally receive their information about pesticides from salesmen, other farmers, landowners (with their tenants), and extension agents in roughly that order. Since two-thirds of Valley tenants are illerate, most usage information is conveyed verbally and/or through demonstration.

Once a farmer has adopted the use of a chemical, there may be follow-up with respect to efficacy but none regarding safety. Thus, since so many farmers cannot read the manufacturers' literature regarding handling procedures, there is a high risk factor (relative to the United States, etc.) associated with potential human, animal, bird, or bee poisoning.

If Stage II is implemented as planned, there would be a considerable increase in pesticide usage in the project area. Reasons for this increase are:

- Increasing the number of hectares which have more than one crop per year (i.e., cropping intensity increased from 1.06 to 1.28 in the original Harza Feasibility Study);
- Converting 7700 ha of land from non-farmed to farmed;
- Employing sprinkler irrigation which will likely cause considerable increases in fungicide usage on several crops;
- The proportionate shifting away from field crops to fruit and vegetable crops which require more chemical pesticides;
- Promoting mechanization, which increases the ease of using pesticides (already the JVFA is purchasing pesticide application machinery for use by its members); and
- Promoting advanced farming techniques which often lead to increased pesticide usage.

Assuming the cropping intensity, cropping patterns, and pesticide usage levels reflected in the Harza reports, the intensity of pesticide usage on currently cropped land will increase by 475%. Total usage in the project area will increase by about 700% when all 21,750 ha in Stage II are cropped. (This does not include any consideration of the increasing use of plastic tunnels and houses, in which more pesticide is used than on open field grown crops.)

Obviously some increase will occur whether or not Stage II is implemented, simply due to normal changes in farming practices. However, the project would still cause per hectare pesticide intensity to increase by 100% and total use in the project area by even more.

Regardless of whether the baseline is today's situation or a future "without Stage II," the next 10-15 years will likely see a great increase in both the intensity and the total quantity of pesticides. This prospect is worrisome given such high usage in the Valley's relatively small area, the illiteracy of farmers, the inability of extension agents to supervise, and the often highly toxic and carcinogenic compounds used in pesticides. Although published documents do not show planning to prepare for these potentially dangerous circumstances, JVA reports that it has assigned JVFA as the sole agency responsible for proper pesticide management.

Chemical fertilizer use is also expected to increase by approximately 90% on the average hectare (actually composite hectare) already under cultivation. For the project area as a whole, total chemical fertilizer usage is expected to increase over current levels by 190% when 21,750 ha are irrigated. However, since fertilizer usage will increase with or without the project, due to the continued improvement in farming practices in the Valley over time, the actual difference in usage with and without the project will be only about 55%.

These fertilizer increases are not likely to pose any significant soil, health, or other problems. The one exception may be contribution to the deterioration of water quality in the Jordan River. Application methods, while generally by hand, should not create health problems among farm workers.

6.4.1.4.9 Livestock

While the livestock activities (primarily dairy) discussed by Harza as part of Stage II will potentially provide employment and nutritional benefits, these livestock projects in themselves will not depend on the provision of additional water. Consequently, their environmental impacts were not evaluated. Nonetheless, other livestock matters important to the success of Stage II are discussed below.

One Valley resident stated: "More than half the families have sheep, less than half have cows, every house has chickens, very few have horses or mules, and most have donkeys." This summary is generally confirmed by the 1975 agricultural census, showing the following populations of livestock and poultry:

Livestock	
Sheep	23,625
Goats	21,477
Cattle	3,929[1]
Donkeys	2,767
Horses, Mules, Camels	378

Poultry	
Chickens	111,450
Pigeons (pairs)	2,458
Ducks and Geese	1,443
Turkeys	1,357
Rabbits	13,196
Beehives	2,187

Currently, sheep and goats owned by Valley inhabitants are grazed in the Valley on grass from the end of May to early September. (During this period, crops generally are not grown, and so most of the land is open to grazing.) In September, owners begin feeding a supplement while

[1]Practically all of these are dairy cattle or replacement heifers.

keeping their animals in the Valley through much of the winter. In mid-February, the animals are moved out of the uplands to graze until May, when they are returned to the Valley for the cycle to begin again.

In general, Stage II is expected to have no significant impact on livestock and poultry numbers in the Valley. However, two impacts are possible on local livestock:

- If the project succeeds in encouraging the growing of more vegetables and other crops in the summer (which may be doubtful except for berseem and some grains), then the land traditionally available for summer grazing may be reduced. Additional grain and fodder is not expected to be grown to compensate for this loss, and hence it is less certain whether livestock owners would benefit financially because they may have to purchase the feed which is now free as grass.
- JVA's planned villages, with their small lot sizes and restrictions on keeping animals, will hinder families owning livestock and poultry. This could negatively affect nutritional intake.

Finally, with the expected increase in the intensity use of certain insecticides highly toxic to bees, it is probable that, unless considerable care is exercised by both pesticide applicators and beekeepers, the Valley's bee "industry" will be affected adversely.

6.4.1.4.10 Agribusiness Enterprises

No available survey included data on the agriculturally related businesses and services in the project area. In addition, except for those

associated projects noted in Section 4.9.2, JVA's Stage II planning documents do not suggest other agribusiness activities expected from the project. Consequently, comments can be made only on first-hand observations of businesses in the Valley, ones cited in reports, others which were mentioned in interviews, and logical projections based on the Valley's current state of agribusiness development.

Numerous small-to-medium sized agriculturally related businesses will develop or expand in the Valley as a result of the project. Those most likely to be found by 1990 are:

- Bulk blending fertilizer facility
- Pesticide formulation operation
- Custom equipment operators[1]
- Jam, jelly, etc., factory
- Commercial cheese production
- Fruit and vegetable grading and packing facilities[1,2]
- Machinery and equipment sales, modification, and repair businesses[1]
- Grain and fodder storage
- Feed mill
- Box/crate production[2]
- Plastic pipe production[3]
- Farm supply stores[1]
- Vegetable seed production
- Transportation and marketing services[1]
- Governmental services:[1] Credit, Cooperatives, Research, Extension, and Water Management

None of these enterprises, at the scale contemplated and if properly managed, should cause significant environmental damage. However, if it does occur the greatest danger probably lies in waste disposal, as

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[1]Already exist at some level of operation.

[2]New facilities already planned.

[3]Already being produced in the Valley.

compared to air pollution, worker safety, etc.[1] Unfortunately in most developing countries, little attention is paid early in the development process to disposal procedures for industrial wastes. Consequently, water, soil, and odor pollution do often occur. It is probably inevitable that the Valley will also experience some waste-related problems.

With the exception of perhaps a central machinery pool and/or some large government of quasi-government organization, no single business seems likely to employ more than 50-75 workers, unless production eventually is to supply markets outside the Valley. However, it is not unreasonable to expect that by the 1990's all of these enterprises in combination will provide 2500-3500 jobs, most of which do not exist now. While local training will be able to provide many of the requisite skills, much of the key manpower will have to come from elsewhere in Jordan and from other countries.

6.4.1.5 Valley Infrastructure

6.4.1.5.1 Transportation

The road system within the impact area consists of 10 primary and eight secondary roads; the network and traffic districts are shown in Figure 6-6. The major north-south roads are Route 45 (the Yarmouk-Dead Sea Road), paralleling the Jordan River in the Valley, and Route 15, along the uplands, which connects Amman with Syria and Aqaba. These two roads are linked by three primary roads; Route 16 in the north, which passes through Irbid and extends to Mafraq; Route 24, which joins near Salt on the way up the escarpment, and Route 30 in the south, the Amman-Jerusalem Highway, which continues to Zarqa and Mafraq.

The Valley settlements are all within short distances of Route 45 or along connecting village roads, due to the physiography of the Valley.

[1]The exception being pesticide formulation and custom pesticide application.

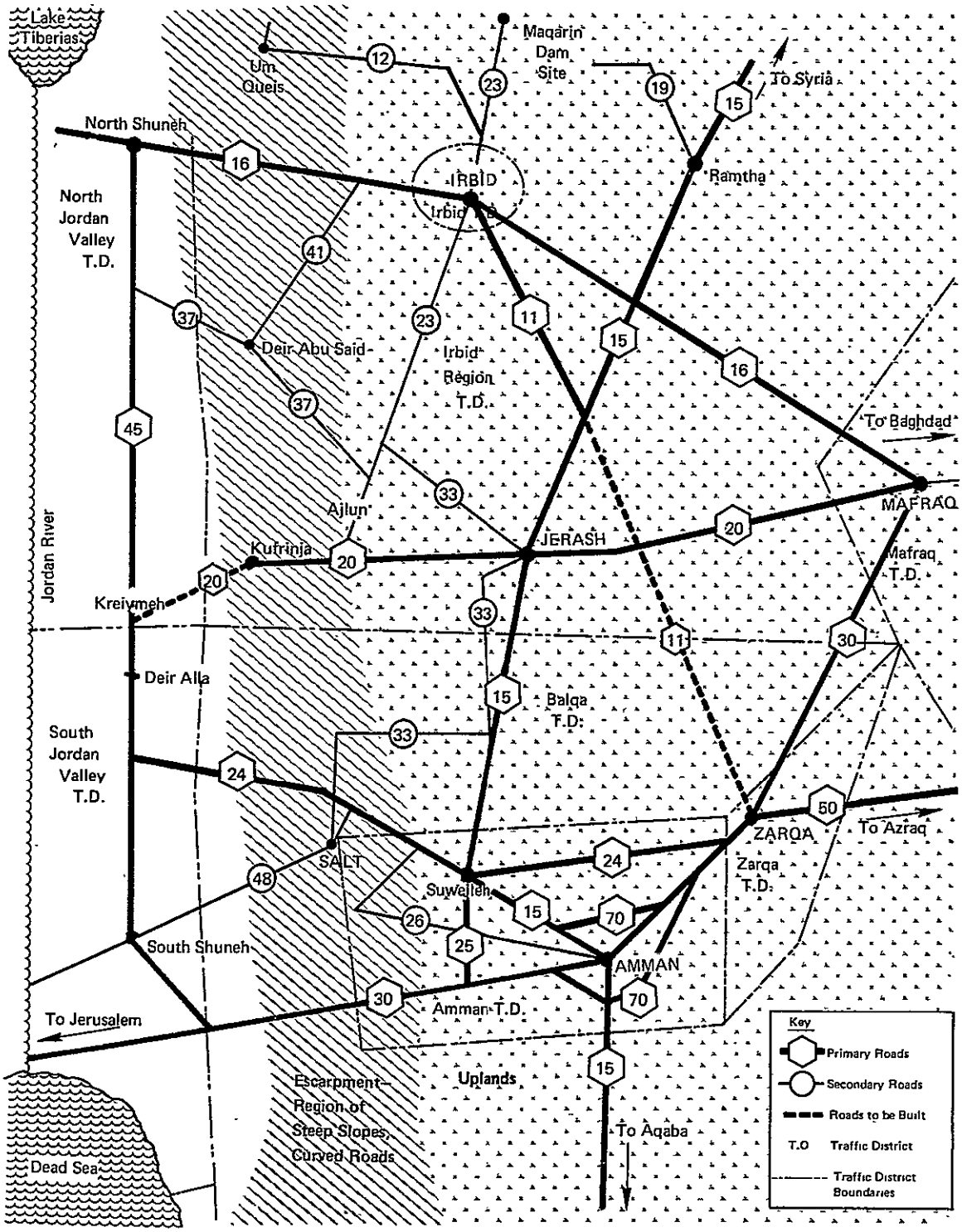

Figure 6-6

Transportation Network
(not to scale)

The upland villages, however, are often less easily accessed because of the mountainous terrain. While the village roads are, for the most part, single-lane, unpaved surfaces, both primary and secondary roads outside the Amman-Zarqa region are paved two-lane roads, although often without shoulders. In the more heavily developed region within and around Amman, are modern four- and six-lane roads.

While the Maqarin Dam project will cause some impact on the road system, it will have negligible impact upon other transportation modes. The increase in agricultural produce which will result from the project will require additional truck transportation from the Valley to the markets of Amman, Irbid, and Syria.

For analytical purposes, the Ministry of Public Works (MPW) has conducted average daily travel (ADT) and vehicle mix counts on all primary and secondary roads and has divided the country into traffic districts, seven of which fall within the impact area. In addition, each road was measured and analyzed for deficiencies along its entire length. Route deficiencies include poor surfaces, inadequate lane or shoulder width, geometry (banking, curves, etc.) and lower levels of service--the ratio of safe speed to operating speed. As of 1976, 71% of the country's major rural road system (excluding village roads) and 52% of the major urban roads were found to be below tolerable conditions. [6-7]

The model used by MPW's contractor, Wilbur Smith and Associates [6-7], to predict traffic conditions for the year 2000 as a function of population and socio-economic factors, incorporated assumptions based on plans for both National and Jordan Valley development. Statistics and projections for population, trip ends, car ownership, and agricultural and industrial production available by districts partly or completely within the impact area are presented in Appendix K.

Overall traffic as represented by district trip ends should double on the average within the impact area. This, in addition to road deterioration could lead to service level deficiencies in the corridor north of Amman. Several roads, including Routes 11, 15, 16, and 20, will probably require major improvements by the year 2000.

Within the Valley, Route 45 presently handles such a low level of traffic (1100 cars per day) that doubling the volume on this primary road will not have a noticeable impact on its service ability. Currently, there is heavy congestion on Route 45 at the major marketing towns of Mu'addi, Kreiymeh, and Manshiya throughout the day, as both heavy and light duty trucks line the roads within the town. The construction of the three JVFA Agricultural Marketing Centers at North and South Shuneh Deir 'Alla will alleviate this problem by shifting this activity off Route 45.

The projected increase in Valley population, income, and therefore, car ownership should have a small effect on village roads. Although these roads are mostly single lane and unpaved, their geometry is such that reaching high speeds (above 30 mph) is usually impossible. Therefore, road surface erosion is not likely to be significantly affected by the increase in traffic volume.

Transportation of agricultural produce from the Valley on light (60%) and heavy (40%) trucks is predominantly on Routes 16, 20, and 24. Truck traffic is heavy (55% of the total) on Route 30, but it is not clear from ADT's what fraction is related to the Valley. If it is assumed, that only half the truck traffic on Route 30 is from the Valley because of the smaller proportion of irrigated land in the southern Valley, below the EGMC, the total number of truck trips leaving and entering the Valley transportation network is about 3100 daily. Agricultural production is scheduled to double by the year 2000, and it is likely that the truck volume will also double. The current proportion

of heavy to light trucks (2:3) should shift towards heavier, larger capacity vehicles as the marketing function is streamlined, reducing the ADT for trucks for the year 2000 slightly from 6200. The increase in traffic volumes and associated congestion could delay the arrival of agricultural produce at the final market, thereby causing higher percentages of loss of some fresh fruits and vegetables.

The completion of Route 20 will shift some of the traffic away from Routes 24 and 16. However, Route 20 is an already congested road between Ajlun and Jerash, because of the combined effect of narrow lanes, hills and slowly moving vehicles on a two-lane, heavily used road. Serious consideration should be given to the proposed Zarqa River Highway as it would divert a large proportion of the future Valley traffic from the existing roads and avoid serious bottlenecks. This highway should be at least two-lane with a third lane for passing on long hills.

Transportation impacts related to the pipeline supplying M&I water to the major upland cities are difficult to identify. There probably will be some increases in industrial production and, therefore, volume of goods transported, but segregation of with-project growth from without-project growth is practically impossible. In any event, the most serious transportation problem facing Jordan now and in the future, is the high accident rate which results primarily from poor driving and dangerous road geometry. Within the Valley, the proposed realignment of Route 45 around each town to avoid its commercial strip would separate through-traffic from local and pedestrian movements and should reduce accidents.

6.4.1.5.2 Communications

At present, the communications system of the Valley consists of post offices in the major villages, plus emergency telephone service provided in the police stations. There is no basic telephone service available yet, although a JVA-commissioned telecommunications feasibility study was completed recently. Eventually, the Valley would be connected to the upland cities and the rest of the world through the microwave system which is now being implemented in the rest of the Kingdom, but no funds have yet been obtained for this project and no timetable established. Meanwhile, the police facilities, two-way radios, and special equipment provided in JVA and other government offices afford the only voice communications out of the Valley. While this level of service may be tolerable as an interim measure, the Valley's economic development will eventually require telephone service at least to the same level as that provided in the upland parts of the Kingdom.

While direct voice communications facilities are not yet generally available, there is widespread use of battery-powered and direct-source radios. This provides Valley residents with their principal source of information and communications from the outside world. The introduction of electricity to the Valley has caused television to become more popular, even though there are problems of program reception. Providing facilities to improve television reception from Amman would apparently be a popular measure with Valley residents. In the Arthur D. Little, Inc., survey, electricity was the second most frequently mentioned village need after potable water.

6.4.1.6 Tourism

Both the Jordan and Yarmouk Valleys are expected to play important roles in Jordan's plans to increase tourism as a major source of foreign income. In 1978, the JVA commissioned a study of the tourism potential of the entire Jordan Rift Valley, including the Jordan and Yarmouk Valleys, for which the first phase has just been completed. (The result of this study was not available for the preparation of this environmental assessment.)

The major features of the two valleys for tourism and recreational development are discussed in the following sub-sections going from North to South.

6.4.1.6.1 Maqarin Lake

The lake to be formed by the construction of the Maqarin Dam will be located in one of the most scenic, interesting, and strategically located areas in the Kingdom. The lake will form in four separate valleys in Jordan and Syria which come together at Maqarin, which was the site of one of the most important battles in Arab history.

It was here on the Yarmouk on 15 August 636 A.D. that Muslim armies won one of their greatest victories over the Byzantine Emperor Herclius, a victory which gave them control for the first time over most of Syria.

The area has the potential for a lakeside resort and recreational activities--resort hotels, camp grounds, boating, and fishing. When the reservoir is filled, it will constitute the largest body of water in northern Jordan, within easy range of Amman for day trips and picnics.

If proposed salvage excavations are carried out on threatened archaeological sites within the reservoir area over the next six years, a major regional museum could be built at Maqarin Lake to display the finds. The reservoir area is rich in remains from the Paleolithic, Neolithic, Early Bronze Age, Roman, and Byzantine periods. While such a museum could never compete with major standing ruins at sites like Petra and

Jerash, it could provide just as interesting a tourist attraction by showing the history and cultural and economic changes of a single area over more than 100,000 years of continuous occupation. Dioramas[1] and wall-sized photographs could be utilized to show the Valley and its historic and archaeological sites as they were before the reservoir existed. One could bring to life the prehistory of the Maqarin area by reconstructing within the museum the living floors from salvaged Paleolithic sites, with original bones and artifacts in situ to demonstrate the life style of inhabitants at the dawn of Man more than 100,000 years ago.

With such a strong combination of recreational and archaeological attractions, Maqarin Lake could become a major stopping point for one- or two-day tours originating in Amman, or for tourists entering Jordan from Syria.

One of the few negative aspects of developing the Maqarin Lake area will be the major fluctuations of the height of the reservoir in different seasons and in different years. Besides raising and lowering the reservoir's shoreline by as much as 50 m or more, such fluctuations will during low periods substantially reduce the surface area of the reservoir. In planning the location and siting of lakeside facilities, such fluctuations should be taken into account.

6.4.1.6.2 The Jordan Hemma

Downstream of the dam on the Yarmouk River is the Jordan Hemma, one of the most popular of Jordan's hot springs, which is heavily used on weekends by visitors from Amman, Irbid, and Damascus, Syria.

These hot springs were used at least as early as Roman and Byzantine times. The remains of the Roman baths here could be excavated and

[1]Scenic representations in which a partly translucent painting is seen from a distance through an opening, or sculptured figures and lifelike details are displayed in miniature to blend with a painted background.

reconstructed as an additional tourist attraction.

On the hillside above Hemma lies Um Qeis, one of the cities of the Roman Decapolis. Um Qeis was an important center of learning in the Graeco-Roman period, with a university that produced the prolific poet Meleager and other major writers of the day. The site has a significant setting overlooking the Jordan and Yarmouk Valleys, as well as Lake Tiberias. Among the standing ruins are two impressive basalt amphitheaters which will be restored by the Ministry of Tourism and Antiquities. There are also plans to uncover the city wall and roof early churches on the sites. Since most of Um Qeis still lies buried beneath the adjacent village, there are plans to move the village so that more of the site can be excavated and exposed. Future five-year plans ought to place much greater emphasis on such excavations, because with a major program of excavation and restoration, Um Qeis has the long-term potential of becoming a major international tourist attraction as impressive as Jerash.

6.4.1.6.3 Pella

About half way between the Yarmouk and the Zarqa Valleys lies Pella, site of another of the Graeco-Roman cities of the Decapolis. Located in the Wadi Jurum just east of the town of Meshare, Pella has a beautiful setting on the banks of a perennial stream overlooking the Jordan Valley. Although the exposed Roman ruins here are not yet extensive, the site already has potential as a tourist attraction. Continuing excavations at the site should enhance its future attractiveness as well. The Ministry of Tourism and Antiquities has already built a structure on the site which eventually will house a museum for the site. Pella would make an excellent brief stopping point on archaelogical tours of the Jordan Valley.

6.4.1.6.4 The Zarqa Valley

The Zarqa Valley is in the center of the Jordan Valley, where the Zarqa River joins the Jordan River to form the Zarqa Triangle which is another area with substantial tourism and recreation potential. The attractions of this area include hot springs along the Zarqa River, the major excavations of Iron age, Bronze age, and Biblical sites in Deir 'Alla, Tell es-Sa'idiyeh, and along the Jordan River (including the site of Christ's baptism) and the scenes of the development of the Jordan Valley itself--the villages, fields, and landscape. The Ministry of Tourism and Antiquities is planning to build a regional archaeological museum at Deir 'Alla to house the finds from this and other major sites being excavated in this area. Such a museum should considerably enhance the area as a tourist attraction. In recognition of the strategic and touristic importance of the area, the JVA has already located its visitors and conference center on a hill above the Zarqa overlooking the fields and villages of the Triangle.

6.4.1.6.5 The Dead Sea

The north end of the Dead Sea--only 40 minutes by road from Amman--holds the potential for a major tourism and recreation center for both local and international visitors. While the present beach facilities are small and in poor condition, there is the potential for rehabilitation of the beach areas along with the development of a resort village at Sweilah on the hill overlooking the Dead Sea. The popularity of the southern part of the Valley as a winter resort area is already in evidence by the fact that a large number of the applicants for the new housing constructed in the villages near the Dead Sea have been from residents of Amman and other upland cities seeking second homes near the Dead Sea.

6.4.1.6.6 Ghassul

Only 3 km from the Dead Sea, Ghassul could become a tourist attraction with the construction of an on-site archaeological museum showing the finds from the site over the past 50 years and using dioramas to show

lifestyles and local economies here between 5000 and 3000 B.C., a critical period in this area for man's development. Important frescoes were found by the British in recent excavations at Ghassul and are being restored by UNESCO experts. With some effort, Ghassul has almost a comparable potential to Jericho, on the occupied West Bank of the Jordan River.

This part of the East Jordan Valley, known in the Bible as the "Plains of Moab," also is rich in Biblical history. As more Biblical sites are excavated in this area (such as Tell Nimrin; see Section 6.4.1.1), they, too, could be developed as tourist attractions.

The only negative aspect to developing the Dead Sea is that its water level appears to be dropping steadily, which makes the beach line singularly unattractive. Recent announcements by both Israel and Jordan to study the development of hydroelectric power by dropping ocean water to the Dead Sea could stabilize the water level in the Dead Sea.

The development of a tourism program for the Valleys will be one of the most important new activities of the JVA in the immediate future. In order to create a viable program with projects that can be financed and supported politically, a major effort will be required to design and measure the potential impacts of activities in each of these areas.

6.4.2 Upland Areas

While the Maqarin Dam and related projects were conceived and planned primarily to provide water to the East Jordan Valley for agricultural irrigation purposes, the provision of some M&I water for the major cities in the uplands was always an important feature of the program. However, the recent reallocation of the water supply to substantially increase M&I at the expense of agricultural service is a major change in national policy, the consequences of which are not fully identifiable at present. The general effect of these changes will be to reduce the emphasis (or at least extend the timetable) on creating new irrigated agricultural land in the Valley and increase the availability of water to handle urban and industrial needs.

The reasons for this shift in water allocation policy stem from the problems being created by rapid urbanization. The most recent population forecasts for the upland urban centers and their hinterland anticipate continued high annual rates of increase.[1] For the city of Amman an average rate of 5.0% per year is expected over the next 20 years, while for the cities of Irbid and Zarqa the average rate is expected to be 4.0% to 4.5%. By comparison, most of the fast growing U.S. metropolitan areas in the "Sun Belt" have been expanding at rates of 3.2% to 3.5% per year during the 1970's, with the exception of Phoenix and greater Tampa which have annual rates of about 4.3% to 4.5%. While these forecasts have been made without the results of the 1978 census, the level of expectation of growth are probably quite reasonable given the recent trends in vital statistics in the Kingdom.

The implications of these forecasts are that by the year 2000 the city of Amman will at least double in population to about 1.6 million while the city of Zarqa and the rest of the Governorate of Amman will have an additional 1.4 million people. The city of Irbid's population will be about 350,000 by the year 2000 while the rest of Irbid and its hinterland will have 650,000 people, about half of them living in smaller cities and towns.

Urban growth of this magnitude makes the problem of supplying M&I water a vital concern. Neither the Amman nor the Irbid regions have adequate supplies of water for their present populations. When the problem of allocating new water resources is brought into focus, the needs for the agricultural development of the East Jordan Valley, which has the capacity to support at the maximum about 150,000 people, are automatically weighed against the needs of Amman, Zarqa, and Irbid -- with a collective population of about 2 million by 2000. The result has been the decision to allocate more water to these urban centers from sources originally designated for the East Jordan Valley.

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[1] Forecast prepared by JICO (Japanese International Consulting Organization) for the Irbid region and by the Amman Regional Planning Group for the Amman region.

6.4.2.1 The Amman Region

The City of Amman and the area within 30 km of its center already contain 62% of the Kingdom's population and close to 90% of its industry. About 350,000 additional people are expected to be living in this area in another five years, with the total population reaching 3 million by 2000. With its size, concentration and expected growth, the needs of the Amman region for new and improved infrastructure and services will be very large well into the future. As a result, major investments in public facilities and services are planned just to keep up with the demands of this growth. The diversion of water to Amman from the Maqarin source is one of the important improvements required just to keep up with this sizeable growth.

At present, water utilization in the Amman region is running at about 45 l/c/day. While higher than other urban centers in the Kingdom, it is still well below the standard of 170 to 180 l/c/day common in equivalent metropolitan centers in the Middle East. The M&I water is currently supplied by wells tapping two aquifers, which are being depleted at a high rate without being sufficiently recharged. About 85% of municipal sewage is currently collected in cess pits, the untreated overflows from which find their way back into the aquifer resulting in serious nitrate build-ups. A modernized sewage collection and treatment system is one of the highest priorities in the plan for the greater Amman region, and a major sewage treatment plant is planned for the Zarqa region. The effluent from both plants will eventually discharge into the Zarqa River which flows into the King Talal Reservoir.

Thus the major impact of the Maqarin Dam and related projects will be to supply a significant portion of the future needs of the Amman region with a larger supply of higher quality water than would be possible relying on existing sources. This supply of water is not expected to induce new growth to the Amman region, but merely to keep up with water demand expected as a result of growth that is already occurring. At present, and until the specific facilities for bringing water from Maqarin via the EGMC to Amman are designed, this is a major impact of the project

that can be anticipated. However, to the extent that Amman residents will have access to any recreational facilities developed around Maqarin Reservoir or in the Jordan Valley, the project will have a positive impact in this regard.

6.4.2.2 The Irbid Region

Because the Maqarin Dam site is located at the northern edge of the Irbid region and is considered to be an integral part of the region's future development planning, the impacts of the dam and related projects are expected to be wider in scope than those in the Amman region. The Irbid region, which is primarily an upland agricultural area with the city of Irbid at its center, is expected to play an important role in the future development of the Kingdom. The city of Irbid is expected to be an alternative site for urban development to Amman, particularly if new industry can be attracted to the city. This, in turn, will require a major infusion of new infrastructure, including water supply, a sewage system, improved roads, and major commercial and cultural facilities. The regional plan for the Irbid region is already well into preparation and features the following:

- Development of new highway facilities, featuring a ring road around the city of Irbid with direct connections into a new high-speed Damascus-to-Amman highway.
- Construction of a new Yarmouk University campus near Irbid.
- Development of a new industrial park on the ring road, which initially will feature maintenance shops for motor vehicles and light industries manufacturing soft drinks, electrical fittings, furniture, and other consumer items.
- Development of the commercial center of Irbid, including construction of more hotel rooms, restaurants, and other facilities to encourage Irbid's role as a major tourist staging area for the archeological and recreational attractions of northern Jordan.

- Construction of a large volume of new housing to handle requirements generated by Palestinian refugees now living in substandard units, the staff and students of the university, and migrants from rural areas now moving to the city.
- Development of modern wholesale produce market to enhance Irbid's role as an agricultural marketing center for both the East Jordan Valley and the upland agricultural areas.
- Development of a new sanitary sewer system for the city of Irbid to overcome the serious problems caused by an inadequate existing system. This is the highest current priority.

The Maqarin Dam is expected to play an extremely important role in the future development of the Irbid region, first and foremost by providing water to support and encourage the industrial and residential growth of the area, but also for tourism and direct employment opportunities. At present, Irbid's water consumption is only 17 l/c/day. In the future, the building of a new pipeline from Maqarin to Irbid is expected to supply this basic need.

It is expected that the reservoir created by the Maqarin Dam will provide an important attraction for both tourists and local families seeking recreation. Hotels, marinas, and park facilities on the reservoir may become an important part of the local economy. Finally, the construction of the dam itself is expected to provide important employment opportunities for the local labor force--particularly for truck drivers and local suppliers. While most construction workers (estimated to number about 400 to 500 during peak construction years) will be housed at the dam site, it is expected that Irbid will be an important staging area for supplies, equipment repairs, and other services, all of which are expected to help the local economy.

As a result, the Maqarin Dam and related projects are expected to be an important positive force in the socio-economic development of the Irbid region and an essential feature in its future development.

6.4.2.3 Other Areas

Aside from Amman and Irbid, the only other major impacts expected from the Maqarin Dam and related projects would be in the Kingdom's second city, Zarqa, which is also destined to receive M&I water from the project. Zarqa's economy is dominated by military installations and is close enough to Amman to be considered as part of the greater Amman region. The ancient city of Salt, the city closest to the East Jordan Valley, has not been growing both because of physical constraints on its site and because of the competition offered by Amman which is only 30 km away. The Maqarin Dam and related projects are not expected to make any significant impact on the declining role of the city of Salt.

The only other potential economic and urban growth center is Aqaba in the far south of the Kingdom. It is the Kingdom's only port and an important tourist center, but it is far enough removed from the Maqarin Dam so that no impacts are expected.

6.4.3 Institutional Factors

6.4.3.1 General Characteristics and Observations

So varied and complex are the projects of Stage II, it is not surprising that their institutional implications are also diverse. Like social impacts, institutional impacts are often more difficult to identify and quantify than are impacts on the physical and biotic environments. Nevertheless, to overlook them is to risk not only being surprised by unpleasant political problems but also losing some benefits expected from physical infrastructure investments.

Several institutional questions emerge from the technical discussions of this and earlier chapters. For example, municipal and village councils are responsible for sewage disposal, which is a problem now and is likely to become critical with population growth; what is being done to develop their sewage management capabilities? Other questions emerge from comparing existing organizations and plans with likely future needs. For example, synchronizing public programs into the package of services needed by farmers and residents is important for success of the Valley development plan; what is being done to ensure clarity and coordination of roles between JVA and other public agencies?

In comparison with Environmental Assessments in the United States, the institutional analysis required here is unusual. The Valley's present organizational pattern, already changing rapidly with economic and population growth, hardly offers as stable a "baseline" as the cliffs of Maqarin's gorge. Projecting today's situation as the "without Stage II" condition would be neither easy nor useful. However, projecting the "with Stage II" pattern is also difficult, because planning for the Valley's institutional needs has been neither so explicit nor so detailed as planning for its physical needs, with the notable exception of the JVFA. Hence, we can comment only on what seems to be JVA's implicit theory of institutional development, on our few observations of the present situation, and on what these suggest for the future. Finally, even though Stage II projects are located in the Yarmouk and Jordan Valleys, their impacts will be felt in two different institutional settings: (1) in the Valley, JVA dominates, legally and practically, a basically new society; (2) on the upland plateau, to which water must be piped for M&I uses, JVA enjoys no legal monopoly and is only one of many established public agencies in an old, even though changing, society.

The following subsections discuss the most important institutions affected by Stage II plans: civil administration or general government, JVA, JVFA, Ministry of Agriculture, and Jordan Cooperative Organization.

6.4.3.2 Civil Administration

Government in the upland offers a useful comparison for understanding institutional dynamics in the Valley. Three levels may be distinguished:

1. governorates, each headed by a Governor, appointed by the Council of Ministers and assisted by one or two Assistant Governors and a small clerical staff;
2. districts, subdistricts, and areas, each headed by a civil administrator, appointed by the Ministry of the Interior and assisted by a small clerical staff; and
3. municipalities and villages, each headed by a municipal mayor or head of village, elected by the citizens but approved by the Ministry of the Interior, and assisted by a small clerical staff of civil servants appointed by the Ministry of Municipalities and Rural Affairs (MMRA).

The MMRA was separated in 1965 from its parent Ministry of the Interior, and must still work closely with it. As suggested by the description above and the lines of authority in Figure 3-8, the division of functions between them is still not defined or clearly understood. In theory, the governors and civil administrators supervise all government services and projects within their jurisdictions; in practice, they apparently have to rely more upon persuasion than upon budgetary controls to coordinate the efforts of regional officials posted by government ministries and agencies. Although the major functions of ministries and offices are outlined by national laws, the important details of organization, job descriptions, budgets, and procedures seem dictated more by word-of-mouth custom than by written directives. Indeed, compared with the masses of data available on engineering and economic aspects of development projects, little information exists on their institutional aspects; Jordanian

officials sometimes seem uncertain about basic data on their own agency and government structure. A 1962 law requiring decentralized budgeting by governorates has reportedly not yet been implemented, due to objections by the Ministry of Finance. Hence, governors and civil administrators seem to have responsibilities for development without commensurate powers to execute them. Small projects, such as slaughterhouses, clinics, and sewage disposal are proposed and executed by local councils and financed by the Municipal and Village Loan Fund (MVLF);[1] technical assistance comes from the MMRA, of which the chief civil servant is required to be a civil engineer. Efforts are underway to strengthen the development roles of regional and local governments.

Government in the Valley differs from that in the uplands in several ways. District and subdistrict officers in the Valley wield little authority or influence, because of JVA domination. They do exercise police powers, which JVA needs occasionally to enforce rules about land and water resources, and take formal delivery from JVA of completed government buildings. However, they report knowing little about JVA's work, playing no role in JVA decisions about their areas, and having little contact with JVA officials except by formal letter and, in emergencies, with its Senior Vice President in Amman. Indeed, JVA does not seem to post even a liaison officer in the Valley, even though JVA's law requires that its headquarters be located there. At the top level, JVA's present Board of Directors includes the Undersecretary of MMRA but no representative from the Ministry of Interior. Like civil officers, Valley residents interviewed by Arthur D. Little, Inc., applauded JVA for its energy and effectiveness in building structures; but both groups also agreed that JVA is too remote, inaccessible, and uncommunicative. Valley mayors and councils are supposed to serve two masters--JVA for planning and MMRA for administration, but at least some villages lack approved

[1]Data about the MVLF were recently assembled by a World Bank mission in preparation of a possible loan, but AID's request that the Bank show them to Arthur D. Little, Inc., for this study was rejected.

councils, due perhaps to conditions common throughout Jordan and perhaps to those peculiar to the Valley. Moreover, the MVLF does not operate in the Valley, since JVA's Village Development Program includes many of these small-scale projects. In sum, the organs of both civil and local government under JVA's jurisdiction seem to have atrophied or been discouraged from growing with the population and its needs. However, the concept of uniting the whole Valley under a single governor or regional council has been considered occasionally and seems welcomed by government officials.

The impacts of Stage II are likely to resemble those already visible from Stage I. They could have both adverse and beneficial aspects, depending partly upon the behavior of JVA, the Ministry of the Interior, and MMRA. Clearly, growth in the Valley's population will require growth in civil and local governments. The weaknesses already reported in both suggest the need for conscious institutional development and training. Although MMRA looks to JVA for this function, JVA is only now beginning to broaden its vision beyond physical development and to recognize the Valley's needs for community development. Unless this is done vigorously, small-scale but important local government functions such as sewage disposal are likely to be performed poorly, with adverse effects on community health. Indeed, just as multimillion-dinar infrastructure projects are best executed by a large agency such as JVA, small-scale local projects are probably best done by local councils, whole members both know local conditions in detail and have personal interests in good results. Civil administrators may be challenged not only by the Valley's population growth, but also by its unusual composition, including high percentages of foreign laborers and working women. Beneficial results may occur if improved management practices demonstrated by the JVA and JVFA are adopted by other government agencies.

6.4.3.3 Jordan Valley Authority

Institutional development and change tends often to lag physical and technical changes. This may be necessary since organization form should follow technical function. But a danger is that the institutional develop-

ment essential for an enterprise may be overlooked or undervalued too long. JVA is widely admired for its energy and effectiveness in building infrastructure projects. But some institutional weaknesses are becoming apparent, as noted in other sections; the JVFA is one response to weaknesses in services needed by Valley farmers to take advantage of water, transportation, and other JVA investments. The implicit assumption underlying JVA's strategy seems to have been to emphasize physical building and to let institutional building occur of its own accord. But JVA, to its credit, is beginning to recognize that physical development must often be supplemented by community development, for example by appointing a social scientist as a senior officer among its engineers and by improving its public information capabilities.

However, experience during Stage I suggests that still more efforts by JVA will be needed during Stage II. Ministries with special functions, such as Education and Health, seem well aware of JVA's work and preparing to accept their schools and clinics when built; but ministries with more general responsibilities, such as Interior and Municipalities and Rural Affairs, do not appear to be preparing their field organizations for the greater roles which the Valley's development will bring. Examples include sewage treatment and disposal, upgrading large villages to municipalities, and enforcing public health and water management regulations. Instead, these ministries seem to assume that JVA is guiding social and community development, and with some reason in view of JVA's law and monopoly power in the Valley.

Rationalizing government in the Valley seems likely to become a more pressing need as Stage II proceeds and population grows. Perhaps a Valley governorate should be created, including present districts and municipal and village councils. Or perhaps a single regional council should replace existing councils. Perhaps another arrangement would be best. Whichever the case, the question deserves explicit and careful attention soon. Moreover, governance relations among JVA, the civil administration, and JVFA (discussed in the next section) should be reviewed and clarified.

6.4.3.4 Agricultural Institutions

Numerous governmental and quasi-governmental agricultural institutions already serve the East Jordan Valley; most prominent are:

- Jordan Valley Authority (JVA)
- Jordan Valley Farmers Association (JVFA)
- Agricultural Credit Corporation (ACC)
- Agricultural Marketing Organization (AMO)
- Ministry of Agriculture: Extension Service, Research Station
- University of Jordan - Research Station
- Various cooperatives (approximately 25-30; primarily marketing)
- Ministry of Supply
- High Council for Agriculture

Given the number of organizations and their broad scope of activities, Arthur D. Little, Inc., was not able to evaluate them in depth. However, some organizational matters important to the success of Stage II did arise.

Newest among these organizations is the Jordan Valley Farmers Association (JVFA), established by law in 1974 but becoming operational only since 1978. Its broad purpose is to facilitate agricultural development by providing farmers with supplies and services previously not satisfactorily available from either government or private sources. In theory, credit, technical assistance, fertilizers and other supplies, marketing of produce, and custom services such as pesticide spraying were provided by public sector organizations. In practice, however, farmers had to depend upon private "commission agents"; these middlemen entrepreneurs still provide credit, shipping boxes, transportation, and market price information, typically with more timeliness and reliability than government agencies, but also usually at much higher cost and not without biasing market information in their own favor. JVFA is intended to compensate for weaknesses of government organizations, break the monopoly power of commission agents, provide a complete package of services at

each farm, and thus improve both the productivity and income of farmers.

As Stage II begins, JVFA's new and inexperienced staff is struggling to implement a law[1] and a plan[2], both of which are comprehensive and complex, in the Valley's economic and institutional conditions, which are also complex and changing. JVFA's complicated organization includes a General Assembly, a Board of Directors, Councils and Assemblies of 33 Development Areas, and a full-time staff. One factor in its success will be the Ministry of Agriculture extension agents serving as Secretaries to the 33 Development Area Councils (only 11 of which are now operating). These poorly trained men will, in effect, be responsible to at least three supervisors in three organizations: JVA's water management technicians, JVFA's councils and staff, and the Ministry of Agriculture's directors. Another factor will be the skill of farmer-members in learning roles and procedures modeled after large cooperative organizations in the United States, where power is associated mainly with the office, rather than after small tribal organizations in Jordan, where power lies with the individual. Valley farmers are familiar with councils of elders who reach decisions by discussion leading to consensus; but they seem unfamiliar and uncomfortable with Development Area Councils, composed often of strangers elected for temporary terms, who are supposed to decide on loans and other matters by voting, a process which starkly identifies winners and losers. Yet another factor in JVFA's success will be its relationships with other public sector organizations. JVFA's objectives are assigned by law:

> . . . . to develop agriculture in the Valley, to enable farmers to <u>participate in formulating and implementing Government policy and agricultural programs in the Valley</u>, to increase their participation in the development of the National Economy, to ensure equitable returns for them and to increase food production through efficient

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[1]Temporary Law No. 19, Official Gazette No. 2488, May 1, 1974.

[2]Savage, Job K., <u>A Report on the Functions and Organizational Aspects of the JVFA</u>, Amman: Agricultural Cooperative Development International for the JVA, December 1976, 105 pp.

> utilization at minimum cost of arable land and water resources in the Valley. (JVFA law, Article 3) [emphasis added]

Such broad objectives, backed by ample funds and talented leadership, place JVFA at the center of Jordan's development efforts in the Valley, and thus require close relations with other major government institutions. Much will depend, of course, on how this law's intentions are implemented, on how JVA organizes to manage its irrigation and other facilities after they are built, and on whether the Valley will be governed by a single regional council or by other means.

Stage II's impacts on JVFA are difficult to foresee in detail. Stage II will provide JVFA with more resources, but will also increase demands for JVFA services. It is likely to require more attention than has been given so far to clarifying, distinguishing, and strengthening the roles of major government and quasi-government institutions.

The JVFA was created, in essence, to compelment the work of the older agricultural organizations. During the transition period, as the JVFA grows to its full potential, difficulties may arise between it and established agencies about such matters as role definitions and divisions of labor. Such problems occur often among agencies in goverments of all countries. But competition among government agencies, like competition among private firms, can be healthy and improve the quality of services available to citizens. However, competition among bureaucracies is not managed automatically, as the marketplace manages business competition. Instead, it must be done consciously and at the top levels of government.

The JVFA is trying to cooperate with some existing organizations, for example, the ACC and the extension service. However, it is competing directly against others, for example, the AMO and a number of cooperatives. In essence, since JVFA's success depends on how well and how quickly it performs its various mandates, it is attempting to attract as members the best farmers, who already belong to competing organizations, while overlooking the needs of the smaller, perhaps riskier farmer, especially tenants, who also need credit, marketing, and other services. Thus, although JVFA may do some things better than older organizations, due in large part to better funding, and foreign advisors, it is still not yet meeting the needs of the majority of the Valley's farmers.

JVFA plans to use the Ministry of Agriculture's extension agents in three roles: (1) as secretarys to Development Area Councils, (2) as credit appraisors for loans, and (3) for disseminating technical information. JVFA now lacks its own staff members who know the farmers well enough to evaluate applications, but it apparently plans to phase extension agents out of this role once it has established sufficient credit histories.

Unfortunately the extension service does not enjoy a good reputation. Many farmers feel that the extension agents do not know the best methods, and instead seek advice from input salesmen, the best farmers, and large landowners. These charges seem justified, although the fault may lie less with the agents than with the system: their transportation is inadequate, partly due to the social stigma of riding motorcycles; the number of farmers assigned to each agent is too large to serve, properly; and, most important, the Ministry does not keep its agents up to date through continuing education. Given these circumstances, one wonders how effectively the agents can work with the JVFA.

Agricultural research in Jordan is described in some detail by Oddvar Aresvik. [6-50] Stevens has recommended research and extension priorities for vine crops in the Valley. [6-51] Some, but not all of those problems,

are being addressed. Based on limited observations, two points can be offered.

First, there seems to be insufficient coordination between the Ministry of Agriculture and the University in establishing research priorities and then assigning them for problem design and testing. Although the two research stations in the Valley, one of the Agricultural Research and Extension Directorate and the other of the College of Agriculture, communicate with each other and do useful work, they appear to be selecting and pursuing topics independent of each other. This practice is questionable when research funds are limited.

Second, it appears that insufficient work is being conducted in irrigation systems. Given the variety of crops, the limitations on water availability and the variations in terrain and soil, evaluating water and system efficiency must receive highest priority. Granted, the research stations are testing crops under drip, sprinkler, and flood methods; but yield-to-water data and other water efficiency measures were apparently not being studied in detail, according to several researchers. It appears that optimal water regimes are being evaluated technically, but suboptimal ones, which might be more economical or which help farmers when water is scarce, are not being examined. Part of the problem, no doubt, is lack of coordination in the design of research programs among agronomists, economists, and water management specialists (who are not yet formally recognized in the needed structure).

Two needed services do not yet appear adequate in spite of efforts by the JVFA and other organizations: farm production credit and market information. Because credit has been analyzed by recent researchers and is the focus of foreign technical assistance, it will not be discussed here. Better market information was requested by many farmers in the survey by Hyslop. [6-47] They are dissatisfied both with the reliability of market price data and by receiving them casually through truckers. Farmers feel they are not getting the best prices, due either to

ignorance or to intentional misinformation by truckers and other informal sources. Apparently no effective government service exists to provide market information both accurately and timely.

Proper application of pesticides is a service of growing importance. Some spraying service is now available from both government and private custom operators. But private applicators can work more flexibly than government employees, for example, working long hours until dusk if needed to cover a farmer's fields quickly and at the best time for the pesticide to act efficiently. Although private sprayers charge much more than government sprayers, some farmers appear willing to pay higher prices for the sake of greater crop yields. However, low-cost, easily available, reliable spraying is clearly needed for the Valley's full agricultural potential to be realized. Thus, the JVA has assigned to the JVFA responsibility for ensuring such service, both through JVFA's field organization and by allowing private firms to offer it.

Finally, perhaps the major institutional concerns now result not from existing institutions but from lack of needed institutions. Two such "non-institutions" were discussed above: pesticide control and water allocation management. The first is needed primarily for health, safety, and economic reasons; the second, for production maximization, equity, and economic viability reasons. Both functions are critical to the overall success of Stage II.

6.4.4 National and International Considerations

Stage II's relationships to various aspects of Jordan's national economy are described in preceding sections. The Maqarin Dam ranks first among priorities for the 1980-85 Plan.

Stage II's international aspects are dictated mainly by its geography, finances, and agricultural economics.

Maqarin's north end would abut Syria. Most of the Yarmouk's water flows from Syrian watersheds, and the new reservoir would inundate parts of Syria. Thus, Syria's cooperation is required both for initial construction and later in maintaining the water supply and reservoir.

Israel occupies the Golan Heights dominating the lower Yarmouk. Its cooperation would be needed in diverting Yarmouk water into the EGMC, especially if the structure is a dam across the whole river and abutting its northern bank. Israel has for some years received about 25 MCM of Yarmouk water for its irrigation systems and would have a claim, under international law of riparian rights, to continue receiving it.

Large amounts of financial aid are needed from foreign countries and international sources because Stage II's estimated cost would exceed Jordan's own resources. The United States and the World Bank are expected to be major donors. Technical assistance in various forms would also be provided and required as part of such loans and grants.

Foreign agricultural laborers, principally from Egypt and Pakistan, are a significant factor in the Valley's economy. Their role in the share-cropping system seems likely to continue. Permission for them to come and go at will is part of Jordan's manpower policy of open borders, which also allows Jordanians to seek jobs abroad and send remittances home.

High-value fruits and vegetables grown in the Valley with waters supplied by Stage II will presumably find a major market in Persian Gulf states. Good trade relations between Jordan and their Arab neighbors would be needed to help realize Stage II's promise of benefiting Jordan's export earnings.

Given Stage II's national and international settings, several impacts seem likely. Nationally, the Valley would increase its role as a

laboratory for testing many kinds of development technologies and approaches which might be adopted elsewhere in Jordan. For example, Jordanians would continue to acquire skills in designing and managing large, complex, integrated projects; Stage II would continue the process of linking Valley towns and villages more closely with Amman and the national government. Internationally as well, Stage II would continue creating economic ties between the Valley and foreign markets and prices. Although inexpensive foreign labor would benefit farm owners, it might initially hamper Jordan's efforts to settle Jordanians; however, JVA believes that technical improvements, such as shifting to pressure-pipe delivery of water and institutional improvements by the JVFA will in time ease labor shortages. Although Stage II would initially require large foreign aid, it would, if successful, eventually strengthen Jordan's economy and help reduce its needs for foreign aid.

Impacts stemming from supplying M&I water to upland cities appear to be only national. Benefits and costs have been mentioned elsewhere. Institutionally, the JVA expects to become a department of the new National Water Authority now being considered. JVA's role will be limited to supplying and delivering water, but not extend within city limits.

PN-AAM-292 duplicate

ENVIRONMENTAL ASSESSMENT

JORDAN VALLEY IRRIGATION PROJECT STAGE II

VOLUME II

United States International
Development Cooperation Agency

Agency for International Development

November 1980

FINAL REPORT

ENVIRONMENTAL ASSESSMENT FOR THE PROPOSED JORDAN VALLEY IRRIGATION PROJECT, STAGE II

VOLUME II

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United States International Development Cooperation Agency
Agency for International Development

Contract No. AID/NE-C-1591

C-82912

November 1980

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7.0 REASONABLE ALTERNATIVES TO THE PROPOSED ACTION

7.1 INTRODUCTION

The analysis of alternatives for the proposed Maqarin Dam and Jordan Valley Irrigation System Project is based on the following factors and assumptions:

- The proposed action represents only Stage II of the Jordan Valley Development Plan. In general, Stage I has been completed and is operational, while Stage III, the ultimate development, has not been planned or described in any detail. It was assumed that Stage II would provide essentially full development of the Yarmouk and side wadi water resources, and that Stage III, if and when it is implemented, would serve mainly to refine Stage II developments rather than serve as a necessary and major subsequential activity.
- The proposed action consists of two principal parts:
  - the constructed facilities that will provide water storage, regulated releases, and water transport for both M & I and irrigation uses; and
  - the Village Development Plan.

  The latter is dependent on the former to the extent that if the irrigation water supply facilities were not provided, the Village Development Plan would require a re-evaluation that would probably result in a substantially reduced scale of development.
- The selection of a final Stage II plan is still in progress and some changes may be expected. The plan favored by the JVA is essentially that described as the Harza "C-1" plan [7-1][1] which features Maqarin Dam constructed to El. 178 m, 126 MCM/yr of water allocated for M&I supply to Amman and

[1]Numbers in brackets, e.g., [7-1], refer to references listed in Appendix B.

Irbid, and 21,750 ha to be irrigated under Stage II. The latter consists of about 14,000 ha currently irrigated, which would be converted to sprinkler or other irrigation method, and about 7750 ha of new land. In addition, some 10,600 ha would continue to be irrigated under Stage I. The plan which is proposed by the World Bank on behalf of the donor group features Maqarin Dam constructed to El. 158 m, with a variable allocation of water between M&I and irrigation uses. The M&I use varies between 1990 and 2010, but is projected to be about 164 MCM/yr at the year 2000 with a total irrigated area of about 24,400 ha for both Stage I and Stage II lands.

- It was assumed that the population of Jordan would continue to grow, that the growth would occur mainly in the upland cities, and that this growth would occur whether or not the proposed action were implemented.

7.2 NO-PROJECT ALTERNATIVE

If the Maqarin Dam were not constructed, agricultural production in the Valley could not be expanded, either in new areas or by the planting of additional crops each year on existing irrigated areas. Water supply for the increasing population in the city of Irbid would probably have to be pumped from the Yarmouk River at Maqarin, thereby reducing flows to the EGMC. The city of Amman would probably have to revert to the original plan of drawing water from the King Talal Reservoir, with higher water treatment plant costs due to the poorer water quality in the Zarqa River. As the demand for water in Amman increased, the flow of the Zarqa River in the Valley would decrease. Thus the increased M&I water use in Amman and Irbid would decrease the flows of water available for irrigation in the Valley, thereby reducing crop production below its present value.

This reduction of water for irrigation must be viewed in light of how the Maqarin Reservoir would serve to increase water supplies. The streamflows in the Yarmouk River (as well as the Zarqa River and the side wadis) are greatest during the rainy season, from December through March. This is also the time when water for irrigation is in least demand. Without a reservoir to store the excess flows, they would pass on to the Jordan River and eventually to the Dead Sea and would thus be lost for irrigation or M&I use during the remaining months of the year when streamflows are low. This annual characteristic of streamflow variation is also reflected over multiple year periods in the form of long-term wet and dry periods, having perhaps a seven-year cycle. The Maqarin Reservoir would be able to store water from wet years for future use during dry years. In short, the Reservoir would optimize the use of Yarmouk River waters by storing excess flows for later use and eliminating the loss of surplus flows to the Dead Sea.

It is not possible to quantify the no-project irrigated crop production loss without a detailed analysis such as using a monthly simulation model. For example, an unusually dry period that occurred after crops

were planted could mean lower yields or outright losses as a result of inadequate river flows to feed the EGMC. This would be unlikely to occur with the reservoir, since stored water would be released on a schedule determined prior to crop planting. Neither is it possible under the no-project scenario to say that future irrigated crop production would be similar to that of recent years, since future years will have an increased M&I withdrawal compared to past years.

Another consequence of the no-project alternative would be the loss of the 20-MW hydroelectric plant at the Maqarin Dam. The energy (60 GWh/yr) would have to be provided by other means, most likely involving use of fossil fuel, a non-renewable resource. Since the hydropower would serve as a peaking source, there would be a further efficiency loss. It is assumed that the 2-MW hydroelectric plant at the King Talal Dam would still be installed, even though it is a part of Stage II, since the dam already exists.

The negative impacts associated with the no-project alternative are, therefore, a loss of M&I water for the upland cities, which have a serious need for additional water, a reduction in irrigated crop production below existing levels, and a loss of hydroelectric energy. These, in turn, would have negative impacts on the health and welfare of the population; more food and fuel would have to be imported and fewer crops would be available for export and for improving Jordan's balance of payments. Over a period of many years, the existing (Stage I) irrigation investment would decline, assuming that the cities had priority to use available streamflows. As a result, there could be an exodus of both people and investors from the Valley.

The beneficial impacts associated with the no-project alternative are limited. The Maqarin Valley would be preserved in its existing state, thereby avoiding potential losses of archaeological sites and existing arable land. Its few residents would not have to be relocated. The

risk of a dam failure, however small, would be eliminated, with its adverse consequences for persons living downstream. Benefits to the East Bank of the Jordan Valley would be primarily limited to the preservation of some archaeological sites that would no longer be subject to disruption from construction or farming activities. Other potential benefits are indirect, that is, fewer health problems attributable to exposure to pesticides or water-related disease vectors. Finally, the level of the Dead Sea would not become lowered as much if the project were not constructed.

The beneficial impacts are relative; if the project were not undertaken, it is likely that the crops lost would be grown elsewhere, not necessarily in Jordan; in this event, the alternative sites may be subject to archaeological losses and to pesticide and disease vector impacts.

A final no-project impact deals with the "saving" of the capital investment that would result if the project were not constructed. Whether this is beneficial or adverse depends on the alternative ways in which the funds could or would be used. Assuming that the equivalent funds were to be invested in Jordan in some other project, what type of project could satisfy the same broad goals as the proposed project? For example, could a new manufacturing complex or expanded tourist facilities provide an equivalent employment opportunity and economic return? Without even attempting the analysis, it can be seen that any such alternative would require additional M&I water supplies, which can best be provided by the proposed project.

In summary, the no-project alternative would adversely affect the future development of Jordan and the aspiration of its people for self-improvement.

7.3 DELAYED PROJECT ALTERNATIVE

In order to assess the delayed project alternative, one needs to know the purpose of the delay, the activities, if any, that would take place during the delay, and the probable duration. The latter may be either definite (i.e., the project is authorized and a starting date is set) or indefinite (i.e., no one knows whether the project will ever be constructed, but it is at least not rejected as in the no-project alternative).

With respect to the Maqarin project, some delays have already occurred in order to perform revised operational and economic analyses because of the recent decision to allocate more water to M&I use. However, these delays are expected to be of relatively short duration and can be viewed as normal for a project of this size. For the purpose of this environmental assesment, a reasonable delay is assumed to be of about 5- to 10-years durations.

Any delay would have a significant adverse impact with respect to water supply for Amman and Irbid. The existing supplies are already inadequate with respect to public health. A delay in the project would result in the need for alternative municipal supplies that would likely be considerably more expensive and/or of lower quality, to the point of constituting a major threat to human health.

With respect to Valley development, the impact of a delay is less clear. Much would depend on whether the delay is definite or indefinite. Under a definite delay, assuming it is not too long, the development activities would slow down but long-range planning and other preparatory work could continue (e.g., construction of housing and other facilities), perhaps in a more orderly fashion. However, if the delay were indefinite and continued for several years, there would be a risk of disenchantment on the part of both residents and investors regarding the future of the Valley. This could lead to land speculation and, in turn, to social tensions that could adversely affect production if and when the project were completed.

A possible beneficial impact of a delay would be with respect to archaeological sites. This assumes that the interim period would be used to survey and investigate the sites prior to any disruption due to the project.

7.4 ALTERNATIVE WATER ALLOCATIONS

As described in the Stage II Feasibility Study [7-2], the Stage II project would have primarily served the Jorday Valley by providing irrigation water for 25,353 ha (269 MCM/yr), of which 11,294 ha would be newly irrigated land. These lands, together with 10,647 ha of Stage I land that are irrigated from supplies other than the EGMC, would bring the total irrigated lands to 36,000 ha. In addition, the Feasibility Study provided for 12 MCM/yr of M&I water for Irbid to be taken from the Maqarin Reservoir, and 8 MCM/yr for Jordan Valley village supply to be taken from EGMC. Amman was to be supplied from the King Talal Reservoir, and 10 MCM/yr evaporative losses were allowed for this operation.

In the revised "C-1" plan, additional water for M&I purposes is provided; specifically, 100 MCM/yr to the Amman area from EGMC, and 26 MCM/yr to the Irbid area from the Maqarin Reservoir. These amounts are allocations; actual supply would be about 5% less to account for transmission and treatment plant losses. Under the "C-1" plan, no water would be withdrawn from the King Talal Reservoir. Harza estimates that roughly half of the M&I water would return to the river systems from effluent discharge from sewage treatment plants or as groundwater seepage. The total irrigated lands would decrease from 36,000 ha to about 32,400 ha, even though the Maqarin Dam would be higher by 20 m.

A series of operational studies were performed by Harza for the staff appraisal report being prepared by the World Bank. The results of some of these studies are shown in Table 7-1. This analysis incorporates the following parameters:

- Maqarin Dam crest elevation of 178 m (note that this differs by 20 m from the Bank's preferred hieght of 158 m).

- 50 MCM/yr for M&I are withdrawn from King Talal Reservoir

Table 7-1

Jordan Valley Irrigation Stage II Project
Operation Studies[1,2]
Inputs and Outputs

Year	M&I Demand from Yarmouk-Zarqa System[3]				Return Flow				Irrigable Area From			Total Irrigable Area		
	Amman	Zarqa	Irbid	Total	Amman	Zarqa	Irbid	Total	Yarmouk System	Zarqa System	Independent Sources	Jordan Valley	Project Area	New Lands
	Mm3				Mm3				ha			ha		
1990	35.0	21.7	17.2	73.9	25.8	19.8	10.2	55.8	21,600	4,025	5,570	31,195	20,548	7,879
1991														
1992														
1993														
1994														
1995	56.1	32.3	24.1	112.5	38.7	26.9	14.0	79.6	18,818	5,500	5,570	29,888	19,241	6,572
1996														
1997	64.6	36.6	26.7	127.9	43.9	28.9	15.6	88.4	17,745	6,100	5,570	29,415	18,768	6,099
1998														
1999														
2000	77.2	41.3	30.7	149.2	51.6	31.9	17.9	101.4	16,500	6,900	5,570	28,970	18,323	5,654
2001														
2002														
2003	91.2	48.1	35.6	174.9	60.2	36.0	20.8	117.0	14,658	7,900	5,570	28,128	17,481	4,812
2004														
2005	100.6	52.7	38.9	192.2	66.0	38.8	22.7	127.5	13,400	8,493	5,570	27,463	16,816	4,147
2006														
2007														
2008														
2009														
2010	127.6	66.6	49.5	243.7	82.6	47.3	28.5	158.4	9,975	10,432	5,570	25,977	15,330	2,661

[1]Marqarin dam crest elevation: 178 m a.s.l.

[2]Assuming 50 Mm3 for M&I are withdrawn from King Talal Dam

[3]M&I demand presented with this table was estimated before issuance of December 1979 Census and includes losses in conveyance system and treatment plants:
Irbid: 3%
Amman and Zarqa: 6%

Source: Technical Data for Appraisal Study by World Bank, Harza Engineering Company.

- Conveyance and treatment plant losses are 3% for Irbid and 6% for Amman-Zarqa

- M&I demand increases from the year 1990 to the year 2010, with associated reductions in total irrigable area

- Return flows from M&I uses are variable, e.g., for Amman it is 74% in 1990 and 65% in 2010; for Zarqa it is 91% and 71%; and for Irbid it is 59% and 58%.

The results shown in Table 7-1 cannot be compared directly with the "C-1" plan, but the data in Table 7-1 do reveal some interesting dynamic trends. As the M&I demand increases, the area irrigated from the Yarmouk System decreases by 54%. But at the same time, due to increasing M&I return flows, the irrigated area from the Zarqa System increases by 159%. But the total irrigable area in the Jordan Valley, including independent sources, decreases by 17%.

In a sense, the adoption of a dynamic water allocation schedule as suggested in Table 7-1 is an alternative to the adoption of a fixed allocation schedule as is presented in the"C-1" plan. The "C-1" schedule is roughly the same as the dynamic schedule for the year 2000, and to this extent, it reflects the "average" conditions under the dynamic schedule.

The use of a dynamic schedule would be the most realistic approach if M&I allocations are to have priority over irrigation uses. But in this event, the entire Valley Development Program should also be revised to reflect the decreasing availability of irrigation water over time as well as the shift in the location of its availability from the Yarmouk System to the Zarqa system. These changes would clearly have an impact on land allocation, farming investments, and village development.

At the present time (October 1980), the project preferred by the JVA (Marqarin Dam to El 178 m) and that considered optimum for financial

reasons by the World Bank (Marqarin Dam to El 158 m) remains an unresolved issue. If further considerations of intangible benefits or other factors should result in the section of the higher dam, the JVA will undoubtedly have to modify its plans to manage the Valley in a manner that recorganizes the ever increasing needs for M&I allocations over the coming years.

7.5 ALTERNATIVE WATER SUPPLY AMOUNTS AND METHODS

7.5.1 Introduction

This section addresses the alternatives relating to the volume of water supply, reservoir sizes and locations, and means for conveying the water from its source to the points of use.

Sources of water supply can be surface flows, groundwater, or both. With respect to groundwater, the National Water Master Plan of Jordan estimates that 20 MCM/yr of additional water could be extracted in the Amman-Zarqa area. This is in agreement with the VBB study of 1976 [7-3] and other reports dealing with the area. Discussion at the University of Jordan suggested that 40 MCM/yr might be available; however, because the total natural recharge is estimated to be 25 MCM/yr, the 20 MCM/yr amount would seem more likely unless future wastewater discharges are allowed to percolate to the groundwater. Other potential sources of groundwater have not been sufficiently evaluated to determine their potential for project use, but it is unlikely that sufficient groundwater could be obtained to serve the major part of the project needs or even the M&I demand.

7.5.2 Maqarin Dam and Reservoir

The only reasonable alternative site for the dam, from consideration of the Yarmouk Valley geometry, is about 5 km downstream from the proposed site. However, extensive geotechnical investigations would be required to determine its foundation adequacy, and it is not considered that the site would provide any significant advantages over the proposed site with respect to either construction cost, operating efficiency, or environmental impacts.

The Khalid site, located about 12 km downstream from the Maqarin site, had been proposed for a 100-m high dam as part of the ultimate development plan (Stage III). However, it is understood that the Khalid project will now be dropped from consideration as a result of plans to divert

the upstream flood flows of the Wadi Raqqad to the Maqarin Reservoir under the revised "C-1" plans.

This leaves the height of the Maqarin Dam as the remaining design alternative. In the original Feasibility Study, a dam with its crest at El 158 m (reservoir of 150 m) was proposed, with the capability for later raising the dam crest to 200 m (reservoir of 190 m). The 200-m dam represents the maximum development for the Yarmouk River flows at Maqarin, that is, a higher dam would not develop increased safe yields for project purposes.

The "C-1" analysis uses a dam with a crest elevation of 178 m (reservoir of 170 m). This design does not include a provision for later raising of the dam. The effect of various dam heights on the water that would be available for irrigation and M&I uses is shown in Figure 7-1. In the "C-1" plan, the reservoir elevation is 170 m, the M&I withdrawals are 126 MCM/yr, and the total Stage II irrigated area is 21,750 ha. As can be seen, a reservoir to El 190 m would provide some increase in project accomplishments, but the increments would end at or about El 192 which represents 100% development.

The approximate construction costs for the dam, spillway and outlet tunnels associated with various sized reservoirs are shown in Figure 7-2.

In its study of economic dam heights, Harza recommends development to El 170 despite the fact that a reservoir at El 155 would represent the optimum economic development (at a 10% opportunity cost of capital). [7-4] The reasons given are (1) no alternative source of water is available in the region and the full economic impact of rejecting the large reservoir cannot be quantified; (2) construction of either dam would preclude construction of additional storage in the near- or medium-term future because the development cost of remaining unregulated water would be very high after completion of the Maqarin Dam; and (3) the cost, at current price levels, of increasing development from El 155 to 170 m amounts to only 15% of the cost of the recommended project.

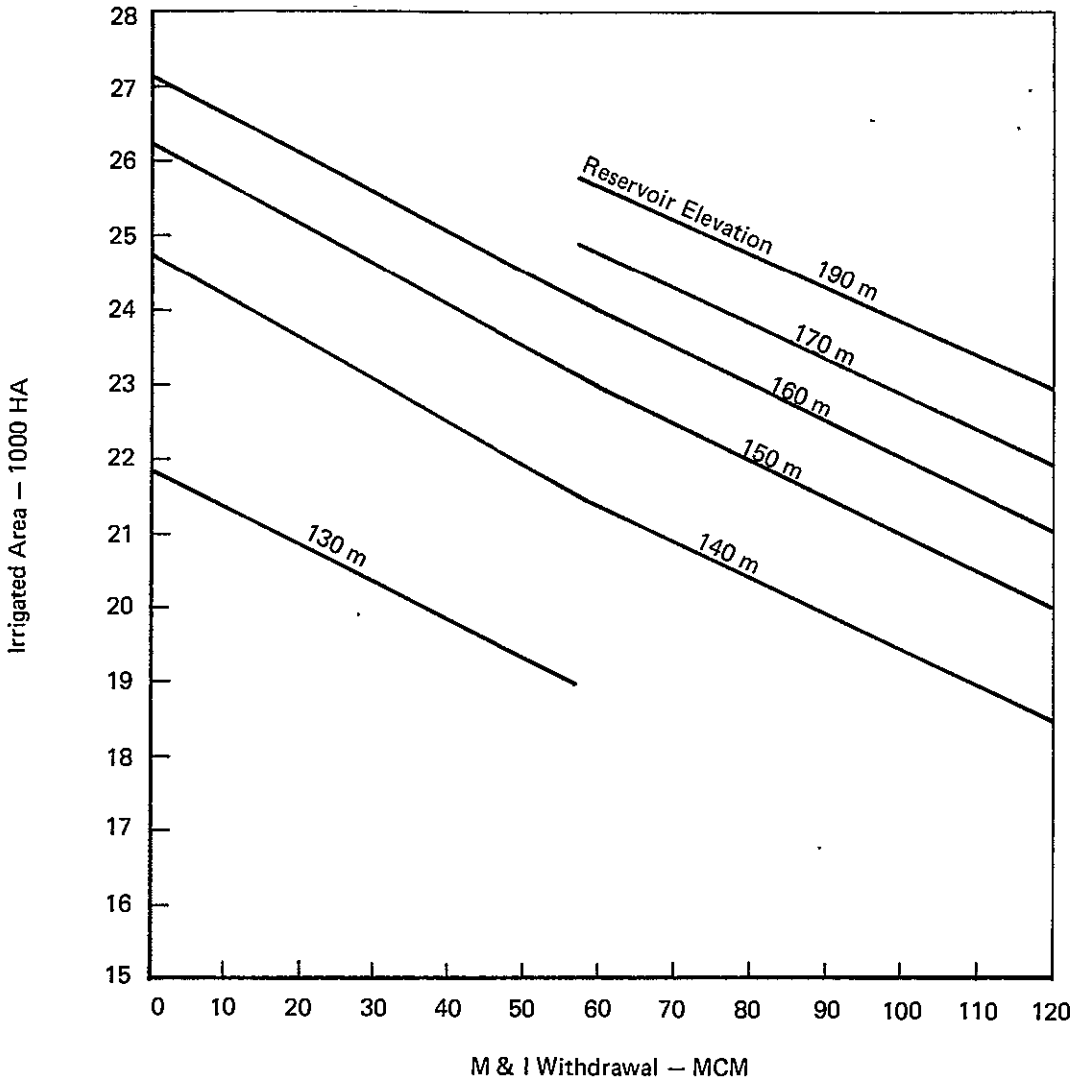

Figure 7-1 Project Accomplishments

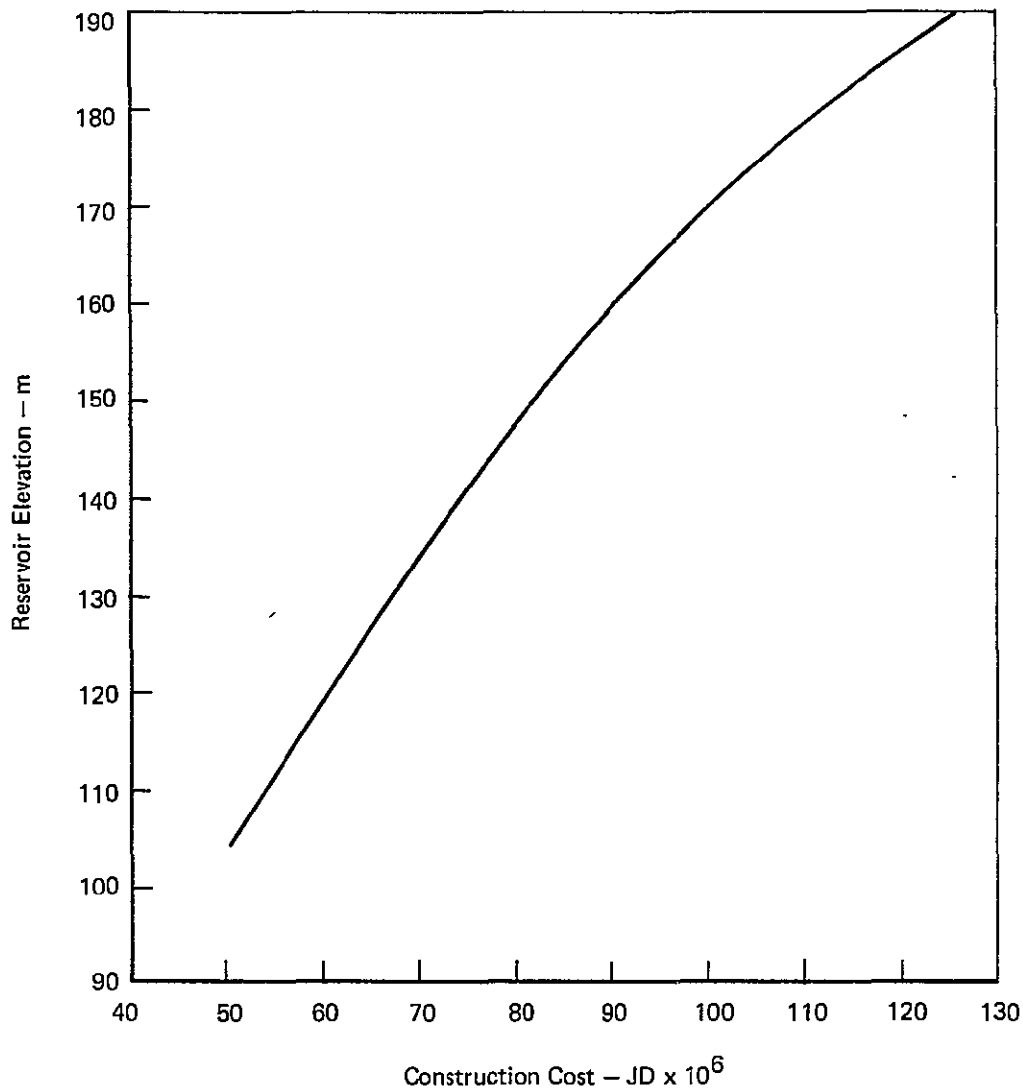

Figure 7-2 Maqarin Dam Cost-Height Curve

The impact on the economy of Jordan and the health of the population as a result of selecting an alternative dam height involve complex cost/benefit analyses and other considerations of national goals, the data for which are not all presently available. The impact on the physical environment would vary somewhat as a function of reservoir height and yield; however, for the probable range of reasonable alternative heights it is not expected that there will be significantly different environmental impacts.

7.5.3 Alternative Diversion Methods

Water released from the Maqarin Reservoir will flow down the Yarmouk River to Adasiye, where it will be diverted into the EGMC except for 25 MCM/yr that will pass downstream for use in the Yarmouk Triangle (Israeli land south of Lake Tiberias, north of the Yarmouk River, and east of the Jordan River). In order to divert the water to the EGMC most effectively, it is proposed to construct a low diversion dam across the Yarmouk River. Since the northern side of the river is under Israeli control, a political understanding will be required.

If an understanding cannot be reached, there are two alternatives for accomplishing the diversion. One would involve an additional low-level, uncontrolled intake located upstream of the existing intake. Under this plan, water from the river would drain off at the left bank, pass through a short tunnel and enter the EGMC. Because of inefficiencies associated with the partial diversion, the Maqarin Dam would have to be about 10 m higher (than the originally proposed 158 m dam height), at an increased construction cost of about JD 7.75 million (1977 price level). The change in environmental impacts associated with this alternative would be primarily the increase in cost.

The second diversion alternative would require a 25-km tunnel from the Maqarin Reservoir to the Wadi Arab Basin, from which the water would flow to the EGMC. This plan would not involve any inefficiencies

that would require additional dam height, and a 40-MW power plant could be located at the end of the tunnel. The additional construction cost is estimated to be JD 23.4 million (1977 price level). The potentially adverse environmental impacts associated with this alternative would be a substantial decrease in the flows in the Yarmouk River downstream of the Maqarin Dam (essentially only the releases needed for supplying 25 MCM/yr to the Yarmouk Triangle), with essentially no flows in the river during the months when no irrigation water is required. As a result, aquatic biota in the river would be harmed. By comparison, under the proposed revised plan, there would always be flows in the river, if only to provide the M&I water demands.

7.6 ALTERNATIVE DAM CONSTRUCTION METHODS

7.6.1 Seepage Cutoff

(Note: Comments below are based on conditions as of April 1979 and do not reflect new investigative data that were subsequently developed.) If the exploratory drilling proposed for future investigations by Harza, as described in Appendix F, discovers a greater degree of solutioning than previously thought, the width and depth of the grout curtains in the preliminary design may have to be increased. If karstic solutioning in the Amman Formation remains a possibility and a fault zone connecting the reservoir with the Amman Formation is found, Harza believes that adverse seepage conditions under the embankment may have to be assumed, requiring either sealing off the reservoir fault zone in the marl or installing filters and drains in the downstream shear zone to control potential seepage under the embankment. [7-5]

The integrity of the bituminous marl at the proposed location of the embankment axis should be examined with more exploratory drilling. Filled solution features intersected by adits in the marl should be excavated to determine if they are isolated or part of a connected network. A contour map of groundwater elevations [7-6] shows a possible anomaly near the proposed axis which is similar to an anomaly correlated to known solution cavities near the downstream shear zone, although boreholes near the upstream anomaly have shown no evidence of faulting or solutioning. This contour map has been interpreted from only a small amount of data, and more boreholes and groundwater elevations are needed for precise contouring.

If the E-W fault crossing the left abutment promontory is confirmed, Harza proposed to extend the positive cutoff and grout curtains at least 500 m into the left abutment to intersect the fault.

The site investigation and cutoff design at Maqarin Dam compares favorably with those other dams in karstic regions, as shown in Table F-1 in Appendix F. However, the complex geology at the Maqarin site requires additional exploration before it can be accurately described.

Large embankment dams have been successfully constructed in karstic terrain, but foundation treatment to retard seepage can be expensive, especially if site investigations underestimate the density of solution features. At Clarence Cannon Dam, an embankment dam designed by the U.S. Army Corps of Engineers, treatment of unanticipated solutioning in the abutments added $5 million [7-7] to the cost of the project.

7.6.2 Embankment Design and Construction

Preliminary static analyses have shown embankment stability to be dependent upon the residual strength of the marl foundation rock. Appropriate undrained laboratory tests to obtain residual strength parameters for use in stability analyses have yet to be conducted. Drained shear tests are needed that can measure residual strength after large displacements along failure planes in marl samples. [7-8]

Pseudo static analyses should be made to estimate embankment stability under earthquake loading. A seismic coefficient equal to the maximum ground acceleration at the dam site that could be produced by the design earthquake should be used in the analyses. If a factor of safety less than 1.1 is calculated, the embankment design may have to be changed. [7-9]

Embankment deformation and cracking are serious consequences of earthquake loading. Special attention must be given to the crest design so that the potential for overtopping and erosion is minimal. As shown in Table F-2, the proposed crest design for Maqarin Dam appears to be consistent with those for other large embankment dams in seismic regions. However, the core and filters in the preliminary design appear to be comparatively narrow. Core widths are usually designed to exceed 30% to 50% of the height of the impounded reservoir so that the seepage gradients are reduced and hydraulic fracturing is prevented. [7-10] The type of material that will be used in the core (residual montmorillonite clay) has also shown a tendency to crack in other dams, especially if compacted when drier than the optimum water content. [7-10] Because the borrow at the site is considerably drier than optimum, closely-

controlled moisture conditioning will be needed to achieve optimum water content. In addition, wider filters and a downstream transition zone that can prevent crack propagation should be used.

Rapid embankment displacements produced by saturation after reservoir impoundment or by earthquakes have been known to produce cracks and allow internal erosion. Consequently, initial reservoir filling should proceed slowly in stages to control settlement rates. Embankment strains and displacements under seismic loads should be calculated using state-of-the-art techniques. [7-11] With this information, the need for a revised design of the embankment zonation can be rationally evaluated.

Instrumentation to measure movements, stresses, and internal water pressure should be installed and readings obtained and analyzed frequently during initial reservoir filling.

7.7 ALTERNATIVE AGRICULTURAL ACTIVITIES

7.7.1 Introduction

Most impacts in the agricultural sector associated with Stage II lend themselves more to mitigating measures (as will be covered in Chapter 8) rather than reasonable alternatives. In addition, for several impacts the distinction between an alternative and a mitigating measure is blurred. Consequently, since no radical alternatives are suggested in this report (e.g., the discontinuation of the use of all pesticides, switching from vegetable to grain farming, etc.), Chapters 7 and 8 should be read together with respect to the alternatives and mitigating measures suggested to reduce the possible adverse impacts of the agricultural portion of Stage II.

7.7.2 Agricultural Production

Appendix G (Agricultural Development) of the Harza Stage II Feasibility Study [7-2] indicates that practically all vegetable crops grown in the Valley should to some degree be grown during the summer months. However, farmers, agronomic researchers, and others associated with agriculture in the Valley do not feel that many of the vegetable crops can be grown either successfully or, more important, profitably during the summer months because of high heat and humidity conditions. Thus, it would appear logical that until further summer vegetable crop research has been conducted, the project should promote only those crops which have already proven themselves as good summer crops for the Valley. Examples would be berseem and, perhaps, one or several of the grains. This alternative to the proposed cropping pattern should require no action on the part of JVA or others, rather only inaction, that is, if questionable summer vegetable crops are not promoted, it is unlikely that farmers not now growing these crops will adopt them in the absence of promotion, except perhaps on a small experimental plot basis.

7.7.3 Land Tenure

The land redistribution process in Stage II will be unable to provide land to all existing tenant farmers or others without land. The beneficiaries of the program will be farmers and non-farmers who own less than 4 ha. In the short run, this poses few problems, except perhaps from an income equity or distribution standpoint. However, in the longer term, such a land tenure system, when combined with moves to consolidate farms to accommodate mechanization, would force many of the tenant farmers out of operation. A partial alternative would be to redefine the land distribution priorities set forth in the 1977 Jordan Valley Development Law. Currently, tenant farmers are third in priority behind farmers who own land and non-farmers who own land. If tenant farmers were moved ahead of the latter group, much of the potential forced dislocation problem may be alleviated. However, there would be a side impact of such a change in that mechanization would be slowed in the Valley and agriculture would remain more labor intensive for a much longer period. This may or may not be desirable depending on the labor/capital situation in Jordan in the future.

7.7.4 Irrigation

The sprinkler irrigation system which had been proposed in the Feasibility Study [7-2] is not currently adaptable to all situations in the Valley because of plant disease problems associated with sprinkler irrigation on certain vegetable crops. The "problem" crops comprise as much as 50% of the valley's cultivated land over a two-year period, given current crop rotation patterns. In light of this situation and until research can provide an economically attractive sprinkler-pest control system for the problem crops, multiple irrigation systems should be used, and has now been adopted, as an alternative in the Valley, that is, combinations of sprinkler, drip, and surface. Individual farming units may use one, two, or all three of these methods depending on their normal crop mix. Currently, if farmers are left to choose, they will use either surface or drip irrigaton systems, neither of which may be employed correctly or optimal for their crop situation. Consequently, if Stage

II were to shift away from its proposed nearly total reliance on sprinklers and if farmers were to be convinced to use sprinklers when they actually are the best system, then groups such as the JVA, JVFA, Ministry of Agriculture, and the most progressive farmers would have to design several types of irrigation system mixes appropriate to the most common crop mix situations. Fortunately, capable foreign and domestic technicians are already working in the Valley who should be able to design the necessary systems.

A second alternative of Stage II in the irrigation field relates to the rate of adoption of non-surface irrigation systems. At present, farmers are not shifting from surface systems to more water efficient systems at the desired rate. The slow rate of conversion can be attributed to two factors: low water prices[1] and relatively abundant water allocations. The solution would be to establish a phased five-year program of price increases (perhaps JD 0.03 per year) and water allocation decreases (perhaps after the first year, 4% to 5% of current surface irrigation allocations each year). Such a program would have to be well publicized so that farmers could adequately plan their shift to more efficient water systems. In addition, liberal credit would have to be made available to finance the shift (credit for both drip and sprinkler, not just the latter as is currently the case).

Currently, no organization responsible for water management/allocation in the Valley appears to have developed adequate procedures or plans for (1) insuring non-abuse of water allocation procedures, (2) establishing optimal release quantities for various types of soils and crops, and (3) providing for the most equitable and/or productive water release schedules during periods of low water availability. (Yield analyses for the Maqarin Reservoir assume 6% water shortfalls as "acceptable.") It is recommended that an organization be designated the respon-

[1]These were recently doubled from 0.03 to 0.06 JD/m^3.

sibility for developing the necessary plans and procedures to cope with these three areas and be given the authority to supervise, implement, and regulate as appropriate. Such an organization should have representation, either formally within the organization or in an advisory capacity, from all interested groups, e.g., farmers, JVA, JVFA, cooperatives, and municipal and village councils.

7.8 ALTERNATIVE VILLAGE DEVELOPMENT

Two perspectives exist for examining alternatives to the Village Development Program: first, alternative concepts to the present program; second, alternative strategies for implementing the present program by emphasizing priorities, methods, and institutional devices different from those now being employed.

7.8.1 Alternative Concepts

When the Village Development Program was being formulated (see Section 6.4.1.3.2.3), its planners made an important policy decision--to improve living conditions in a series of many villages along the whole length of the Valley, instead of restricting development to one or a few locations only. The planners sought to locate farm families close to their fields, and thus to minimize the need for a long daily commute. The result was the plan for 34 villages, with only three to have populations over 12,000.

While this concept is reasonable for developing a region specializing in agriculture, it may not respond successfully either to pressures created by non-agricultural development or to long-term pressures. So long as the Valley's population works mainly in agriculture, the small-village concept may hold up. However, if work opportunities become more varied, with people in commerce, tourism, public services, and industrial activities, including the present agricultural families whose children may wish to pursue non-agricultural careers, people may demand larger and more urban settlements then now planned.

Evidence already exists that South Shuneh, the largest village in the south, is attracting many non-farming families. Judging by the 440 applications for the 100 available new housing units in South Shuneh received by JVA, about half of those seeking housing are neither Valley residents nor qualified by their occupations and skills. Many seek second, alternative residences to their main homes in Amman or Salt. Increased economic activity and wealth in the Valley are likely to

create more non-farm jobs. These will probably emerge in the larger villages, thus creating pressure on these villages to expand beyond their designated boundaries.

The options for handling this situation are:

- Increase the densities allowable in all existing villages and continue encouraging equal development of all villages;
- Revise the plans for only three to five strategically located villages (North and South Shuneh, Mashira, Kreimah, and Deir Alla-Muaddi) to anticipate a more intense and urbanized development; and
- Discourage growth of non-agricultural population above that for which existing villages have capacity through continuation of strong development controls and economic measures.

Now, there is probably no "best" alternative. However, JVA should continue to reexamine its basic village development concept in light of likely future population pressures. A reliable information system is needed to track changes in population, economic activity, and their facility and service requirements. Policies can thus be adjusted.

7.8.2 Alternative Implementation Strategies

While implementing its Village Development Program, JVA has made a number of important changes in operating policies and plans as it gained experience with the program. For example, first, it now constructs new low-income housing units on every second lot rather than on every lot, in order to provide more open space around each building. Second, JVA is starting the replatting of village land in the more open and less congested villages, in order to obtain experience in handling this very difficult and delicate task before going on to large and congested villages. Third, JVA now allows electricity to be connected to existing houses prior to completion of replatting and land allocation.

The assessment of the environmental impacts of the Village Development Program suggests other changes and adjustments which bear careful analysis:

- Reexamine the current priority and plans for sewage treatment, including the possibility of central sewage treatment facilities in larger villages instead of the presently planned household septic tanks. This is most important in light of current and potential water quality problems.
- Reexamine the method of replatting, especially in the more densely developed villages. The rigidity of the gridiron of 12 x 24 m lots, when applied to dense villages, may lead to very complicated problems in designating property lines and may thus delay the process of land reallocation. This, in turn, could delay such steps as making home improvements and building decent streets. More flexible platting standards and principles may be necessary for these difficult situations.
- Reexamine the housing program to encourage more variety in type and layout of low-cost units, including some subdivisions more appealing to farm families by providing for animals, other subdivisions attracting smaller professional households, and still other units and facilities for migrant workers and their families. Now, the program offers only one kind of unit and in only one kind of large-scale layout. While there are enough applicants to fill these units, it is not at all clear that these units, when fully occupied, will meet the needs of or be accessible to the several categories of Valley residents.
- Design more programs to train various groups, including women and young people whose future interest and opportunities in farm work may be limited.
- Design more programs to encourage new Valley-related business enterprises, such as construction materials and contracting,

local transportation, equipment repair, home maintenance, and other services that will be needed as the Valley's living conditions improve.

- Develop more preventive health programs, for example, by providing medical examination facilities in schools.

To deal with these and other issues, JVA needs stronger planning skills which stress both physical and social-economic environmental planning. Now, because JVA planners are preoccupied with construction management, they cannot devote much effort either into monitoring the current program or into analyzing and planning for the issues mentioned above. While JVA does recognize this problem, a larger effort is needed to organize and implement its planning operation.

7.9 ALTERNATIVE INSTITUTIONAL APPROACHES

As with alternative options to village development, alternative approaches to institutional development can usefully be considered from two perspectives: first, alternative concepts to the present approach; second, alternative stragegies for implementing the present approach, by emphasizing methods different from those now being used. The development of institutions (or their lack of development) is closely related to the successful use of physical infrastructure facilities, especially irrigation works and planned villages.

7.9.1 Alternative Concepts

Four sets of present concepts and alternative possibilities seem important for success of the Valley Development Program.

First, the planning documents sponsored and published by the JVA devote almost no explicit attention to the several kinds of institutional needs implicit in the Valley Development Program. These needs include, for example, the organization for maintaining and operating the irrigation distribution system, community organizations in villages affected and created by JVA's program, and government institutions needed to provide or supervise public services. However, JVA is responsible by law for social as well as physical aspects of the Valley's development. Although to date it seems to have been to let institutions develop by themselves, its leaders state their intention to pay more attention to institution building. Moreover, JVA will retain responsiblity for long-term care of the irrigation works, but will turn over schools and clinics, when completed, to the Ministries of Education and Health.

An encouraging initiative, of course, is creating the JVFA to cope with weaknesses in agricultural production. Also encouraging are other steps such as adding social scientists to JVA's staff and conducting a socio-economic census of Valley inhabitants. A potentially complementary step outside of JVA is the beginning of a national social development plan.

These steps point the way to the basic alternative concept, namely, giving explicit policy attention to institutional needs and development. Moreover, these initial steps could provide the data needed for effective policy formulation and planning. This is not meant to imply that JVA or other government institutions should necessarily launch themselves into a major program of building new institutions. On the contrary, the best role may be simply to provide planning, research, and technical assistance services to encourage private institutions to grow in their own ways; indeed, the Valley already shows encouraging evidence of enterprise. Instead, the alternative to the present approach is to develop a conscious policy and strategy for institutional growth and the role which JVA should play, if any. Such a policy would ideally be linked with both the alternative irrigation organization for water management/allocation proposed above in Section 7.7.4 and the alternative village development steps and programs identified above in Section 7.8.

Second, the existing approach to governing the Valley has at least three alternatives. One would be to replace the Valley portions of the Irbid and Balqa Governorates with a single, new Valley Governorate. Another would be to create a single Valley regional council, without municipal and village councils and supervised directly by a central government agency, such as the JVA, Interior, or MMRA. A third would be a single Valley regional council together with vigorous municipal and village councils, similar to the governance pattern planned for the JVFA. Other combinations also are possible. Each would have strengths and weaknesses. For example, a single regional council without municipal and village counterparts might not sufficiently recognize the different characteristics of population and development in the Valley's different sections; a Valley-wide council together with municipal and village councils might lead to confusion of roles; a single Valley Governorate might well be limited to a small role left over from the strong legal, organizational, and financial roles now played by the JVA. A possible solution for the last dilemma would be for JVA's

president to exercise concurrently the title and responsibilities of Governor of the Valley, perhaps for a limited period of 10 or 20 years; this approach would not only reduce organizational confusion and recognize realities, but also educate JVA to the requirements and responsibilities of governing. Regardless of details of possible alternatives, it seems likely that the present governance structure will not be adequate for the Valley's future population and economic character; hence, JVA and the Government of Jordan should at least review that structure and consider possible alternatives.

Third, large, complex, centrally managed government organizations are emerging and tending to displace small, village-based, locally managed private organizations. Given the requirements of large and costly public works projects, this is inevitable and necessary in some degree. However, large organizations are susceptible to weaknesses and usually cannot perform all functions effectively.

An alternative approach is to recognize the legitimate functions to be performed by small, local institutions, both governmental and private. While large organizations such as JVA and JVFA are needed for the major and national tasks, such as building dams and importing agricultural inputs, small organizations are still needed for complementary small-scale and local tasks, such as sewage treatment and disposal, enforcing pesticide safety regulations, and, in the private sector, handling household and farm-size construction. Within the first point above, recognizing institutional development needs, the likely future roles of small, local organizations could be recognized and anticipated. In particular, local government institutions, including both the central government's district organizations and the municipal and village councils, could be strengthened rather than ignored.

Fourth, the JVA conceives of itself, and is commonly perceived by others, as playing merely a temporary role, namely, constructing public projects and handing them over to other agencies. Perhaps also the JVA organization

is temporary. Although this concept seems admirable, it also has inherent dangers.

For example, emphasizing short-term physical building can lead to ignoring longer-term institutional development; difficult problems may be overlooked and postponed for the permanent agency to face later. At worst, the temporary concept may encourage irresponsible attitudes and decisions by public officials.

An alternative concept is to assume that because the dams, canals, and villages are constructed to be permanent, they need complementary institutions also designed to be permanent. While the actual construction of public works requires only a short time, the needs of operations and maintenance remain permanently. As noted in Chapter 6, JVA's published plans do not address the organization needed to operate the canal and irrigation system. Whether JVA should remain to perform these functions or they should be passed to another new or existing organization may not be clear. However, it seems important now both to recognize legitimate permanent needs and to design the institutional capacity to meet them.

7.9.2 Alternative Implementation Strategies

Regardless of which alternative concepts guide the Valley's future development, there are several alternative strategies and methods to the present implementation techniques.

JVA seems to have recognized formally the research and planning functions only recently, by creating a Planning and Program Unit headed by an economist. Of course, planning has been and will remain a major responsibility of JVA's top managers. However, it appears that JVA managers have paid much attention to initial planning, but little to systematic monitoring and adjustment of programs during implementation. Occasional adjustments have been made; for example, the lot size was

doubled after realizing that village houses were spaced together too tightly; occasional progress reviews have been assembled for donors. But programs as large and varied as those of JVA require regular, systematic, and disciplined monitoring and review. Moreover, this should be done not only for external authorities, but in the first instance for JVA's top managers themselves. Planning can be conceived as a one-time exercise; the alternative is some form of "rolling planning" with regular reviews and adjustments in response to changing circumstances discovered while executing the plans. A properly staffed and organized planning unit should have, as one of its tools, a simple but reliable management information system (MIS). The MIS should not only provide analyzed operating data in usable form and timely fashion to top managers; but also should feed summarized information back to middle-level division and field managers, so that each can know his own performance and have both the opportunity and incentive to improve it.

Formal working relations exist, with various degrees of effectiveness, between JVA and several functional ministries, such as Health, Education, and Agriculture, for whom JVA is building facilities. However, the general government ministries, such as Interior and MMRA, appear less informed and clear about JVA's programs and schedules; yet they, too, are concerned and affected by JVA's activities. Instead of providing only minimal information and liaison with other agencies and groups, an alternative approach for JVA would be to adopt a broad program of information and education, both general and specific. Indeed, JVA can serve within Jordan as a laboratory for research, development, and training in new or improved methods of public administration needed by other government agencies. JVA could usefully learn from such accomplishments in recent decades by the Tennessee Valley Authority.

Finally, Jordanian officials can either continue the existing pattern of Valley governance or attempt to clarify and rationalize it in response to new conditions created by JVA's successful program. Whichever concepts and forms of governance are best, they should be chosen consciously and clearly rather than left mainly to tradition and chance.

8.0 ADVERSE IMPACTS WHICH CANNOT BE AVOIDED AND MITIGATING MEASURES

8.1 INTRODUCTION

The construction and operation of almost any facility involving large areas of land can be expected to cause significant impacts on several environmental parameters, some of which will be adverse and unavoidable. These impacts can be viewed as the environmental cost of the project and may be expressed in both tangible and intangible terms. Mitigating measures are supplementary actions that will be or could be taken to reduce or eliminate the severity of these impacts, generally at some additional cost to the project. This chapter serves to summarize the unavoidable adverse impacts associated with the proposed project and to identify actual or potential mitigating measures. The impacts are addressed using three categories; those associated with (1) the construction phase, (2) the operations phase, and (3) the socio-economic aspects of the project.

8.2 CONSTRUCTION-RELATED IMPACTS

Unavoidable adverse impacts associated with construction generally involve earthmoving and building of structures. These activities will occur at the Maqarin Dam site, the diversion dam at Adasiye, the EGMC extension, and M&I pipeline routes to Amman and Irbid, and new housing and other municipal service buildings, and on new farmland that is prepared for irrigation.

There are four potentially significant adverse impacts associated with construction. First, the construction activities may destroy sites having archaeological value. These are described in Section 6.4.1.1.2.3. Two types of mitigating actions are possible: (1) conduct pre-construction surveys to locate the sites and perform salvage excavations prior to construction; and (2) relocate the constructed facilities to avoid the sites. The latter could include the setting aside and fencing of parts of the new irrigated lands areas. Lands set aside could be taken from the 3600 ha that will no longer be irrigated due to increased M&I water allocations.

Another adverse impact associated with construction activity is the increased erosion and sedimentation, whether from wind or water, as the land is disturbed and prior to post-construction activities. Mitigating measures include planning of excavation and grading work so as to minimize exposed areas with respect to both the size and time that an area is exposed, installation of temporary drainage system including sediment settling ponds, and placement of oil, calcium chloride, or sprinkled water on construction haul roads.

The construction of the Maqarin Dam will disrupt the Himma Branch of the Hejaz Railroad, thereby cutting service to a few villages in the downstream Yarmouk Valley. The proposed mitigating action involves either a relocated railroad section or a new road into the Valley.

The fourth adverse impact from construction involves the habitat loss for aquatic and terrestrial biota, primarily in the Maqarin Reservoir and for the new irrigated lands. Mitigating actions that can be taken involve the setting aside, with perhaps some preparation, or alternative habitat areas having environments similar to the lost areas. Competitition for arable land in the limited Mediterranean/high rainfall regions would appear to limit possibilities for preserving or creating indigenous habitat in such areas.

8.3 OPERATIONS-RELATED IMPACTS

8.3.1 General

There are several unavoidable adverse impacts associated with the operations phase. Stage II will change the streamflow regime in the Yarmouk River from a natural state to one that will be essentially 100% regulated. It will also cause the transfer of most of the water to M&I and irrigation uses, with associated high consumptive losses. Operations will transform arid lands to irrigated land, with associated changes in the microclimate and the natural habitat. The overall irrigation activities, including both existing and new lands, will affect the groundwater table and quality. The population in the Valley will increase, with associated problems regarding water supply, sewage disposal and solid waste disposal.

8.3.2 Water Resources

The filling of the Maqarin Reservoir will cause the loss of 20-30 ha of cultivatable land and will require relocation of the few persons living there. The existing wildlife habitat will also be lost. Relocation of residents will serve as a mitigating measure, but there is no suitable mitigating action for the loss of wildlife habitat. The loss of cultivatable land is partly mitigated by the opening of new irrigated land in the Valley, but this does not cover reservoir land located in Syria. As the reservoir rises and fluctuates, archaeological sites will be subject to destruction. Mitigating actions would include salvage excavations prior to the filling of the reservoir.

The transfer of water from the Yarmouk River will deplete its flows into the Jordan River and reduce the Jordan's flow into the Dead Sea. Irrigation return flows will not equal the original streamflows, and the lower Yarmouk and the Jordan Rivers will become more polluted as a result of less water for dilution and more salts and other chemicals leaching from farm and village lands to the rivers. It is estimated that the Dead Sea level would drop about 10 meters as a result of reduced flows attributable to the project. Mitigating actions would involve measures to minimize evaporative losses and control of waste and drainage water to minimize dissolved solids in return flows. The drop in the Dead Sea

level may eventually be reversed by ocean inflows via hydroelectric projects that have been proposed by the governments of both Israel and Jordan.

The application of irrigation water to farmland can have several adverse impacts. In areas with high water tables, the soil can become waterlogged. This can be mitigated using drainpipe and ditches. The soil can also undergo salt buildup as irrigation water evaporates. This impact can be mitigated by periodic flushing of the soils. Another action would be to reduce the salinity of irrigation water by diverting high capacity saline springs located along the Yarmouk River upstream of the Adasiye Diversion Dam to a point on the river below the dam.

8.3.3 Soils

The move to greater cropping intensity and eventually greater mechanization will increase machinery usage in the fields. On clay type soils this can lead to soil compaction with its related problems. In order to mitigate this adverse impact, annual subsoiling can be undertaken whereby the soil is turned over 45-60 cm deep. Deep plowing can be helpful but is generally not sufficient over time. Farmers with clay-type soils should be made aware of this situation as should operators who machine-prepare land for planting at a per dunum charge.

Much land in the south that was to be irrigated in the future from the EGMC has already been cleared, is being cleared, is having rocks removed, or is already undergoing a leaching process to remove salts. It now appears that due to increased M&I allocation of water some of this land will not be cultivated. If this land is subsequently abandoned in its current state, wind and water erosion could eventually occur. To avoid this, provisions should be made to plant these areas with a drought resistant cover.

8.3.4 Pesticides

As a result of Stage II, pesticide use in the Valley for currently cropped hectares is expected to increase by 475% from present usage levels. Total usage in the Valley will increase 700% since uncultivated

lands not now using pesticides will be placed into production. Some highly toxic compounds are being used as well as several that are undergoing review by the EPA in the United States. This, coupled with an illiteracy rate of over 65% among farmers and pesticide labels printed in English or other non-Arabic languages, poses a potentially dangerous situation for an area as concentrated and topographically confined as the Jordan Valley. Several actions can be taken to mitigate the possible negative impact of pesticide usage (which at this time cannot be avoided):

- Increase pest control research in the following areas:
  - Pesticides (optimal compounds, rate, and usage frequency),
  - Agronomic (pest resistant varieties), and
  - IPM (Integrated Pest Management using pesticides, predators, bacteria, etc., in combination);
- Establish a governmental pesticide supervisory group to undertake or implement as appropriate:
  - Regulations or guidelines,
  - Supervision of the application of highly toxic or environmentally sensitive compounds,
  - Licensing of custom pest control applicators, and
  - Monitoring residue levels in crops, soil, air, water as needed;
- Promote centralized, easily supervised public or private pesticide application operators who would:
  - Monitor pest levels and recommend treatment only when necessary (for curative as opposed to preventive control programs) and
  - Apply all highly toxic or environmentally sensitive compounds; and
- Require all pesticides sold in Jordan to be accompanied by a label in Arabic and English.

The pesticide issue is that area of Stage II in most need of attention from a physical environment and human safety and health standpoint.

8.3.5 Health

The microclimate in irrigated areas will become more humid, and there is the possibility that small pools of water may occur that could serve as a breeding place for mosquitoes and habitat for snails. These, in turn, could contribute to the spread of vector-carried disease. Mitigating actions would inclue the control of open water pools, use of pesticides, and public health education and monitoring.

The existing Malaria Control Unit has proven itself effective, and given the necessary resources, it should be able to maintain tight control over the malaria problem. Schistosomiasis, on the other hand, has not received sufficient attention. Recent training activities and the development of a Schistosomiasis Control Unit are positive signs, but more work is needed. In particular, it is essential that national snail surveys be taken and that surveillance procedures be established to detect infections in both snail and human populations.

The increased agricultural activities in the Valley will require an increased population, with associated village development and needs for utilities. Sewage disposal will be a problem and could result in adverse health effects and groundwater contamination if adequate leaching is not provided, particularly for water supplies obtained from wells. Mitigating actions would include proper design of wastewater disposal facilities and monitoring of groundwater quality.

8.3.6 Biology

As discussed in Chapter 6, impacts directly attributable to Stage II actions included habitat losses for aquatic and terrestrial biota in the regions of the proposed Maqarin Reservoir and Jordan Valley new lands development. By and large, such losses do not appear to be subject to mitigation for those species that can only survive under environmental conditions as they presently exist. One mitigative measure that can offset such losses, to some extent, is the reserving or creating of habitat similar to that being lost, but in another location. Such action does not appear feasible for aquatic species due to the limited and/or already altered nature of water

resources in Jordan. Competition for arable land in the limited Mediterranean/high rainfall regions would appear to limit possibilities for preserving or creating indigenous terrestrial habitat in such areas as well. The exception might be the recreation and/or improvement of arid habitat elsewhere in Jordan. The proposed legislation that would establish wildlife reservations in Jordan might help to preserve habitat for some species, but it is not designed to offset losses created by this project.

Measures that could mitigate Stage II impacts that represent incremental changes in an ongoing development process are largely related to long-term land and water use management practice. Examples include:

- Successful revegetation (especially in areas of more severe topography), restriction of grazing by domesticated animals to rangeland carrying capacity, and restriction of agriculture on marginal lands would reduce potential erosion siltation and increasing desertification problems associated with this proposed action.

- Limiting agricultural runoff, erosion, septic seepage and other pollutants into usable water supplies would reduce water quality problems and potential impacts to biological systems that are associated with adverse water quality.

One of the greatest difficulties in describing specific mitigative actions is the lack of an adequate data base especially for the Yarmouk Valley and the Jordan Valley. For this reason, Appendix C-2 was added, identifying several key areas for gathering additional information that would enable an incorporation of mitigating actions into the planning process. It is important to note that programs, either ongoing or planned, do exist in Jordan and that these are focused on attempts to address some of the environmental issues identified for the country. Although many of these issues are those also identified as potential or existing problems in regions that are the subject of this report, existing programs are

essentially directed at other regions of the country and some are of very limited scope. Expansion of such programs to include the Jordan and Yarmouk Valleys and associated wadis (in addition to the Zarqa), and in some cases, increasing their design scope would help in the identification of specific actions that would mitigate some of the impacts identified. (Appendix C describes some of these planned or ongoing programs.)

8.4 SOCIO-ECONOMIC IMPACTS

There are several indirect impacts associated with the Stage II project that fall in the general socio-economic area. The degree to which they are adverse and unavoidable and the number of persons they will impact cannot be readily quantified, since it will depend on unknown future events. Accordingly, the discussions that follow serve to identify these impacts and to suggest potential mitigating actions.

8.4.1 Land Redistribution

Misunderstandings still exist in the Valley regarding the procedures for redistributing land. This is especially true of the smaller farmers, both landowners and tenants. Hopes have been unnecessarily raised for many and now are being lost, with resulting disillusionment and cynicism. Care should be taken when publicizing all facets of the redistribution program that facts are accurate and complete, and that all necessary persons are apprised of these facts. Each farmer or landowner who receives land or has it taken away should be made to understand how the quantities and locations of these land actions were determined. In addition, and perhaps even more importantly, those who did not receive land but thought perhaps they should have (e.g., tenant farmers) should be made aware of why they were unable to receive land allocations when others, many non-farmers, could.

Under the proposed land redistribution program in Stage II, few if any existing tenant farmers will receive land. Consequently, this makes them vulnerable to dislocation as farms consolidate and mechanize. Since it is probable that such dislocations will eventually occur (unless mechanization results only from the pressures imposed by labor shortages, including foreign labor), provisions should be made for channeling those former tenant farmers into new occupations. If social status perceptions permit, some can become machinery operators and/or owners. However, this can only absorb a portion of those who may lose their farms. The remainder will have to find jobs in non-agricultural production in the Valley or elsewhere in Jordan.

Land appropriated then redistributed in Stage I prior to 1967 was "purchased" and then "sold" by the government at a cost of JD 8-40 per dunum. Currently, the redistribution committee which sets land values has recommended a price of JD 300 per dunum. Since the land price is supposed to reflect the value of the land without water, JVA is strenuously objecting to this high valuation since they feel it will place an undue financial burden on those small owners who are allocated land and must pay for it. Consequently, JVA is recommending that the JD 8-40 per dunum price used in the north still be used today since it more nearly reflects the value of the land without water.

The JD 300 per dunum seems to represent a fair agricultural value for the land with water. However, the JD 8-40 would be too low a price for the land without water since no doubt considerable inflation has occurred in Jordan since 1967. Consequently, a land price between that recommended by JVA and that by the redistribution committee should be considered to ensure that new landowners can afford their new land and old landowners do not lose the reimbursement to which they can legitimately lay claim. An index related to cost movements in Jordan (perhaps to non-irrigated land elsewhere in Jordan) should be applied to the 8-40 JD per dunum prices to arrive at a reasonable price.

8.4.2 Agricultural Production

There is increasing competition for the marketing of fresh vegetables in the oil-exporting nations of the Middle East which have traditionally been the outlet for much of Jordan's fruit and vegetable production. In addition, the European market is becoming extremely competitive. Consequently, if in the future this market becomes an unattractive one, the Jordan Valley may find it necessary to switch from such a high dependence on fruit and vegetable production to more reliance on grains and other field crops. Since these crops require considerably different infrastructural requirements (both physical and institutional) than fruits and vegetables, the government should monitor this situation carefully. If at any time the mid- to long-term market situation appears

to be turning against Jordan's export of fruits and vegetables, then the appropriate organizations both in and outside the Valley should begin planning the support structure necessary for a different agricultural crop mix.

Fruit and vegetable prices can be extremely volatile from year to year. Consequently, vegetable producers' net incomes may range from quite profitable to high loss situations. A crop may lose money for two or more consecutive years before making a profit. Under such situations, a farmer's ability to repay loans (agricultural investment, seasonal crop, or even housing mortgage) can vary considerably from year to year. Therefore, those credit programs (ACC, JVFA, Village Development Housing, and others) available to farmers must be sufficiently flexible to permit justifiable deferred payments or refinancing under such adverse market price situations. The lending institution should, of course, evaluate whether the loss posture was avoidable by the farmer, and, if so, it should take supervisory steps to insure avoidance of an unnecessary situation.

8.4.3 Livestock, Poultry, and Other Animals

The cultivation of new lands and the increased use of lands for farming in the summer months when Valley residents often graze their animals in the lowlands may mean a reduction in lands available for grazing. This may increase the usage intensity of lands already over-grazed outside the Valley. Until a national program has been developed to cope with the over-grazing issue, no realistic solution for the Valley animals can be forwarded with hopes of success. It is possible that increased availability of crop stubble, increased availability of forage and grain crops produced in the Valley, and increased income levels for those farmers with animals may resolve the problem by itself. This, of course, depends on the availability of non-grazing feedstuffs for household (versus commercial) animals, and the ability and willingness of livestock owners to purchase these feedstuffs.

Village development housing designs and lot sizes do not lend themselves to maintaining household animals or poultry flocks. As a result, egg, milk, and meat consumption of those who move into these houses may fall. Consequently, two suggestions are made:

- For previously constructed village development housing, make provisions for livestock and poultry to be raised near the housing projects if health conditions permit.
- For future housing built by the government, ensure that housing design and lot size lends itself to the livestock and poultry needs of the likely inhabitants of this housing.

A number of the pesticides employed in the Valley can be toxic to bees. Consequently, beekeepers need to know which compounds pose the greatest threat to their bees, which crops these pesticides are apt to be used on, and the most probable time of the year applications will occur. With this information they can take steps to protect their bees. The information can be provided to the beekeepers by the Ministry of Agriculture's Research and Extension Department. In addition, once a supervisory agency has been established and centralized application becomes widespread, the beekeeper can work with these groups to reduce the hazard potential to his bees.

8.4.4 Agriculturally Related Enterprises

The principal environmental impact that may arise with the advent of the various agriculturally related businesses resulting from Stage II is the waste disposal issue. This will be of particular importance for pesticide formulation, fertilizer blending, and various manufacturing/food processing facilities. To ensure that the disposal operations undertaken by enterprises such as these do not cause easily avoidable environmental and health problems, appropriate waste disposal regulations can be adopted and enforced. These regulations should take into consideration additional costs that are inherent in them and ensure that the benefits derived (i.e., the negative impacts avoided) are worth this cost. Existing U.S. regulatory cost studies (primarily by the EPA) could aid in this environmental/safety/health benefit-financial cost evaluation process.

9.0 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

This chapter explores the extent to which the proposed action involves trade-offs between short-term environmental gains at the expense of long-term losses, or vice versa, and the extent to which the proposed action forecloses future options. In this context, short-term and long-term do not refer to any fixed time periods but are viewed in terms of environmentally significant consequences of the proposed action.

The project involves several actions. Those of interest for this discussion are construction of the Maqarin Dam, irrigation of farmland, village development, supply of M&I water to the upland cities, and application of pesticides.

Construction and operation of the Maqarin Dam will represent a long-term change in the topography of the Yarmouk Valley and the flows in the Yarmouk River. The existing appearance of the Yarmouk Valley will change, although some persons would claim that the dam and reservoir could enhance its scenic qualities. The reservoir will trap sediments that would otherwise move downstream, eventually filling the reservoir, and the annual flow regime of the Yarmouk River will change from uncontrolled (with high winter flows) to regulated (with more uniform monthly flows). However, the Yarmouk River does not provide the same annual flooding and silt deposition of the downstream floodplains as was characteristic of the Nile River. As a result, it is not expected that the Maqarin Dam will have significant short- or long-term affect on downstream floodplains.

The dam and reservoir, as well as the extension of the EGMC and the preparation of new irrigated lands, could destroy sites of archaeological interest if mitigating actions are not taken. Once destroyed, these sites would be lost forever. The irrigation of land also creates a threat of introduction of schistosomiasis in Jordan. Once established, it would be difficult to eradicate and would have a debilitating effect on many future generations.

The development of a new village tends to be a permanent action in that once houses and streets are established it is difficult to change the layout. For this reason, future generations will have to live with today's planning. Thus the size of house lots and the location and width of streets should be selected with consideration for the needs of future generations.

By supplying M&I water to the upland cities, the project will indirectly permit their growth. This, in turn, will shape the distribution and the activities of the population in Jordan in the future; that is, it will promote upland growth at the expense of Valley growth, particularly since about 3600 ha of land cannot be irrigated. However, this trend does not represent an adverse affect on long-term productivity, and, indeed, it could well be construed as beneficial to future generations.

The final item deals with the use of pesticides in the short term. The concern here is with overuse and subsequent contamination of the soil and groundwater resources. Contamination of groundwater could also occur from improper sewage and solid waste disposal facilities. Such contamination is difficult to eliminate and could persist for many decades. Because water will increasingly be needed in the future as the population of Jordan increases and because groundwater is one of the only remaining sources, every effort should be made to protect it for long-term use.

10.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF NATURAL OR CULTURAL RESOURCES

There are two natural resources that will for all practical intents be irreversibly and irretrievably committed as a result of the project. One is the physical shape of the Maqarin Valley, which will be occupied by a dam and reservoir; the other is surface water supply, which will be diverted for use for irrigation and M&I supply. Although the diversions could be discontinued at any time by simple changes at the control structures, it would be impractical to do so once people became dependent on the supply. As a result of the diversion, the flow of water from the Yarmouk River to the Jordan River will decrease, and the Dead Sea will drop in elevation by about 10 meters. This drop may eventually be regained if ocean waters are discharged into the Dead Sea to generate hydroelectric power. The estimated annual changes in surface flows are shown in Figure 4-12 of Chapter 4.

The cultural resource that is subject to irretrievable loss is represented by sites of archaeological interest located both in the Jordan Valley and Maqarin Reservoir. The extent of such losses will depend on the mitigating actions that may be taken to locate and salvage the sites prior to construction activities and filling of the reservoir. The sites are described in detail in Section 6.4.1.1 and in Appendix I.

The constructed facilities will, of course, consume the materials of construction, mainly rock, soil and cement, with some amount of steel, plus the energy and labor needed for their manufacture and installation. However, as a result of the project the water resources of the country will be developed for the beneficial use of its population. Furthermore, the hydroelectric power that will be generated will be derived from a renewable power source, therby decreasing the need for fossil fuel, a non-renewable resource.

11.0 OTHER POLICY INTERESTS AND CONSIDERATIONS OFFSETTING ADVERSE ENVIRONMENTAL IMPACTS

A number of unavoidable adverse environmental impacts were identified in Chapter 8. Except for those associated with new construction activities, for example, inundation of arable land and archaeological sites by the proposed Maqarin Reservoir, most impacts likely from Stage II are merely incremental additions to those already caused by Stage I activities. Fortunately, the nature of the whole Valley Development Program is to use natural resources, create jobs, and attract population, rather than to destroy resources and displace people and their livelihoods. Moreover, many of the adverse impacts likely from Stage II can be mitigated by effective action by JVA.

Several larger interests and considerations of the United States, AID, and Jordan seem likely to offset the Stage II remaining adverse environmental effects. U.S. foreign policy seeks to strengthen the economic and social wellbeing of a country which has long been friendly and which must play an important role in encouraging peace and stability in the strategically important Middle East. AID is charged with helping to implement U.S. foreign policy; it wants and needs the cooperation of the Government of Jordan which, in turn, sees development of the Valley as a key component in the country's overall development strategy and also ranks the Maqarin Dam among its top three development priorities. Jordan seeks, through Stage II, to increase its foreign exchange earnings potential, to strengthen and balance its economic base, to employ underused natural and human resources, to help support a growing population, and to help improve the economic and social status of disadvantaged Jordanians. Not to be overlooked, also, is fostering national pride by accomplishing successfully a program which has been dreamed of for decades and which is large and challenging by any standards.

APPENDIX A

DEFINITIONS, ABBREVIATIONS AND UNITS

A.1 DEFINITIONS

Action or Proposed Action - In Environmental Impact Statements and Assessments, the planned projects, construction, or activities which would affect the environment and are thus being analyzed.

Aluvium - Clay, silt, sand, or gravel deposited by running water.

Anerobic - Characterized by the lack of free oxygen.

Anticline - An arch of stratified rock in which the layers bend downward in opposite directions from the crest.

Argillacious - Relating to clay or clay materials.

Aquifer - A water-bearing layer of permeable rock, sand or gravel.

Benthic Region - The bottom of a body of water.

Biochemical Oxygen Demand - The amount of dissolved oxygen required to meet the metabolic needs of aerobic organisms in water that is rich in organic matter, such as sewage. (Also known as Biological Oxygen Demand.)

Biota - All the species of plants and animals occurring in a certain area.

Central Jordan Valley - Deir 'Alla Subdistrict, in Balqa Governorate, from Dirar down to just above Karama.

Conurbation - An aggregation or continuous network of urban communities.

Crop hectares - Double or triple counting of hectares in agricultural production which produce more than one crop per year.

Dissolved Oxygen - Oxygen gas dissolved in water.

Dissolved Solids - The total amount of dissolved material, organic and inorganic, contained in water or wastes.

East Bank - A political term commonly used after the 1948 war to refer to all Jordanian territory east of the Jordan River and to distinguish it from the West Bank or Arab areas of Palestine. "East Bank" thus includes not only the geographic eastern bank of the Jordan River Valley, but also all of the upland plateaus and eastern deserts comprising the former Trans-Jordan. This definition is important to remember when studying Jordanian statistics.

East Jordan Valley - Used in this report to refer to that portion of the Jordan River Valley that lies east of the Jordan River, as opposed to any parts of the Jordan River Valley west of the Jordan River.

Ecosystem - An integrated unit or "system" in nature, sufficient into itself with a balanced assortment of life forms to be studied as a separate entity.

Endangered Species - In this report, the term is used in the vernacular for species believed to be suffering serious population declines.

Environment - The combination of all external influences and conditions affecting the life, development and ultimate survival of an organism, including man.

Eutrophication - A situation in a water body where plant growth has reached "nuisance" proportions.

Ghor - In the East Jordan Valley, land located above the flood plain of the river itself but below the steep hills leading to the upland plateau.

Habitat - The sum total of environmental conditions of a specific place that is occupied by an organism, population, or community.

Harza - Harza Overseas Engineering Company.

Karstic - A topography formed over limestone, dolomite, or gypsum and characterized by sinkholes, caves, and underground drainage.

Katar - Transition zone between the Ghor and the Zor.

Mined water - Groundwater removed by pumping in excess of groundwater recharge.

Montmorillionite - A soft clayey mineral.

North Jordan Valley - North Shuneh District, in Irbid Governorate, extending from Adasiye down to and including Khazma.

pH - A measure of the acidity or alkalinity of a material, liquid or solid. pH is represented on a scale of 0 to 14 with 7 representing a neutral state, 0 representing the most acid and 14 the most alkaline.

Phreatic aquifer - Groundwater occurring in a zone of saturation having a water table as distinguished from artesian or confined water.

Phytoplankton - Relatively minute floating plants, usually algae, whose movements are more or less dependent on currents.

Platting - Laying out lots on the ground by determining the location of property lines and boundaries.

Runoff - The portion of rainfall, melted snow or irrigation water that flows across ground surface and eventually to streams.

Seismicity - Quality of being subject to earth vibrations or earthquake.

South Jordan Valley - South Shuneh sub-district, in Balqa Governorate, from Karama south to shore of Dead Sea.

Subsidence - A local mass movement that involves principally the gradual downward settling or sinking of the earth's surface with little or no horizontal motion.

Talus - A slope formed by accumulated rock debris or a collection of rock debris at the base of a cliff.

Tectonic - Pertaining to the deformation of the earth's crust.

Turbidity - Opaqueness or reduced clarity of a body of water due to suspended matter.

Wadi - River or stream bed that is dry for part of the year.

West Bank - Commonly refers to the Arab areas of Palestine, located mainly on the sloping Jordan Valley lands west of the Jordan River and the Dead Sea. Controlled by Jordan between 1948 and 1967, and since often termed the "occupied territory."

Yarmouk Triangle - Israeli land north of the Yarmouk River and south of Lake Tiberias.

Zarqa Triangle - Valley land along the Zarqa River.

Zor - In the East Jordan Valley, land that forms a flood plain immediately adjacent to the Jordan River.

A.2 ABBREVIATIONS

ACC	- Agricultural Credit Corporation
ADT	- Average Daily Traffic
BOD	- Biochemical Oxygen Demand
DO	- Dissolved Oxygen
EA	- Environmental Assessment
EPA	- United States Environmental Protection Agency
EGMC	- East Ghor Main Canal
GDP	- Gross Domestic Product
GNP	- Gross National Product
IBRD	- International Bank for Reconstruction and Development ("World Bank")
JVA	- Jordan Valley Authority
JVFA	- Jordan Valley Farmers' Association
M&I	- Municipal and Industrial
MIS	- Management Information System
MMRA	- Ministry of Municipal and Rural Affairs
MPW	- Ministry of Public Works
MVLF	- Municipal and Village Loan Fund
NPC	- National Planning Council
TDS	- Total Dissolved Solids
U.S. AID	- United States Agency for International Development
WHO	- World Health Organization

A.3 UNITS

(English equivalents shown as approximate values.)

Length

mm	- millimeter = 0.001 m	0.04 inches
cm	- centimeter = 0.01 m	0.39 inches
m	- meter	3.28 feet
km	- kilometer = 1000 m	0.62 miles

Area

ha	- hectare = 10,000 m^2	2.47 acres
du	- dunum = 0.1 ha	0.25 acres

Volume

MCM	- million cubic meters	
l	- liter = 1000 cm^3	1.06 quart

Mass

g	- gram	0.035 ounces
kg	- kilogram = 1000 g	2.2 pounds
tonne	- metric ton = 1000 kg	1.1 tons

Electrical

V	- volt	Prefix:	k - kilo = 10^3
A	- amp		M - mega = 10^6
W	- watt		G - giga = 10^9

Time

s	- second
h	- hour
d	- day

Money

JD	- Jordanian Dinar (about $3.00)
fils	- 0.001 JD

Other

ppm	- parts per million

APPENDIX B

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APPENDIX C

BIOTIC ENVIRONMENT

C.1 SPECIES LIST

Of the few species lists that do exist for Jordan, two were chosen for this appendix. Both provide some indication of the significance of the species listed. Very old lists were not included because of the amount of environmental change that has occurred in Jordan during this century. The list of mammals prepared by Clark [C-1][1] for the Royal Society for the Conservation of Nature (RSCN) is especially useful as it indicates those species considered threatened or endangered in Jordan. Only excerpts of the report are included here. The full report should be consulted for the descriptions of known ranges and reported sightings of the mammals listed.

The data presented below were taken by Clark from Harrison (1964, 1968, and 1972), Nelson (1973), the International Zoo Yearbook for 1976 and from the author's personal observations. [C-1]

Clark indicates that a good deal more collecting remains to be done before a comprehensive picture of Jordan's mammals can be drawn. Future systematic surveys may discover several more species, particularly of the smaller insectivores and rodents. In the list reported here, only definite Jordanian records have been used.

Of the 69 mammals that have been reliably recorded in Jordan, five are locally extinct:

Brown bear	*Ursus arctos*
Asiatic lion	*Panthera leo persica*
Arabian onyx	*Onyx leucoryx*
Fallow deer	*Dama dama*
Syrian wild ass	*Equus heriones hemip*

[1]Numbers in brackets, e.g., [C-1] refer to references listed in Appendix B.

The last-mentioned subspecies is probably entirely extinct.

The status of five species is considered uncertain:

Wolf	*Canis lupus*
Leopard	*Panthera pardus*
Cheetah	*Acinonyx jubatus*
Dorcas gazelle	*Gazella dorcas*
Goitred gazelle	*Gazalla subgutturosa*

Three species may be regarded as endangered:

Striped hyaena	*Hyaena hyaena*
Ibex	*Capra ibex*
Mountain gazelle	*Gazella gasella*

As stated by Clark:

> "It is difficult to know where to end this list of endangered species. Many have been recorded only very infrequently; but the fact that an animal is rare may not necessarily be an indication of endangerment. Anecdotal accounts, however, do suggest that several other species were once commoner than they are today, for example, wild boar (*Sus scrofa*), caracal lynx (*Caracal caracal*) and Indian crested porcupine (*Hystrix indica*). Data on past distribution and abundance of most mammals are so incomplete that it is impossible to draw sound judgments."

Clark states that priority species ought to be selected for reintroduction programs. Certain ungulates of the semi-arid steppe may be the best species to begin with:

Goitred gazelle
Arabian onyx
Dorcas gazelle
Wild ass

In a second phase, species such as Mountain gazelle, Ibex, and Fallow deer could be kept at Shaumari although they would not necessarily be for release in badia terrain. In a later phase, a second reserve with captive breeding facilities in the western part of the country could be used.

According to Clark:

> "At a much later stage the reintroduction of carnivores may become feasible. This is likely to be many years in the future at a time when the prey species are in sufficient abundance to support predation. Reintroduction of captive carnivores is not an easy matter; the fact that they will not have learnt to hunt has to be overcome and the transition made to a self-supporting status."

This list of Jordan's mammals as reported by Clark is shown in Table C-1. A list of bird species is shown in Table C-2.

Table C-1

List of Jordan's Mammals

ORDER INSECTIVORA (INSECTIVORES)

Family ERINACEIDAE (HEDGEHOGS)

Erinaceus europaeus Linnaeus 1758 European hedgehog

Hemiechinus Auritus Gmelin 1770 Long-eared hedgehog

Paraechinus aethiopicus Ehrenberg 1833 Ethiopian hedgehog

Family SORICIDAE (SHREWS)

Suncus etruscus Savi 1822 Savi's pygmy shrew

Crocidura russula Hermann 1780 Common European white-toothed shrew

ORDER CHIROPTERA (BATS)

SUB-ORDER MEGACHIROPTERA

Family PTEROPODIDAE (FRUIT-EATING BATS)

Rousettus aegyptiacus E. Geoffroy 1810 Egyptian fruit bat

Family RHINOPOMATIDAE (MOUSE-TAILED BATS)

Rhinopoma microphyllum Brünnich 1782 Greater mouse-tailed bat

Rhinopoma hardwickei Gray 1821 Lesser mouse-tailed bat

Family EMEALLONURIDAE (SHEATH-TAILED BATS)

Taphozous nudiventris Cretzschmar 1820 *vel* 1831 Naked-bellied tomb bat

Family NYCTERIDAE (SLIT-FACED BATS)

Nycteris thebaica Geoffroy 1818 Egyptian slit-faced bat

Family RHINOLOPHIDAE (HORSESHOE BATS)

Rhinolophus ferrum-equinum Schreber 1774 Greater horseshoe bat

Rhinolophus hipposideros Bechstein 1800 Lesser horseshoe bat

Rhinolophus euryale Blasius 1853 Mediterranean horseshoe bat

Rhinolophus blasii Peters 1866

Family HIPPOSIDERIDAE (LEAF-NOSED BATS)

Asellia tridens E. Geoffroy 1813 Trident leaf-nosed bat

Family MOLOSSIDAE (FREE-TAILED BATS)

Tadarida teniotis Rafinesque 1814 European free-tailed bat

Table C-1 (continued)

Family VESPERTILIONIDAE (VESPERTILIONINE BATS)

Nyctalus noctula Schreber 1774 Common noctule

Pipistrellus kuhli Kuhl 1819 Kuhl's pipistrelle

Octonycteris hemprichi Peters 1859 Hemprich's long-eared bat

Miniopterus schreibersi Kuhl 1819 Schreiber's bat

ORDER CARNIVORA (CARNIVORES)

Family CANIDAE (DOGS, JACKALS, WOLVES AND FOXES)

Canis aureus Linnaeus 1758 Asiatic jackal

Canis lupus Linnaeus 1758 Wolf

Vulpes vulpes Linnaeus 1758 Common red fox

Family URSIDAE (BEARS)

Ursus arctos Linnaeus 1758 Brown bear

Family MUSTELIDAE (MUSTELIDS)

Martes foina Erxleben 1777 Beech or stone marten

Vormela peregusna Güldenstaedt 1770 Marbled polecat

Meles meles Linaeus 1758 Badger

Lutra lutra Linaeus 1758 Common ottor

Family VIVERRIDAE (GENETS AND MONGOOSES)

Herpestes ichneumon Linnaeus 1758 Egyptian mongoose or ichneumon

Family HYAENIDAE (HYAENAS)

Hyaena hyaena Linnaeus 1758 Striped hyaena

Family FELIDAE (CATS)

Felis silvestris Schreber 1777 Wild cat

Felis chaus Güldenstaedt 1776 Jungle cat

Caracal caracal Schreber 1776 Caracal lynx

Panthera leo persica Meyer 1862 Asiatic lion

Panthera pardus Linnaeus 1758 Leopard

Acinonyx jubatus Schreber 1776 Cheetah

ORDER HYRACOIDEA (HYRAXES)

Family PROCAVIIDAE

Table C-1 (continued)

ORDER ARTIODACTYLA (EVEN-TOED UNGULATES)

SUB-ORDER RUMINANTIA (RUMINANTS or CUD-CHEWERS)

Family BOVIDAE (BOVIDS)

Capra ibex Linnaeus 1758 Ibex

Onyx leucoryx Pallas 1777 Arabian onyx

Gazella gazella Pallas 1766 Mountain gazelle

Gazella dorcas Linaeus 1758 Dorcas gazelle

Gazella subgutturosa Güldenstaedt 1780 Goitred or Persian gazelle

Family CERVIDAE (DEER)

Dama dama Linnaeus 1758 Fallow deer

SUB-ORDER SUIFORMES

Family SUIDAE (PIGS)

Sus scrofa Linnaeus 1758 Wild boar

ORDER PERISSODACTYLA (ODD-TOED UNGULATES)

Family EQUIDAE (HORSES AND ASSES)

Equus hemiones hemippus I. Geoffroy 1855 Syrian wild ass or onager

ORDER LAGOMORPHA (LAGOMORPHS)

Family LEPORIDAE (HARES AND RABBITS)

Lepus capensis Linnaeus 1758 Cape hare

ORDER RODENTIA (RODENTS)

Family SCIURIDAE (SQUIRRELS, FLYING SQUIRRELS AND MARMOTS)

Sciurus anomalus Güldenstaedt 1785 Persian squirrel

Family HYSTRICIDAE (PORCUPINES)

Hystrix indica Kerr 1792 Indian crested porcupine

Family DIPODIDAE (JERBOAS, BIRCH MICE AND JUMPING MICE)

Allactaga euphratica Thomas 1881 Euphrates jerboa

Jaculus jaculus Linnaeus 1758 Lesser jerboa

Family MUSCARDINIDAE (DORMICE)

Eliomys melanurus Wagner 1840 Southwest Asian garden dormouse

Table C-1 (continued)

Family SPALACIDAE (MOLE RATS)

Spalax leucodon Nordmann 1840 Lesser mole rat

Family MURIDAE (RATS AND MICE)

Apodemus mystacinus Danford and Alston 1877 Broad-toothed field mouse

Rattus rattus Linnaeus 1758 House or black rat

Mus Musculus Linnaeus 1758 House mouse

Acomys dimidiatus Cretzschmar 1826 Spiny mouse

Acomys russatus Wagner 1840 Golden spiny mouse

Nesokia indica Gray and Hardwicke 1832 Short-tailed bandicoot rat

Family CRICETIDAE (HAMSTERS, GERBILS, VOLES, ETC.)

Gerbillus Henleyi de Winton 1903 Pygmy gerbil

Gerbillus nanus Blanford 1875 Baluchistan gerbil

Gerbillus dasyurus Wagner 1842 Wagner's gerbil

Gerbillus andersoni de Winton 1902 Anderson's gerbil

Gerbillus gerbillus Olivier 1801 Lesser Egyptian gerbil

Meriones tristrami Thomas 1892 Tristram's jird

Meriones libycus Lichtenstein 1823 Libyan jird

Meriones crassus Sundevall 1842 Sundevall's jird

Sekeetamys calurus Thomas 1892 Bushy-tailed jird

Psammomys obesus Cretzschmar 1828 Fat jird

Microtus socialis Pallas 1773 Social vole

Table C-2

Bird Species Observed in Jordan

Key: B -- breeding proved PM -- passage migrant
(B) -- breeding presumed V -- vagrant
NA -- status not ascertained

Little Grebe	Podiceps ruficollis	(B)
Little Bittern	Ixobrychus minutus	PM
Night Heron	Nycticorax nycticorax	PM
Squacco Heron	Ardeola ralloides	PM
Great White Egret	Egretta alba	PM
Yellow-billed Egret	Egretta intermedia	V
Little Egret	Egretta garzetta	PM
Grey Heron	Ardea cinerea	PM
Purple Heron	Ardea purpurea	NA
White Stork	Ciconia ciconia	PM
Black Stork	Ciconia nigra	PM
Shelduck	Tadorna tadorna	NA
Mallard	Anas platyrhynchos	(B)
Teal	Anas crecca	NA
Pintail	Anas acuta	NA
Gargancy	Anas querquedula	PM
Shoveler	Anas clypeata	NA
Osprey	Pandion haliactus	PM
Honey Buzzard	Pernis apivorus	PM
Black Kite	Milvus migrans	PM
Goshawk	Accipiter gentilis	V
Levant Sparrowhawk	Accipiter brevipes	PM
Sparrowhawk	Accipiter nisus	PM
Long-legged Buzzard	Buteo rufinus	B
Buzzard	Buteo buteo	PM
P.D.		M

Table C-2 (continued)

Booted Eagle	Hieraetus pennatus	NA
Bonelli's Eagle	Hieraetus fasciatus	B
Steppe Eagle	Aquila repax	PM
Spotted or Lesser Spotted Eagle	Aquila clanga or pomarina	PM
Golden Eagle	Aquila chrysaetos	NA
Short-toed Eagle	Circaetus gallicus	NA
Pallid Harrier	Circus macrourus	PM
Montagu's Harrier	Circus pygargus	PM
Marsh Harrier	Circus acruginosus	(B)
Egyptian Vulture	Neophron percnopterus	B
Lammergeier	Gypactus barbatus	B
Lappet-faced Vulture	Torgos tracheliotus	NA
Black Vulture	Aegypius monachus	NA
Griffon Vulture	Gyps fulvus	(B)
Saker	Falco cherrug	PM
Lanner	Falco biarmicus	NA
Barbary Falcon	Falco pelegrinoides	(B)
Hobby	Falco subbuteo	PM
Red-footed Falcon	Falco vespertinus	PM
Lesser Kestrel	Falco naumanni	B
Kestrel	Falco tinnunculus	B
Chukar Partridge	Alectoris chukar	B
Sand Partridge	Ammoperdix heyi	B
Quail	Coturnix coturnix	PM
Water Rail	Rallus aquaticus	NA
Spotted Crake	Porzana porzana	NA
Baillon's Crake	Prozana pusilla	B
Corncrake	Crex crex	PM
Moorhen	Gallinula chloropus	(B)
Coot	Fulica atra	(B)
Houbara Bustard	Chlamydotis undulata	B
Oystercatcher	Haematopus ostralegus	PM
Ringed Plover	Charadrius hiaticula	PM
Kentish Plover	Charadrius alexandrinus	B

Table C-2 (continued)

Lesser Sand Plover	Charadrius monogolus	B
Greater Sand Plover	Charadrius leschenaultii	PM
White-tailed Plover	Vanellus leucurus	(B)
Spur-winged Plover	Vanellus sponosus	B
Temminck's Stint	Calidris temminckii	PM
Dunlin	Calidris alpina	PM
Curlew Sandpiper	Calidris ferruginea	PM
Ruff	Philomachus pugnax	PM
Spotted Redshank	Tringa erythropus	PM
Redshank	Tringa totanus	PM
Greenshank	Tringa nebularia	PM
Green Sanpiper	Tringa ochropus	PM
Wood Sandpiper	Tringa glareola	PM
Common Sandpiper	Tringa hypoleucos	PM
Curlew	Numenius arquata	PM
Snipe	Gallinago gallinago	PM
Jack Snope	Lymnocryptes minimus	PM
Black-winged Stilt	Himantopus himantopus	PM
Avocet	Recurvirostra avosetta	B
Stone Curlew	Burhinus oedicnemus	(B)
Cream-coloured Courser	Cursorius cursor	B
Pratincole	Glareola pratincola	(B)
White-eyed Gull	Larus leucopthalmus	V
Black-headed Gull	Larus ridibundus	PM
Slender-billed Gull	Larus genei	NA
Lesser Black-backed Gull	Larus fuscus	PM
Black Tern	Chlidonias niger	PM
Whiskered Tern	Chlidonias hybrida	PM
Gull-billed Tern	Gelochelidon nilotica	PM
Common Tern	Sterna hirundo	PM
Pin-tailed Sandgrouse	Pterocles alchata	(B)
Spotted or Black-bellied Sandgrouse	Pterocles senegallus or orientalis	(B)

Table C-2 (continued)

Rock Dove	Columba livia	B
Turtle Dove	Streptopelia turtur	PM
Cuckoo	Cuculus canorus	NA
Great Spotted Cuckoo	Clamator glandarius	NA
Bruce's Scops Owl	Otus brucei	B
Little Owl	Athene noctua	B
Nubian Nighjar	Caprimulgus nubicus	NA
Egyptian Nighjar	Caprimulgus aegyptii	NA
White-rumped Swift	Apus affinis	(B)
Pallid Swift	Apus pallidus	(B)
Swift	Apus apus	NA
Alpine Swift	Apus melba	(B)
Smyrna Kingfisher	Halcyon smyrnensis	B
Kingfisher	Alcedo atthis	(B)
Bee-eater	Merops apiaster	B
Blue-cheeked Bee-eater	Merops superciliosus	(B)
Hoopoe	Upupa epops	(B)
Roller	Coracias garrulus	(B)
Wryneck	Jynx torquilla	PM
Desert Lakr	Ammomanes deserti	B
Bar-tailed Desert Lark	Ammomanes cincturus	B
Hoopoe Lark	Alaemon alaudipes	B
Short-toed Lark	Calandrella cinerea	B
Lesser Short-toed Lark	Calandrella rufescens	NA
Calandra Lark	Melanocorypha calandra	B
Bimaculated Lark	Melanocorypha bimaculata	PM
Thick-billed Lark	Rhamphocorys clot-bey	(B)
Temminck's Horned Lark	Eremophila bilopha	B
Crested Lark	Galerida cristata	B
Sand Martin	Riparia riparia	PM
Crag Martin	Hirundo rupestris	PM
Pale Crag Martin	Hirundo obsoleta	B
Swallow	Hirundo rustica	(B)
Red-rumped Swallow	Hirundo daurica	B

Table C-2 (continued)

House Martin	Delichon urbica	PM
Tawny Pipit	Anthus campestris	PM
Long-billed Pipit	Anthus similis	B
Tree Pipit	Anthus trivialis	PM
Meadow Pipit	Anthus pratensis	PM
Red-throated Pipit	Anthus cervinus	PM
Water Pipit	Anthus spinoletta	PM
Yellow Wagtail	Motacilla flava	PM
White Wagtail	Motacilla alba	PM
Common Bulbul	Pycnonotus barbatus	B
Red-backed Shrike	Lanius collurio	PM
Masked Shrike	Lanius nubicus	B
Woodchat Shrike	Lanius senator	NA
Lesser Grey Shrike	Lanius minor	PM
Great Grey Shrike	Lanius excubitor	B
Cetti's Warbler	Cettia cetti	(B)
River Warbler	Locustella fluviatilis	PM
Moustached Warbler	Lusciniola melanopogon	(B)
Sedge Warbler	Acrocephalus schoenobaenus	PM
Reed Warbler	Acrocephalus scirpaccus	B
Clamorous Reed Warbler	Acrocephalus stentoreus	B
Icterine Warbler	Hippolais icterina	PM
Olive-tree Warbler	Hippolais olivetorum	PM
Upcher's Warbler	Hippolais languida	PM
Olivaceous Warbler	Hippolais pallida	B
Booted Warbler	Hippolais caligata	PM
Barred Warbler	Sylvia nisoria	PM
Orphean Warbler	Sylvia hortensis	NA
Blackcap	Sylvia atricapilla	MM
Whitethroat	Sylvia communis	NA
Lesser Whitethroat	Sylvia curruca	NA
Sardinian Warbler	Sylvia melanocephala	(B)
Spectacled Warbler	Sylvia conspicillata	B

Table C-2 (continued)

Willow Warbler	Phylloscopus trochilus	PM
Chiffchaff	Phylloscopus collybita	PM
Bonelli's Warbler	Phyllosopus bonelli	PM
Wood Warbler	Phylloscopus sibilatrix	PM
Graceful Warbler	Prinia gracilis	B
Streaked Scrub Warbler	Scotocera inquieta	B
Fan-tailed Warbler	Cisticola juncidis	B
Pied Flycatcher	Ficedula hypoleuca	PM
Collared Flycatcher	Ficedula albicollis	PM
Spotted Flycatcher	Muscicapa strata	PM
Whinchat	Saxicola rubetra	PM
Stonechat	Saxicola torquata	NA
Wheatear	Oenanthe oenanthe	NA
Black-eared Wheatear	Oenanthe hispanica	B
Mourning Chat	Oenanthe lugeus	B
Desert Wheatear	Oenanthe deserti	B
Tristram's Chat	Oenanthe moesta	B
Red-tailed Wheatear	Oenanthe xanthoprymna	NA
Isabelline Wheatear	Oenanthe isabellina	B
Hooded Chat	Oenanthe monacha	(B)
White-crowned Black Chat	Oenanthe leucopyga	B
Blackstart	Cercomela melanura	B
Rufous Bush Chat	Cercotrichas galactotes	B
Rock Thrush	Monticola saxitilis	PM
Blue Rock Thrush	Monticola solitarius	B
Black Redstart	Phoenicurus ochruros	NA
Redstart	Phoenicurus phoenicurus	PM
Nightingale	Luscinia megarhynchos	PM
Thrush Nightingale	Luscinia luscinia	PM
Bluethroat	Luscinia svecica	PM
Arabian Babbler	Turdoides squamiceps	B
Great Tit	Parus major	B
Palestine Sunbird	Nectarinia osea	B
Corn Bunting	Emberiza calandra	B

Table C-2 (continued)

Ashy-head Bunting	Emberiza cineracea	NA
Ortolan Bunting	Emberiza hortulana	PM
Cretzschmar's Bunting	Emberiza caesia	(B)
Striped Bunting	Emberiza striolata	NA
Black-headed Bunting	Emberiza melanocephala	PM
Tristram's Serin	Serinus syriacus	(B)
Greenfinch	Carduelis chloris	B
Goldfinch	Carduelis carduelis	B
Linnet	Acanthis cannabina	B
Trumpeter Bullfinch	Rhodopechys githaginea	(B)
Sinai Rosefinch	Carpodacus sinoicus	(B)
House Sparrow	Passer domesticus	B
Spanish Sparrow	Passer hispaniolensis	B
Dead Sea Sparrow	Passer moabiticus	B
Pale Rock Sparrow	Petronia brachydactyla	B
Rock Sparrow	Petronia petronia	B
Tristram's Grackle	Onychognathus tristramii	B
Starling	Sturnus vulgaris	PM
Golden Oriole	Oriolus oriolus	NA
Jay	Garrulus glandarius	B
Hooded Crow	Corvus corone	(B)
Brown-necked Raven	Corvus ruficollis	B
Raven	Corvus corax	(B)
Fan-tailed Raven	Corvus rhidipurus	B

Analysis

B	Breeding proved or certainly taking place
(B)	Breeding presumed or strongly suspected
PM	Passage migrants only
V	Vagrants
NA	Status not ascertained (breeding often possible)

Source: Mountfort, G. Portrait of a Desert; The Study of an Expedition to Jordan, Houghton Mifflin, 1965.

C.2 EXAMPLES OF ONGOING PROGRAMS RELATED TO JORDAN'S BIOLOGICAL REGIME, WITH SUGGESTIONS FOR FUTURE RESEARCH AREAS

C.2.1 Examples of Ongoing Programs

During the course of interviews in 1979 conducted to gather information related to actions that are the subject of this assessment, we identfied a number of planned or ongoing environmentally related programs. Examples of these programs are listed below. The list is not intended to be exhaustive, but rather, illustrative of resources available within Jordan that present ongoing efforts aimed at mitigating existing environmental problems.[1] At present, the focus of programs identified here is in locations other than those directly associated with the Maqarin Dam or the Jordan Valley. A great number are also still small in scope, or in initial phases of development.

C.2.1.1 Terrestrial Ecosystems

Problems with overgrazing by domesticated herds, soil erosion, and rapid rates of siltation in established reservoirs are recognized as areas of concern in Jordan. Some existing and planned programs illustrate ongoing efforts to address these issues as well as other areas of concern.

- The Ministry of Agriculture

A grazing control program is planned. Initial focus will be in the North Zarqa region, with additional watershed areas added each year. The plan includes the fencing off of selected grazing land within watersheds, with food being provided for animals in areas outside the enclosed areas (by the World Food Program). Herders will then be formed into cooperatives based on tribal associations, with lands being designated

[1] It is acknowledged that these programs exist under myriad funding/consulting arrangements from within Jordan and through donor nations. Given the scope of this program and the frequent lack of published information for ongoing projects, this section focuses only on the existence of efforts that could serve to mitigate existing environmental problems. No attempt has been made here to identify individual projects and their funding sources, or to assess their scope in terms of long-term solutions (unless such information was immediately obvious).

for specific tribal sectors. Management assistance will be provided by the government. Studies conducted on grazing will focus on the carrying capacity of rangeland.

An aerial survey of the Zarqa catchment has been completed and a soil specialist will be examining the feasibility of revegetation programs for this highly eroded area. A land-based soil survey to identify soil capabilities and stability is being conducted on the dry-farming plateau regions (higher rainfall areas). To date, survey of several large areas have been nearly completed.

Revegetation programs have been the focus of two departments with areas of responsibility presently separated by average annual rainfall (>250mm/year and <250mm/year). A forest service has existed since 1927, but lack of funds prevented any emphasis on reforestation (aforestation) efforts until the 1950's. In lower rainfall areas, 20 to 25 different species are presently being used in revegetation efforts, with *Pinus halepensis* and *P. pinea* being important evergreen species in the program. The former is noted for its drought resistance. Success in this program continues to be hampered by losses caused by lack of water, grazing, fire, and cutting for firewood. In higher rainfall areas, an olive tree planting program with upland farmers (now including other fruit and nut species) has existed since 1964. Tree planting has been in conjunction with terracing for soil and water conservation. Full potential crop productivity is not expected under this program as these lands are not irrigated. However, much better control over destruction of seedlings by grazing has been accomplished because of farmer involvement.

Through an Agricultural Extension Service, some research on developing disease-resistant strains has been initiated. This program is being conducted in the Jordan Valley.

- The Royal Scientific Society

An ongoing program has identified some effects of increased urban development on agriculture. A study of levels of trace elements (Fe, As, Pb and Zn) in feed and sheep and cow livers is not yet completed, but is reportedly indicating differences based on proximity to urbanized areas.

- The University of Jordan

A survey of the flora of the entire country of Jordan has been ongoing since 1972, with 20,000 specimens collected to date. A completed checklist of species may be available in a year. Investigations include attempts to correlate indigenous species with soil types in order to identify good candidates for revegetation programs, especially in desert areas.

- The Royal Society for Conservation of Nature

This society (a privately constituted body) was founded in 1966 for the purpose of promoting interest in nature as well as implementing conservation programs. Legislation is being introduced proposing the establishment of a ministry level authority for establishing and administering wildlife preserves. A hunting law was passed in 1966, but enforcement has not been good. The proposed ministry would have this authority. The society, through efforts to identify potential wildlife preservation areas, has begun the compilation of lists of natural mammalian populations still in existence in Jordan (see Appendix C-1), including those considered locally endangered and in need of protection. It has also taken on the very difficult task of increasing public awareness of and interest in the preservation of Jordan's remaining natural systems. One such example is the society's recently published booklet, "Introduction to the Wildlife of the Hashemite Kingdom of Jordan."

C.2.1.2 Aquatic Ecosystems

Relatively less effort is presently being directed toward examination of aquatic ecosystems, although awareness of the implications of degraded water quality certainly exists.

- The Royal Scientific Society

Over the past few years, projects have been initiated to examine effluent water quality from treatment plants and both intake and effluent water quality from a small number of industries (dairy processing and detergent and biscuit production). To date, there have been problems in some cases with organizing meaningful sampling schedules that reflect the variability of waste loads. Data from this program were not yet available.

- The University of Jordan

Some study of algae and bacteria from the King Talal Reservoir is being conducted, although data from these studies were not yet available.

- Ministry of Agriculture

As described in Chapter 6 of this report, a study of fish farming potential has been completed. [C-2]

C.2.2 Examples of Areas Where Additional Research is Needed

As noted in the previous section, interviews with individuals associated with environmentally related disciplines in Jordan in addition to project-related site visits and reviews of existing reports led to the formulation of this list of suggested areas for future/additional programs. As already noted, ongoing programs exist. Very little effort has been directed to date toward existing and potential problems affecting the Jordan Valley or the Yarmouk Valley, while a number of ongoing programs are either in preliminary stages of implementation or of limited scope. It was not the intent or focus of this project to evaluate these existing programs. Both as a result of this assessment and in response to reviewers' comments, we note that efforts to date have not been centered in the two above-mentioned valleys. While the list is not intended to be comprehensive, it does focus on several areas in which programs would greatly help efforts to mitigate existing or potential environmental problems.

C.2.2.1 Aquatic Resources

The limited quantity of water quality data has been referred to in a number of places in the assessment report. While some information does exist, we understand that little work has been done on the heavy metals content in water and almost none on organic constituents in water (specifically, pesticide residues). In addition to human health effects, degraded water quality can have adverse effects on livestock, agricultural productivity, fish productivity (and, in the extreme, create hazards as a result of fish consumption). Observations at the Wadi Ziglab are a case in point, and this is illustrated below:

Because a report stated that snails and other fauna were absent from this reservoir and vegetation present was dead, the Ziglab Reservoir was visited on one trip through the Jordan Valley in 1979. (Schinski, 1978 - see Reference 3-11.) Our observation supported those made earlier: we did not observe floating mats of algae or algae scum on rocks along the access road edge of the reservoir; no snails or other aquatic invertebrates were observed on the several dozen rocks that were overturned. Lack of microscopic data and actual biological sampling of the full reservoir make it impossible to verify fully that no life exists in this body of water. Nonetheless, the conditions observed appeared unusual when compared to similar water bodies visited.

At the very least, understanding existing water quality would be extremely important considering existing and potential uses of this water, including agriculture, drinking water, and potentially for stocked fish. More importantly, understanding water quality conditions and causes at this reservoir has implications for understanding potential problems in other impounded waters in Jordan. In general, water quality monitoring on a regular basis would provide useful and important input for establishing or setting priorities in water use management and appear important for many of Jordan's water supplies.

C.2.2.2 Soil Conservation

The problems of soil erosion and its consequences (siltation, degraded land quality) have been discussed in this report. Revegetation programs have been in effect for several decades and several approaches to existing erosion problems were described in the previous section. Coping with erosion through continued and extensive reforestation/revegetation programs will require land use management that considers competition for limited land resources (e.g., agriculture, grazing land, and urban development).

Understanding the implications of land carrying capacity for grazing, agriculture on marginal land, and the lack of vegetation in aquifer recharge areas could maximize the soundness of land use management. Studies of this nature in the Jordan Valley uplands, wadis entering the valley (other than the Zarqa) and the Yarmouk catchment are at present almost non-existent. They could provide useful inputs for planning in these areas, considering the potential for erosion/siltation in the event that further development in the Yarmouk Valley causes increased devegetation.

C.2.2.3 Natural Biological Populations

It has been difficult to project precise impact potential and to outline mitigation for existing biological systems (other than in the generic sense) from the Stage II project because of a general lack of information on natural populations. Sentiment exists for wildlife protection among some sectors of Jordan's population as exemplified by the following quotation:

> "In common with all other countries, Jordan faces problems equating the needs of wildlife with the mounting human requirements for more land for agriculture, industry and urban development. If wildlife and the beauties of nature are to survive, this equation can only be brought about by wise compromise. The need to protect our natural environment is imperative. Jordan in the past lost many

of its larger wild animal species, either by the destruction of their natural habitats or by excessive hunting. Both the government of Jordan and the Royal Society for the Conservation of Nature are determined that further losses must be prevented." [C-3]

The creation of preserves can certainly serve to protect populations of large mammals and some bird species, as well as other organisms.

Better understanding of the extent and size of existing populations could provide input for any land use management programs. Many reptiles, birds and insects, for example, serve to help control some pests common to agriculture. Leaving areas of natural vegetation uncleared and allowing natural succession processes to occur in some areas designated for revegetation are a potential mitigative action. However, one cannot achieve success in managing natural or domestic populations without better understanding of the nature of the existing populations. Furthermore, it must be noted that pesticide use often affects predator populations as well as the intended pest species. Experience being gained in achieving pest control by encouraging natural predator or competitor populations could serve as an effective supplement to any long-range pest control program.

Similarly, in the aquatic environment, development of a data base on the inorganic and organic nutrient balance and seasonal variations in planktonic populations would allow understanding of the eutrophication processes that degrade water quality in impoundments in Jordan's environment. This can serve as input for long-range water supply planning for municipal, agricultural, and recreational uses.

APPENDIX D

DATA AVAILABILITY ON POPULATION AND LABOR FORCE CHARACTERISTICS

Statistical data on population and manpower characteristics and trends in Jordan is limited. The last national census was taken in 1961. Political upheavals then and the resultant in-migration of large numbers of Palestinians have completely altered population and labor force profiles in the past ten years. The national census which will be undertaken this year will provide pertinent data; preliminary results of the Valley census which was conducted in the Spring of 1979 were not available during the preparation of this report.

The principal source of demographic and labor force characteristics is the multi-purpose Household Sample Survey which has been conducted since 1971. However, this sample does not include the substantial number of foreigners participating in the labor force. Foreign labor accounts for as much as one third of the current labor force according to interviews with Ministry of Labor officials. Data on the agricultural labor force were taken from the 1975 Census of Agriculture. This data base includes foreign laborers, but does not specify country of origin and it does not break out foreign from domestic workers. There is no data base which includes the number of Jordanians working abroad. This information can be estimated from work papers and trips abroad, but these estimating procedures are considered crude at best by the Jordanian Department of Statistics.

APPENDIX E

SURVEY OF FIVE EAST JORDAN VALLEY VILLAGES

E.1 OBJECTIVES AND SELECTION OF VILLAGES

During April, 1979, 75 interviews were conducted using Jordanian interpreters. In addition to seeking impressionistic data, the objectives were to:

- Ascertain the level of modernization within the villages as expressed by the villagers' attitudes and expectations;
- Understand local decision-making processes;
- Learn about the role of women in the Valley's development; and,
- Collect opinions of Valley residents about JVA programs and plans.

The criteria used in choosing the five villages were:

- Geographical distribution;
- Variety of land ownership patterns;
- Representatives of types of Village government; and,
- Variety of anticipated impacts of the village development program and projected population increases, based upon PADCO's plan.

See Figure 6-5 for the locations of the selected villages. Application of criteria is shown in Table E-1. These five villages are generally representative of the 32 villages built by JVA. Villages range in size from several hundred to several thousand residents. Farm tenancy is high in all, ranging from 50 to 100 percent. Farm owner-operators are more prevalent in the north. Most village governments are headed by mukhtars, but a few have village or municipal councils.

Table E-1

Selected Village Data

Villages Surveyed	1973 Population	Design Pop. at full Development	Land Ownership Pattern	Form of Government	VILLAGE DEVELOPMENT PROGRAM STRUCTURES: Schools	Health Clinics	Community Centers	Govt. Bldg.	Housing
Wadi El Yabbis (North)	3186	7900	50% T.F.[1]/50% Own.[2]	Mukhtar	2				X
Kreiymeh (Middle)	6678	7900	70% T.F./30% Own.	Municipality	2	1	1	1	X
Balawneh (Middle)	2105	3000	95% T.F./5% Own.	Mukhtar	2				
Eddbab (Middle)	606	1000	50% T.F./50% Own.	Village Council	2				X
Karama (South)	2575	13000	100% T.F.	Mukhtar		1		1	X

[1] T.F. = tenant farmer

[2] Own. = owner operator farmer

Source: PADCO Village Reports and AID Project Paper, Jordan: Jordan Valley Village Development II

E.2 METHODOLOGY

Three types of interview guides were prepared: overview, men, and women. The overview guide was used with male and female school teachers, who were able to provide both insider and outsider points of view since many of the male teachers originated from outside their village, but had lived in them for some time; since separate housing was not available for single female school teachers, only those who were married lived within the school village or a nearby village. The adult male questionnaire was modified for interviews with local government officials. The types of guides used and the information sought are from various villagers outlined in Table E-2. The number and types of interviews are presented in Table E-3.

Understanding of both the survey's objectives and the intent of its questions was critical to its success. Thus, the guides were prepared with help from a Jordanian sociologist who was also the interpreter in four villages. The most difficult questions to design and ask concerned local government and decision-making. Local government is not highly developed in the Valley, apparently in part because the JVA has in effect taken over many government functions. The value and role of local officials other than as respected elders, was difficult to ascertain, even by the interpreter.

Table E-2

Types of Interviews

Type of Interview Guide	Type of Interviews	Types of Information Sought
Village Overview	Male and/or Female School Teacher	Origin of Village's people Services offered in Village Transportation availability Agricultural activity; crops grown; machinery used; and, land ownership patterns
Women's Questionnaire	Women	Family life Agricultural Activity Level of Satisfaction Skill Development Expectations Village Needs
Male Questionnare	Men	Family Life Agricultural Activity Expectations Modernization Level and Future Expectations Village Government[1] View of JVA Programs[1]
Male Questionnaire modified for local government officials	Mukhtar, Sheikh, Council Member, Mayor	Office Functions How acquired Office Local Decision Making and Opinion-Forming Process Cooperation with JVA

[1]Initially, women were also queried on these forms, but these questions were deleted because women were so obviously uncomfortable about answering them.

Table E-3

Types of Residents Interviewed

	Women	Men	Teacher	Mukhtar/Sheikh	Totals
Kreiymeh	13	9	1	1	24
Eddbab	3	5	1	2	11
Karama	5	4		1	10
Balawneh	10	4	1	1	16
Wadi El Yabbis	8	3	2	1	14
	39	25	5	6	75

E.3 SUMMARY OF FINDINGS

E.3.1 Attitudes and Expectations

Most Valley villages are inhabited by Palestinian tenant farmers. Except at Karama, which has experienced considerable disruption of its community life, most residents expressed satisfaction with their lives and their villages. Both men and women were very optimistic about the future. They stated high aspirations for sons and daughters, whom they hope will obtain enough education to enter professions; those mentioned again and again were: teaching, medicine, and engineering. While the upwardly-mobile attitudes of poor parents may at first appear unrealistic, they do not seem so in light of the large numbers of young Valley men who work abroad, earning salaries far in excess of their parents. Of all adults interviewed, not one wanted a son to become a farmer or a daughter to marry a farmer, because farm life was too difficult.

Valley families are large, ranging from five to thirteen children. The largest families were found in Karama. Valley women want to use birth control methods to limit family size. This is true not only of young women, but also of women nearing the end of their child-bearing years.

Little variation was expressed about village needs. They are, in descending order: water, electricity, clinics, roads, schools and garbage collection.

E.3.2 Local Government

The interviewees were articulate about village and national political and social issues. This was probably attributable partly to the circumstances of the Palestinians. Most village governments are headed by a mukhtar or a mukhtar's council. These men mediate family and tribal conflicts, and serve as personal references for villagers seeking employment. Mukhtars also act as notary publics signing marriage, and birth certificates, passports, and identity papers. Some mukhtars and villagers expect that mukhtars should be a link between the central government and the village. However, this role is not clearly defined;

moreover, villagers generally considered mukhtars ineffective in transmitting their wishes and desires to government agencies, particularly the JVA. The villagers solution, and sometimes also the mukhtar's, was to establish a village council. It was assumed that a council would have more legitimacy and influence with JVA than an individual. In at least two villages, residents were very critical of mukhtars, claiming that they acted in their own self-interest rather than that of the village; the solution was to establish village councils, over which the villagers felt they would have more control.

The only village in which local government was viewed in both a positive and effective light was the Municipality of Kreiymeh. Here the municipal government provided services viewed as important to the community and the mayor was seen as making decisions that affected the community's development and was also being able to deal with the JVA.

E.3.3 View of JVA Programs

Except in Karama, where most residents were cynical or negative about government programs in general and the JVA program in particular, interviewers viewed JVA projects positively. In many cases, they held the JVA responsible for most of what happened in village life, not just irrigation and buildings. They even expected the JVA to provide them with a village council postal service, and other programs outside of JVA's jurisdiction. The only program which was criticized by almost every interviewee was the housing program for farm families: both the design and the high density were stated as inappropriate to the way of life in the Valley. Repeatedly, villagers said that houses were too small, too close together for children to play in yards or families to sleep outside in summer, and too hot because the ceilings were too low. Several also said that the houses were too expensive, but since they weren't seriously considering living in them, this was not a major concern.

E.3.4 Women's Expectations and Skill Development

Many women would like to improve their skills. However, most think primarily of household skills, such as nutrition, child care, sewing, spinning, and embroidery, rather than marketable skills. Nearly all responded favorably to the establishment of community centers; these centers and their programs were viewed primarily as social outlets, rather than as an opportunities for developing employable skills.

Although many of the women work in agricultural activity, either with their husbands or as paid laborers, only those of Karama expressed interest in improving their agricultural skills. To other women, working in the fields indicates low status. In general, those women in the most desperate financial circumstances, namely widows and wives and daughters of very poor families, were interested in finding better jobs and earning more money. Most said that child care would not be a problem, since their mother, in-laws or eldest daughters could care for the children.

Awareness and understanding of economic and social development processes increased with literacy. Female teachers were the only women who felt comfortable talking about how local decisions were made, about the types of community development projects most suitable for the village, and about investment strategies. We did not explore women's informal social systems, but it seemed likely that female teachers provide leadership for women's programs.

APPENDIX F

REVIEW OF SITE INVESTIGATION AND GEOTECHNICAL DESIGN FOR MAQARIN DAM

F.1 SCOPE OF REVIEW

(Note: This Appendix is based on the design assumptions and data that were current in April 1979.) The geologic and geotechnical investigation conducted by Harza Overseas Engineering Company for the siting and design of the Maqarin embankment dam were reviewed to identify site conditions that might adversely affect the performance of the dam and to recommend future investigations or design modifications that could reveal or mitigate these adverse conditions. The scope of the review included:

1) Review and synthesis of geotechnical data obtained from site investigations supervised by Harza at the Maqarin site,
2) Review of available information on the geology of North Jordan,
3) Review of literature on site investigations and seepage cutoff designs for large dams in karstic terrain,
4) Review of seismic analysis and design of large embankment dams in high risk earthquake zones, and
5) Discussions with Harza geologists and engineers and members of the Jordan Valley Irrigation Project Review Board of Consultants concerning recent developments in the site investigation and embankment design.

F.2 SITE INVESTIGATIONS IN KARSTIC TERRAIN

A comparison of pre-construction site investigations for dams in karstic terrain has been made to assist in the evaluation of the investigation at Maqarin Dam. The results given in Table F-1 show that the amount of exploratory drilling at Maqarin Dam compares favorably with that performed at other dams sited in solutioned limestone. In addition, extensive geophysical surveys and adit programs have been carried out at the Maqarin site to supplement the information obtained by exploratory drilling. However, it is important to note that complexity of the site geology and the depth of solutioning are important factors controlling the scale of the investigation. In dams reviewed in Table F-1 (except for Dix River), the site investigations were adequate to identify the karstic processes responsible for solutioning; and in most cases, the depth of solutioning was less than that discovered at Maqarin Dam site. Preliminary site investigations at dams in karstic terrain should continue until the mechanisms and extent of solutioning are understood sufficiently to permit the design of an effective cutoff system.

It is generally recognized that exploratory drilling is insufficient to identify the extent of solutioning [F-1, F-2, F-3][1] and other methods, such as piezometric surveys, are needed. Piezometric and permeability studies can reveal buried solution channels if they are not plugged with impermeable materials; but because of this limitation, it cannot be concluded from these studies that solutioning does <u>not</u> exist at a site. Field investigations at the Maqarin site designed to measure average formation permeabilities have shown the foundation rock (marl) to be generally impermeable. However, measurement of average permeabilities can mask potential seepage problems related to local zones of high permeability, as suggested by Louis and Maini [F-4], and these measurements provide no information regarding the size and extent of

[1]Numbers in brackets, e.g., [F-1] refer to references listed in Appendix B.

Table F-1

Comparison of Pre-Construction Site Investigations and Seepage Cutoff Designs for Dams in Karstic Terrain
Maqarin Dam - Jordan

Dam and Location	Design Engineer	Dimensions (m)		Karst Geology	Site Investigation		Grout Curtain			Other
		Height	Length		No of Drill Holes	Cumulative Length (m)	Rows	Length (m)	Depth (m)	
Maqarin Dam (1979) Jordan	Harza Overseas Engineering Co.	160	570	Solutioned limestone near reservoir elevation, underlain by marl with plugged solution features localized in shear zones. Possible karstic limestone >90m beneath dam	96	10,500	4 in abutments 1 below dam	1,200	90	Possible concrete cutoff wall 100m into abutment through solutioned limestone
Cerro de Oro Dam (1974) Mexico	Ministry of Hydraulic Resources	55	1,700	Solutioned, massive limestone, open channels to 70 m below base of dam	116	4,500	5	1,900	70	-
Kruscica Dam (1960) Yugoslavia	Elektroprojekt Consulting Engineers	81	300	Jointed and fractured cavernous limestone, springs, sinkholes, especially in abutments	89	12,000	2 in abutments 1 below dam	1,200	150	-
Keban Dam (1970) Turkey	Electrical Investigation Administration	167	1,155	Severely faulting and jointed limestone, with brecciated zones, joint solutioning, and caverns	300	5,000	2	>1,155	35	Concrete cutoff wall through cavern and brecciated zone (>200m long)
Oymapinar Dam (1970) Turkey	Electrical Investigation Administration	152	300	Severely faulted and jointed limestone with joint solutioning to 50m below base of dam	87	11,000	2	>300	>50	-
Dix River Dam (1923) Kentucky	L. P. Harza	85	315	Massive limestone, bedding plane and joint solutioning not discovered by initial site investigations	57	2,800	1	315	50	Grouting to seal leaks required after impounding
J. Percy Priest Dam (1963) Tennessee	U.S. Army Corps of Engineers	40	840	Massive limestone with thin shale beds, sinkholes joint solutioning, cavities up to 3 m diameter at shallow depths	107	1,000	2	>840	20	All fissures intersected in dam foundation backfilled with concrete
Anchor Dam (1960) Wyoming	U.S. Bureau of Reclamation	64	200	Sandstone with thin beds of dolomite some joint solutioning, 4 large 30m long connected cavities beneath dam, partially filled with clay	42	3,550	3	200	30	Cavities completely cleaned and backfilled with concrete
Clarence Cannon Dam (1977) Missouri	U.S. Army Corps of Engineers	42	600	Jointed, solutioned limestone in abutments with some large cavities	147	?	3 in abutments 1 below dam	1,000	30	Concrete 62m long to cut off large cavity in left abutment

Source: Geotechnical Engineers Inc.

filled solution channels. At Anchor Dam [F-2], pumping tests failed to detect filled solution cavities. During construction, large filled karst features were uncovered. It was believed that the head of impounded reservoir water (64 m) could cause erosion and opening of these channels. Consequently, these features were cleaned and backfilled with concrete, resulting in a large increase in construction costs (over $1.5 million). The impounded reservoir head at Maqarin (130 m) could induce piping of similar features, and efforts should be made (such as excavation of filled features intersected in adits) to investigate the possibility of continuous, plugged solution channels existing at the Maqarin site. Table F-1 shows that the grout curtains at Maqarin, and thus the cost of foundation treatment, are comparatively large. Early discovery of hidden solution features and prescription of treatment could economize construction costs.

F.3 FUTURE INVESTIGATIONS PROPOSED BY HARZA AT THE MAQARIN SITE

Despite the extensive investigations that have been conducted at the dam site, uncertainties remain regarding the depth and nature (localized at faults or widely developed) of solutioning in the foundation rock below the dam. Consequently, Harza has proposed additional exploration scheduled for completion by January 1980 that will address these uncertainties and include:

1) Additional drilling 5500 m in angled boreholes extending into the Amman formation to explore the proposed E-W and upstream faults and to search for additional shear zones and weathered marl masses at the proposed location of the dam axis;
2) Excavation in the left abutment to examine the quality of the chalky limestone and evaluate the need for a positive cutoff;
3) Drilling and sampling of left and right abutment basalts to further examine their quality and potential use as rock fill in the embankment shells;
4) Extension of adits (approximately 800 m) in the left abutment to investigate possible faults;
5) Hydrogeologic studies of the Amman formation, including two pumping tests in deep wells and additional piezometric measurements;
6) Petrographic studies of unusual limestone mineralization in the left abutment; and
7) Mineralogic studies of clay inclusions in weathered marl.

Generally, future investigations will be concentrated in the left abutment; much less attention will be given to the right abutment.

F.4 STATIC STABILITY ANALYSES OF THE MAQARIN ENVIRONMENT

Parametric, static stability analyses of the upstream and downstream embankment shells were made by Harza for the following cases:

1) End of construction,
2) Steady seepage at maximum storage pool, and
3) Rapid drawdown to minimum pool.

Circular and non-circular failure surfaces were modeled in embankment cross sections. Shear strength properties for the clay core were obtained from feasibility level studies [F-5], and properties for basalt rock fill were determined from the literature. Because the shear strength of the marl composing the embankment foundation was unknown and the marl is differentially weathered, the phi angle representing shear strength was varied from 8° to 36°.

Effective stress analyses indicated that the most likely failure surface would pass through the downstream shell and into the marl under steady seepage conditions at maximum storage pool if the phi angle of the marl was less than 28°. A phi angle of the marl equal to at least 24° was necessary to calculate the minimum acceptable factor of safety (1.5).

Harza has recently conducted laboratory tests on marl samples to measure residual strength parameters that can be used in design stability analyses. Because much of the marl at the dam site is weathered and slickensided, Harza has concluded that residual strength parameters may give a conservative representation of the foundation shear strength. Laboratory tests have included one-direction direct shear tests on saw-cut and uncut samples with maximum horizontal displacements per cycle equal to 10% of the sample width (approximately 0.75 cm) and consolidated-undrained triaxial tests on fresh marl [F-6] and corresponding stress deformation curves have shown little or no reduction in shear strength from peak values measured after small displacement (approximately 0.2 cm) along the failure plane. On the basis of these test results, Harza has

recommended that the design residual strength of the foundation marl should be represented by a phi angle of 33°. Phi angles obtained from the undrained slurry tests were much larger and have been considered unreliable by Harza. Future tests on clay infillings found in jointed marl are planned to obtain a conservative lower bound estimate of the foundation shear strength.

The direct shear tests conducted by Harza may not be appropriate for measuring residual strength in marl. Maximum displacements allowed in these tests may not have been sufficient to permit strength reduction to residual values. Rotational shear tests on marl of similar composition [F-7] showed that displacements greater than 10 cm were needed to measure residual strength (peak strength was attained at nearly 0.1 cm displacement along the failure plane). Because evaluation of the embankment stability is strongly dependent on the foundation shear strength, further testing to measure the residual strength of the marl are recommended.

F.5 SEISMIC ANALYSIS OF MAQARIN DAM

The response of the Maqarin embankment to potential earthquake loading has not been completely analyzed by Harza. A preliminary design earthquake chosen from instrumented records alone has been proposed for use in these analyses, but Peak [F-8] recommends that the following geologic studies should be conducted to aid in the selection of a design earthquake:

1) Identification of active faults within 100 miles of the dam site,
2) Measurement of active fault lengths,
3) Compilation of the magnitude and type of visible fault movement, and
4) Correlation of fault movement with recorded earthquakes.

Such studies are planned by Harza, and this information may help select the maximum credible earthquake affecting the dam site.

Preliminary pseudo static stability analyses are usually made to estimate embankment stability under earthquake loading at maximum pool. Seed [F-9] recommends using an allowable safety factor of 1.1 in pseudo static analyses with seismic coefficients related to maximum ground accelerations. However, he warns that results of these analyses may not reflect the true stability of the embankment of uncertainties in choosing the seismic coefficient and:

1) Improper representation of the dam as a rigid body,
2) Neglect of other than horizontal components of earthquake acceleration, and
3) Neglect of ground acceleration variation with time and location within the embankment.

Other mechanisms known to be responsible for embankment instability (i.e., liquefaction) cannot analyzed by pseudo static methods; thus these analyses have been unable to predict failures that have been

observed in dams subjected to earthquake loads. More sophisticated techniques that relate dam stability to embankment deformations are needed. Leeds [F-10] recommends using the following time-dependent parameters (obtained from available earthquake records, micro-seismic studies, or statistical correlations with fault movements) to characterize a design earthquake: acceleration, frequency of shaking, amplitude and duration of ground movement, and attenuation with distance. Additional studies at the Maqarin site are planned in order to obtain these parameters.

Dynamic testing of embankment materials is necessary to measure properties that can be used to represent the embankment response to time-dependent earthquake disturbances. These properties include dynamic shear strength and stress-deformation characteristics, Poisson's ratio, and damping factors. Finite element techniques are frequently used to analyze the dynamic behavior of large dams. [F-1] With these techniques, total and differential settlements in the embankment can be predicted.

It is recommended that further consideration be given to using deformation analyses techniques to predict the embankment and foundation response to earthquake loading.

Special precautions are usually taken to improve the earthquake resistance of embankment dams. Freeboard and crest width are usually increased to prevent overtopping by seiches or landslide-induced waves. Erosion is also prevented by the generous use of riprap. Because cracking and internal erosion are serious consequences of large movements induced by earthquakes, wide, impervious cores are usually accompanied by transition zones to prevent advancing erosion by their self-healing characteristics. These designs are often empirically based, and it is useful to compare the crest and core designs of the Maqarin Dam to those in other dams sited in high risk seismic zones. Table F-2 shows that the Maqarin Dam crest is conservatively designed in comparison to embankment dams of

Table F-2

Examples of Large Embankment Dams in High Risk Seismic Zones
Maqarin Dam - Jordan

Dam and Location	Design Engineers	Dam Height, h (m)	Reservoir Capacity ($m^3 \times 10^{-6}$)	Crest Details		Core Design			Thickness of Transition Zone or Filters (m)
				Freeboard Above Max Storage (m)	Width (m)	Mid-Height Thickness, t (m)	$\frac{t}{h/2}$	Composition	
Maqarin Dam (1979) Jordan	Harza Overseas Engineering Co.	160	200	8.0	12.0	23	0.29	high plasticity clay	6
Kremasta Dam (1963) Greece	Engineering Consultants Inc.	163	4,740	5.0	10.0	40	0.49	high plasticity clay	4
San Luis Dam (1967) California	U.S. Bureau of Reclamation	116	2,520	3.1	9.1	115m (most of dam impermeable)	2.0	well-graded, impermeable clay, silt, sand, gravel	-
Oroville Dam (1967) California	Dept. of Water Resources (Calif.) and Consulting Board for Earthquake Analysis	228	4,490	6.0	14.0	45	0.39	sandy, silty, clay	35
Netzahualcotyl Dam (1964) Mexico	Ministry of Hydraulic Resources	137	12,960	7.0	10.0	65	0.95	high plasticity clay	10
Mica Dam (1970) Canada	Caseco Consultants	244	24,700	7.6	11.0	45	0.37	impermeable till	-

Source: Geotechnical Engineers Inc.

similar size in earthquake zones. However, because the core is composed of materials that have a potential for cracking and the average thickness of the core is not comparatively large, internal erosion and leakage produced by earthquake movements are more likely in the Maqarin Dam than in most of the dams reviewed in Table F-2. It is recommended that a suitable transition zone be added to the Maqarin Dam or the core and filters widened.

Foundation treatment of dams reviewed in Table F-2 has commonly included removal of all loose, liquefiable materials from beneath the dam and grouting to strengthen weak rock. These measures are also planned for the Maqarin Dam. A comprehensive instrumentation plan to monitor the characteristics of earthquakes affecting the dam site, embankment movements, and water pressures within the dam should be installed during construction to permit early recognition of incipient dam failure.

APPENDIX G

WATER RESOURCES

G.1 INTRODUCTION

The objective of this appendix is to:

- supplement and document information presented in the water resources section of this study; and
- state assumptions made but not given in Section 6.2.3 of the water allocation analysis.

This appendix has two sections:

- a water resources section providing information about the mean monthly flows of wadis and rivers and the inflow/outflow of the EGMC; and
- a system operation section giving briefly the calculation background for the impact analysis presented in Section 6.2.3.

The information presented in this appendix is based on a Stage II project as defined by Harza in its Civil Design Memorandum C-1 [4-2][1], August 1979, and which we refer to as the "C-1" project. The principal features of the "C-1" project are:

- Maqarin Dam constructed to elevation 178 m, with a maximum reservoir elevation of 170 m;
- Inflows to Maqarin Reservoir of 210.7 MCM/yr from the Yarmouk River and 48 MCM/yr from Wadi Raqqad;
- M&I water allocations of 100 MCM/yr to Amman, obtained from the EGMC, and 26 MCM/yr to Irbid, obtained from Maqarin Reservoir;

[1]Number in brackets, e.g., [4-2], refer to references located in Appendix B.

- Irrigation water allocations to irrigate 21,750 ha of land under Stage II, which when added to the 10,647 ha irrigated under Stage I will provide for 32,397 ha under irrigation.

Data were obtained from existing reports and from information gathered during field visits. No field data were collected. The water supply and demand system is shown schematically in Figure 4-12, with node numbers assigned to key locations. For each node, two mean annual flow values (or related parameters) were determined; the first represents the present conditions (i.e., 1978 without the project), and the second represents future conditions with the project in operation. The two flow values are generally given in the text as two values separated by a slash, e.g., 225.0/210.7, indicating the present and future values of flow, respectively. The difference between the two values represents the impact of the project on flows. The future flow values were obtained from data derived by Harza from a simulation analysis of the project operation using 25 years of historical hydrologic record. The results of the simulation are given in Annex G at the end of this appendix.

The results of the analysis are shown in mean annual values in Figure 4-12. A few mean monthly river and wadi flow values are shown in Table G-1. The estimates presented in this study were derived from averaged annually expected data. This analysis, therefore, is indicative of only the probable water balance with the project and cannot be regarded as a planning document, since it does not take account of the stochastic nature of the water availability. Although the numerical estimates are given as absolute numbers for the purpose of facilitating reading, they must be considered as rough estimates only.

Table G-1

Mean Monthly Streamflows[1]
(MCM)

RIVER (NODE)[2]	ANNUAL	Monthly Flows											
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Jordan River (King Hussein Bridge)	980.0	63.2	71.6	86.7	116.1	141.9	119.7	85.2	67.9	55.1	55.9	58.9	57.7
Yarmouk River Historical at Maqarin	255.6	16.2	16.5	23.6	35.3	36.7	34.2	19.4	15.3	13.9	14.3	14.9	15.2
Yarmouk River Adjusted Flows[3] (Maqarin site)	240.3	14.9	16.5	23.6	35.3	36.8	34.2	18.2	12.8	11.5	11.6	12.2	12.7
Yarmouk River Adjusted at Adasiye[3]	390.3	21.8	24.2	36.9	60.2	64.9	56.1	26.0	21.8	19.0	19.6	19.9	19.9
Wadi Arab	28.8	2.3	2.5	2.9	2.8	2.6	2.6	2.3	2.2	2.1	2.1	2.2	2.2
Wadi Ziglab	9.5	0.8	0.9	1.0	1.0	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7
Wadi Jurum	11.2	1.0	0.9	0.9	1.0	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.9
Wadi Yabis	3.3	0.2	0.2	0.3	0.4	0.5	0.5	0.3	0.2	0.2	0.2	0 2	0.2
Wadi Kufrinja	6.1	0.3	0.4	0.5	0.8	0.9	0.9	0.6	0.4	0.3	0.3	0.3	0.3
Wadi Rajib	7.1	0.5	0.5	0.6	0.8	0.9	1.0	0.6	0.5	0.5	0.4	0.4	0.4
Zarqa River	67.3	3.3	4.1	7.1	11.5	11.5	9.1	6.0	4.1	2.8	2.6	2 6	2.6
Wadi Shueib	7.9	0.4	0.6	0.8	1.0	1.0	1.0	0.7	0.6	0.5	0.5	0.5	0.4
Wadi Kafrein	14.3	0.4	0.5	1.1	1.9	2.1	2.4	1.8	1.3	1.0	0.8	0.6	0.5
Wadi Hisban	5.0	0.3	0.3	0.4	0.5	0.6	0.6	0.5	0.4	0.4	0.4	0.3	0.3

[1]Source of Historical Flows are from Appendix A, Hydrology, Jordan Valley Irrigation Project, Stage II, Harza Engineering Company, January 1978.
[2]Refer to Figure 4-12.
[3]Adjusted flows are historical flows reduced to account for Syrian withdrawals of 15 3 MCM/yr in 1978.

G.2 WATER RESOURCES

The Jordan River is the largest river in the area and flows from Lake Tiberias in the north to the Dead Sea in the south. There is no outlet to this sea and, at present, its level (El -392.9 m) is declining as a result of more evaporation than total inflow. The mean monthly flows of the Jordan River are given in Table G-1.

Flowing into the Jordan River from the east are two rivers--Yarmouk and Zarqa--which drain from the plateau area, and nine major wadis located along the escarpment. These are shown schematically in Figure 4-2. Their mean monthly flows are also given in Table G-1.

The EGMC serves mainly irrigation purposes at present and is supplied by the Yarmouk River, the side wadis Yabis and Kufrinja and Rajib, Wadi Ziglab (Ziglab Reservoir) and the Zarqa River. Mean annual inflows, outflows and efficiency of the EGMC are given in Table G-2.

Table G-2

East Ghor Canal Water Flows for Irrigation[1]

(MCM/yr)

YEAR	INFLOWS					OUTFLOWS			EFFICIENCY
(Jan-Dec)	Yarmouk River	Side Wadis[2]	Ziglab Dam/Reservoir	Zarqa River[3]	Total	Irrigation Consumption	Wasted[4] Water	Losses[5]	
1978	128.9	11.1	5.9	6.6	152.5	95.4	26.0	31.1	0.8
1977	126.8	5.9	6.7	-	139.4	90.2	27.3	21.9	0.8
1976	126.1	12.9	6.4	-	145.4	89.3	26.4	29.7	0.8
1975	125.6	29.5	4.5	-	159.6	87.4	45.6	26.6	0.8
1974	124.6	36.9	3.3	-	164.8	76.6	66.0	22.2	0.9
1973	112.0	31.7	6.7	-	150.4	97.9	34.3	18.2	0.9
1972	149.0	47.3	-	-	196.9	76.4	77.2	43.3	0.8
1971	115.9	51.0	-	-	166.9	64.9	49.6	52.3	0.7
1970	72.5	59.6	-	-	132.2	33.2	31.6	67.4	0.5
1969	97.7	50.1	-	-	147.9	48.0	61.2	38.7	0.7
1968	150.5	43.0	-	-	193.6	68.3	102.8	22.4	0.9
1967	136.1	30.7	-	-	166.8	73.1	69.6	24.2	0.9
1966	134.5	22.1	-	-	156.5	94.3	41.7	20.6	0.9
1965	138.9	9.9	-	-	148.9	61.8	73.1	14.0	0.9
1964	109.1	8.0	-	-	117.1	43.3	55.5	18.3	0.8
1963	93.4	2.9	-	-	96.3	37.4	37.3	21.6	0.8
1962	70.6	-	-	-	70.6	13.3	53.2	4.1	0.9

[1]Present irrigation areas from the ECMC total: 11,927 to 13,500 ha (depending on the reference).

[2]Yabis, Kufrinja, and Rajib.

[3]As regulated by King Talal Reservoir.

[4]Flood quantities of wadis and water quantities at the end of the canal.

[5]Evaporation, unregistered withdrawals and other losses.

Source: Jordan Valley Authority, April 1979.

G.3 SYSTEM OPERATION

G.3.1 Yarmouk River Flows

The mean annual flow of the Yarmouk River at the Maqarin site, based on historical streamflow records (1953-1975) was 255.6 MCM/yr. [G-1] But the major part of the watershed lies in Syria, and because of increased use of the upstream water for irrigation by Syria during the above period, the historical flows at Maqarin were reduced to 240.3 MCM/yr, which we have taken as the "present" value. It is estimated that the mean annual flow at Maqarin by the year 2000 (the "future" condition under the "C-1" plan) will be further reduced by new Syrian withdrawals. The corresponding flows from the Yarmouk River into Maqarin Reservoir are therefore 240.3/210.7 MCM/yr.

At present, all flows from Wadi Raqqad discharge into the lower Yarmouk River. Under the "C-1" plan, a small diversion dam would be constructed on Wadi Raqqad to divert heavy flows into Maqarin Reservoir. These flows are expected to average 48 MCM/yr.

Return flows from M&I supply are expected to be 50% of the supply. The Irbid return flows will be to Wadi Arab, and the Amman return flows (including Zarqa) will be to the Zarqa River upstream of King Talal Reservoir.

G.3.2 Dead Sea

The present Jordan River inflow to the Dead Sea is about 1,000 MCM/yr. The average annual rainfall on the surface of the Sea is 80 mm. Average annual inflow from all surface and underground sources other than the Jordan River is about 350 MCM/yr. The hypsometric curves of the Dead Sea are given in Figure G-1. The evaporation from the water surface is 1,310 mm/yr at El -399.0 m, decreasing to 1,270 mm/yr at El -407.0 and below. [G-2] The impacts of the Jordan River flow upon the Dead Sea elevations are given in Table G-3. These estimates result from a water budget computational procedure used by the U.S. Geological Survey. [G-2]

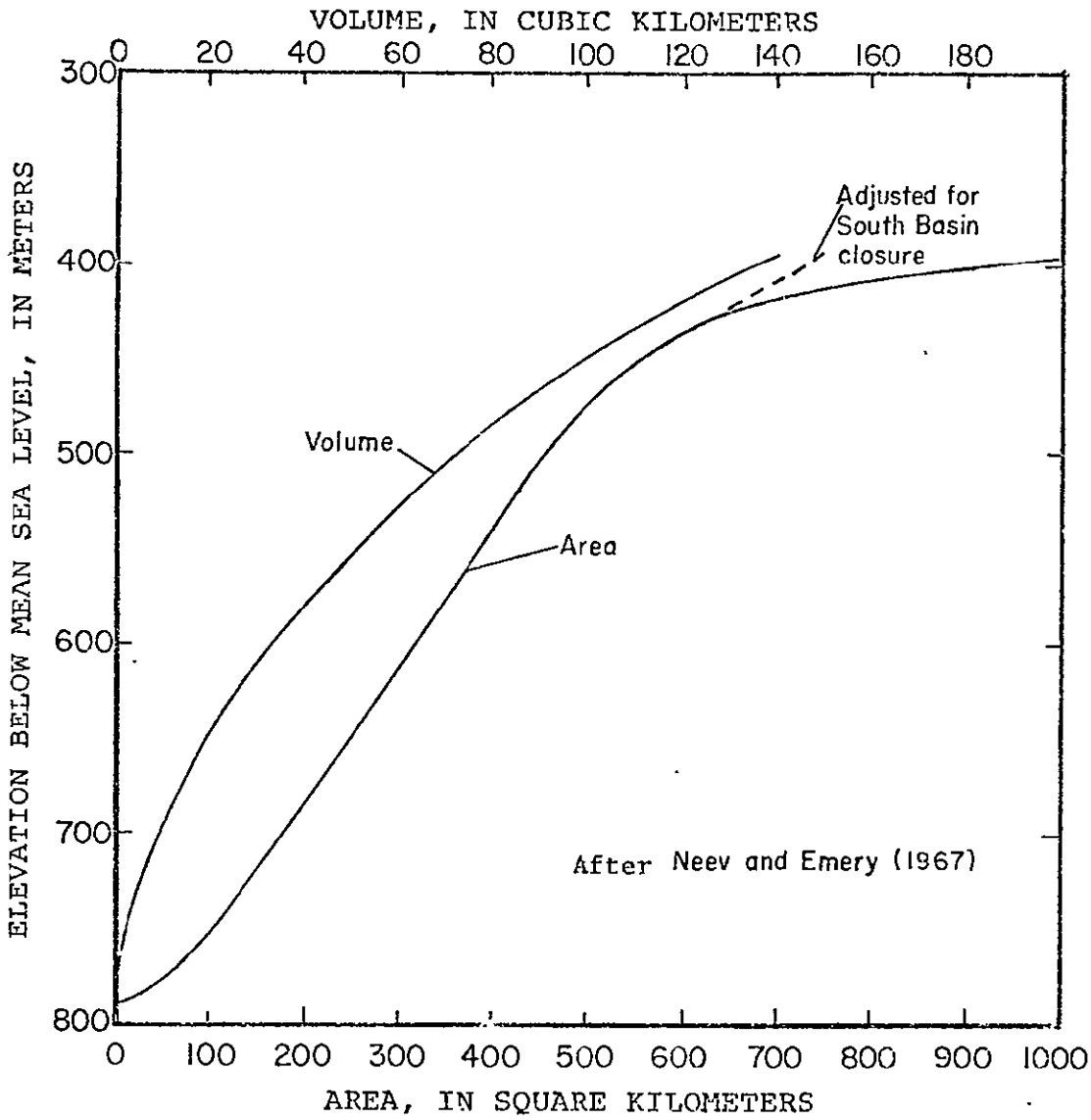

Figure G-1 Hypsometric Curves for the Dead Sea

Source: S.P. Sauer. Recent and Projected Changes in the Dead Sea Level and Effects on Mineral Production from the Sea, 1978.

Table G-3

Dead Sea Elevation Versus Inflows

INFLOWS (MCM)		DEAD SEA ELEVATION (m)
Jordan River	Other Inflows	
0	0	-450.0
0	350	-428.6
250	350	-414.4
500	350	-401.5
550	350	-399.0
750	350	-389.0

Source: S.P. Sauer. Recent and Projected Changes in the Dead Sea Level and Effects on Mineral Production from the Sea, 1978.

The Dead Sea elevation experiences a change in elevation of approximately 5.1 m per 100 MCM of net Jordan River inflows, given constant rates of "other inflows." Although it is expected that the development of the area (with or without the project) may impact the "other inflows" also; this consideration has not been incorporated into the numerical calculation. Rather it was assumed that a Jordan River flow reduction of 204.5 MCM/yr (because of the project, node 104) would imply a change in elevation of approximately 10.2 m. This excludes any future impact on the Dead Sea which may occur as a result of inflows from the Mediterranean Sea or the Red Sea to generate hydroelectric power.

G.3.3 Water Balance Analysis

The water balance analysis was performed using annual data (supply/demand) and is presented in a step-by-step calculation procedure in Table G-4. The monthly river-wadi records represent mostly a 25-year period, but their stochastic nature was not taken into account. The analysis deals with mean annual estimates and assumes (explicitly) a reservoir of infinite size. Implicitly, however, the size of reservoir is assumed finite (i.e., crest 178.0 m, Harza [4-2]), because only such a reservoir can supplement the water resources of the Valley to irrigate a total area of 32,397 ha in the future. The model (analysis) was not calibrated; therefore, the predicted outflow value from the canal of 37.4 MCM/yr (node 9) should not be used for planning purposes. The reported (by JVA) flow record value for node 8 is 26.0 MCM/yr (Table G-2, 1978), a value which is close to the estimated one and provides a good test considering the number of assumptions made.

Table G-4†

Calculation Steps[1] of the Water Balance Analysis[2] (Present/Future)
Jordan Valley M&I/Irrigation

Step	Equation	Description	Node [#]	Present [1978] (MCM/yr; ha)	Future (Harza Study) (MCM/yr;ha)
(A)	INFLOW TO EGMC				
(1)		Yarmouk natural flow, upstream Maqarin	11	240.3[19]	240.3
(2)		Syrian withdrawals	13	0.0	29.6
(3)	=(1)-(2)	Net Yarmouk inflow to Maqarin reservoir	1	240.3	210.7
(4)		Wadi Raqqad diversion	12	0.0	48.0
(5)		Irbid M&I (withdrawal from Maqarin reservoir)	21	0.0	26.0
	(5.1)	Net reservoir evaporation[12]		0.0	8.1
	(5.2)=(3)+(4)-(5)-(5.1)	Theoretical flow downstream of Maqarin Res.		240.3	224.6
	(5.3)	Operational releases from Maqarin reservoir		N/A	202.1
	(5.4)	Operational spills from Maqarin reservoir		N/A	22.5
	(5.5)=(5.3)+(5.4)	Total outflow from reservoir		N/A	224.6
(6)	=(3)+(4)-(5)-(5.1)-(5.4)	Normal flow downstream from reservoir[14]	2	240.3	202.1
(7)		Total Wadi Raqqad flow (natural)		73.3	73.3
(8)	=(7)-(4)	Wadi Raqqad flow into Yarmouk River	31	73.3	25.3
(9)		Total unregulated Yarmouk/Raqqad flow		150.0	150.0
(10)	=(9)-(7)	Unregulated Yarmouk flow except for Wadi Raqqad	14	76.7	76.7
(11)	=(6)+(8)+(10)	Yarmouk flow at Adasiye	3	390.3	304.1
(12)		Inflow to EGMC (record of JVA; 1978)[13]		128.9	N/A
(13)	=(11)-(12)	Yarmouk flow below EGMC	4	261.4	25.0[2]
	(13.1)	Flood flow (spill unused) to lower Yarmouk River		N/A	17.9
	(13.2)	Diverted but not used spill flow, EGMC		N/A	5.3
(14)	=(11)-(13)	Inflow to EGMC	5	128.9	279.1
(B)	EGMC IRRIGATION ALLOCATIONS SUPPLIES AND USES				
(15)	=0.95·26 MCM	M&I to Irbid	22	0.0	24 7
(16)	=0.5·(15)	Return flow to Wadi Arab[6]	64	0:0	12.4
(17)		North irrigated project (ha)		4,010.0	4,010.0
(18)		Zarqa irrigated project (ha)		5,077.0	9,097.0
(19)		South project (ha)		1,560.0	1,560.0
(20)		Other project (ha)		2,132.0	0.0
(21)		Total irrigated area (ha)[15]		24,706 0	32,397.0
(22)	=(21)-(17+18+19+20)	EGMC - irrigated areas (ha)		11,927.0	17,730.0
(23)	=(22)*10,910x10^{-6}	Water requirements EGMC[8]		130.1	193.4
(24)		Total EGMC length (km)		96.0	96.0
(25)	=(23/24)	MCM/km/yr EGMC		1.355	2.015

†See footnotes of Figure 4-12.

Table G-4 (continued)

Step	Equation	Description	Node [#]	Present [1978] (MCM/yr; ha)	Future (Harza Study) (MCM/yr;ha)
(C)	NORTH IRRIGATION PROJECTS (km 0-24)				
(26)		Wadi Arab basic flow		28.8	28.8
(27)	=(16)	Return flow Irbid	64	0.0	12.4
(28)	=(26)+(27)	Total Wadi Arab	63	28.8	41.2
(29)		Wadi Ziglab	61	3.6	3.6
(30)		Wadi Jurum	60	11.2	11.2
(31)	=(28)+(29)+(30)	Available flow of north wadi system		43.6	56.0
(32)	$=4,010*10,910*10^{-6}$	Irrigation water requirements (4,010 ha)		43.7	43 7
(33)	=(31)-(32)	Excess of water (not discharged into EGMC)	62	0.0	12.3
(34)	=(24)+(25)	Water consumption EGMC (24 km)		32.5	48.36
(35)	=(14)-(34)	Flow at node 6 EGMC	6	96.4	230.7
(D)	VARIOUS IRRIGATION AREAS (attributed to EGMC); km 24-60				
(36)		Wadi Yabis flow	73	3.3	3.3
(37)		Wadi Kufrinja flow	72	6.1	6.1
(38)		Wadi Rajib flow	71	7.1	7.1
(39)	=(36+37+38)	Total flow from above wadis		16.5	16.5
(40)	=(39)	Inflow to EGMC (flood flow included)[4]	74	16.5	16.5
(41)	=(36)+(25)	Water requirements EGMC (36 km)		48.8	72.54
(42)	=(35)+(40)-(41)	Flow at node 7 EGMC	7	64.1	174 6
(E)	AMMAN, IRRIGATION FROM EGMC; km 60-78				
(43)		Amman M&I		0.0	100.0
(44)	=(60-78)*(25)	Irrigation water requirements of EGMC system		24.39	36.27
(45)	=(42)-(43)-(44)	Water surplus		39.7	38.4
(F)	ZARQA IRRIGATION PROJECTS; km 60-78				
(46)		Zarqa River flow	87	67.3	67.3
	(46.1)	Water allocation to Amman	86	0.0	95.0
(47)	=0.5*(46.1)	Return flow to Zarqa River	85	0.0	47.5
(48)	=(46)+(47)	Total Zarqa flow	83	67.3	114.8
(49)	$=48x10^{-6}/10,910$	Available water to irrigating (ha)		6,168.0	10,522.0
(50)		Irrigation objectives		5,077.0	9,097.0
	(50.1)	Water requirements for irrigation objectives	82	55 4	99.3
(51)	=(49)-(50)	Potential further development (ha)		1,091.0	1,425.0
(52)	$=(51)x10,910x10^{-6}$	Water available from non-developed areas		11 9	15.5
	(52.1)=(45)+(52)	Flow at km 78, EGMC	8	51 6	53.9
(G)	SOUTH EGMC IRRIGATION PROJECTS; km 78-96[5]				
(53)	=(25)*(96-78)	EGMC water requirements (96-78) km		24.39	36.27

Table G-4 (continued)

Step	Equation	Description	Node [#]	Present [1978] (MCM/yr; ha)	Future (Harza Study) (MCM/yr;ha)
(H)	OTHER SOUTH PROJECTS				
(55)		K-H project water demand (1,560 ha)		17.0	17.0
(56)		Water supply (Wadi Shueib, K.H)	91+101+102	27.2	27.2
(57)		Water surplus to EGMC	100	10.2	10.2
(58)		"Other" minor projects (2132 ha)[9]		2,132 0	0.0
(59)	$=(58)\times10{,}910\times10^{-6}$	Water requirements for above (MCM)		23.3	0.0
(60)	=(52.1)-(53)+(57)	Total flow at canal, km 96	9	37.4	27.9
(61)	$=(60)\times10^{6}/10{,}910$	Potential irrigation from available EGMC[10]		3,428.0	2,551.0
(I)	JORDAN RIVER/DEAD SEA				
(62)		Inflow to Jordan River from Yarkout		246.1	25.0
(63)	=0.20·24,706x10,910	Irrigation return flows to Jordan River[7]	93	53.9	70.7
(64)		Record 1979 of Jordan River flow, Dead Sea	104	1,000.0	N/A
(65)	=(64)-(62)-(63)	Remaining sources inflow out of Jordan River to Dead Sea		700.0	700.0
	(65.1)	Total inflow to Dead Sea	104		
(66)	=1,000-(65)	Flow reduction due to development		0 0	-204.3
(67)		USGS curve; $\Delta h=10.2$ m $\Delta Q=200$MCM = -204.3 MCM			
(68)		Dead Sea elevation (m)		-392.9	-403.1

ANNEX G

Results of a Simulation Run
(Seven Sheets)

Basic Data:

Yarmouk Inflow to Maqarin	210.7 MCM/yr
Wadi Raqqad Diversion	48.0 MCM/yr
Maqarin Dam Elevation	178 m
Maximum Reservoir Elevation	170 m
Minimum Reservoir Elevation	105 m
M&I Supply, Amman	99.75 MCM/yr
M&I Supply, Irbid	26.25 MCM/yr
Return Flow	50%
Jordan Valley Irrigation Requirements Area Irrigated	 193.42 MCM/yr 17,730 ha
Yarmouk Triangle Requirements	25.0 MCM/yr
Years of Hydrologic Input	25 years

Source: Harza Overseas Engineering Company, Planning Memorandum No. 1, September 1979.

MADIRIN RESERVOIR OPERATION STUDY. MAXIMUM RESERVOIR VOLUME = 486.00. ELEV= 170.00

RESERVOIR ELEVATION-VOLUME-AREA DATA

ELEVATION	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0	170.0	180.0	190.0	200.0
VOLUME	.00	16.00	30.00	51.00	80.00	116.00	160.00	208.00	261.00	328.00	404.00	486.00	574.00	692.00	816.00
AREA	.000	1.100	1.630	2.950	2.950	3.700	4.800	5.200	6.000	6.900	7.800	8.800	9.900	11.000	12.200

THE MINIMUM VOLUME IS 48.060
THE MAXIMUM VOLUME IS 486.000

YARMOUK RIVER STREAMFLOW (MCM)

		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	ANNUAL
1	0	9.70	14.30	18.80	59.00	108.60	28.00	18.20	8.20	7.20	6.20	8.20	9.20	294.00
2	0	13.70	18.30	21.80	81.60	13.60	11.40	7.20	6.20	4.20	5.20	6.20	7.20	136.00
3	0	9.70	22.30	30.80	42.60	29.60	21.40	14.20	11.20	10.20	12.20	12.20	12.20	228.00
4	0	13.70	17.30	22.80	23.00	28.60	36.40	13.20	11.20	16.20	12.20	12.20	11.20	218.00
5	0	13.70	18.30	23.80	31.80	21.60	15.40	11.20	9.20	9.20	11.20	11.20	10.20	186.00
6	0	11.70	14.30	16.80	17.00	16.60	14.40	9.20	10.20	9.20	9.20	10.20	10.20	147.00
7	0	11.70	14.30	16.80	18.00	15.60	13.40	11.20	11.20	10.20	9.20	10.20	9.20	151.00
8	0	11.70	16.30	18.80	23.00	25.60	18.40	12.20	13.20	10.20	9.20	9.20	10.20	178.00
9	0	14.00	17.20	36.20	27.40	29.60	16.00	7.50	7.70	6.90	7.70	9.30	11.30	191.00
10	0	15.80	14.80	21.30	21.80	24.20	21.20	10.30	9.50	7.60	7.60	9.40	10.40	172.70
11	0	12.10	15.30	21.90	19.70	48.50	30.20	10.60	9.30	7.90	7.60	9.20	9.20	197.50
12	0	10.80	15.50	27.90	58.50	49.70	17.70	11.00	9.10	7.70	8.70	9.00	8.70	235.10
13	0	11.60	14.10	17.50	17.20	16.40	19.60	8.30	5.20	5.10	5.60	6.20	8.00	134.80
14	0	17.90	18.00	41.70	34.90	61.50	96.30	28.10	16.40	17.20	19.50	22.20	22.20	395.20
15	0	5.30	8.40	11.60	69.30	37.00	6.80	4.90	5.40	6.60	6.10	7.80	8.50	177.30
16	0	14.10	16.50	67.30	141.80	81.10	110.00	27.80	13.80	9.30	9.60	10.20	10.00	511.50
17	0	13.30	18.80	17.40	27.20	20.80	42.50	12.20	10.70	8.60	9.00	9.00	8.60	198.10
18	0	9.70	11.00	12.10	20.30	22.20	22.40	46.20	11.70	8.70	8.20	8.70	8.40	189.60
19	0	9.70	13.40	13.10	19.70	23.90	16.60	14.80	14.00	8.80	7.60	8.60	8.40	158.10
20	0	9.70	13.30	16.60	20.90	23.00	33.20	9.50	8.30	7.80	6.70	6.60	6.90	162.50
21	0	14.70	16.10	25.50	53.30	70.60	60.80	15.10	11.60	9.40	8.90	9.80	9.80	303.20
22	0	15.00	7.50	17.10	15.00	21.30	22.70	9.50	9.50	9.70	11.70	8.90	9.30	157.80
23	0	11.50	13.60	16.70	17.10	22.20	29.50	16.30	11.10	9.20	8.70	9.00	9.20	174.10
24	0	13.50	16.30	20.50	23.00	20.70	19.60	11.80	9.50	9.30	9.80	9.10	8.50	171.60
25	0	13.00	14.30	20.30	25.90	23.00	39.40	13.20	14.30	10.20	9.60	8.50	8.40	200.10

DIVERSION FROM WADI RAQQAD (MCM)

		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	ANNUAL
1	0	.00	.00	4.80	40.00	40.00	5.80	7.90	.00	.00	.00	.00	.00	98.50
2	0	-.00	-.00	.60	1.10	1.70	4.30	1.70	-.00	-.00	-.00	-.00	-.00	9.40
3	0	-.00	-.00	13.60	27.10	10.50	5.60	.60	-.00	-.00	-.00	-.00	-.00	57.60
4	0	-.00	-.00	-.00	5.80	16.70	6.30	-.00	-.00	-.00	-.00	-.00	-.00	28.80
5	0	-.00	-.00	3.20	38.10	2.20	-.00	-.00	-.00	-.00	-.00	-.00	-.00	43.50
6	0	-.00	-.00	.10	2.90	11.50	8.90	.60	-.00	-.00	-.00	-.00	-.00	23.30
7	0	-.00	-.00	-.00	1.70	-.00	-.00	-.00	-.00	-.00	-.00	-.00	-.00	1.70
8	0	-.00	-.00	-.00	-.00	10.50	-.00	-.00	-.00	-.00	-.00	-.00	-.00	10.50
9	0	-.00	-.00	19.00	10.00	19.60	.70	-.00	-.00	-.00	-.00	-.00	-.00	49.30
10	0	-.00	-.00	-.00	13.00	11.60	8.30	-.00	-.00	-.00	-.00	-.00	-.00	33.30
11	0	2.10	1.00	5.70	2.60	32.80	23.00	5.80	5.70	6.30	6.10	5.90	5.40	102.80
12	0	8.40	10.20	8.00	28.40	32.40	6.40	6.70	4.70	4.80	5.10	5.50	5.70	122.50
13	0	4.00	3.20	3.00	9.50	12.60	10.40	4.60	5.10	4.80	5.00	5.80	6.30	74.30
14	0	-.00	-.00	10.40	27.10	28.80	40.00	10.80	-.00	-.00	-.00	-.00	-.00	117.10
15	0	-.00	-.00	-.00	-.00	-.00	17.30	1.70	-.00	-.00	-.00	-.00	-.00	19.00
16	0	-.00	-.00	9.30	22.80	11.90	17.40	2.70	-.00	-.00	-.00	-.00	-.00	64.10
17	0	-.00	-.00	.20	2.00	.90	5.10	-.00	-.00	-.00	-.00	-.00	-.00	8.20
18	0	3.50	20.30	25.20	.00	8.30	35.90	-.00	6.70	2.10	9.30	10.70	7.90	129.90
19	0	-.00	-.00	5.60	5.10	13.90	1.60	-.00	-.00	-.00	-.00	-.00	-.00	26.20
20	0	-.00	-.00	-.00	.80	1.30	3.30	-.00	-.00	-.00	-.00	-.00	-.00	5.40
21	0	-.00	-.00	4.30	6.70	9.90	8.30	.20	-.00	-.00	-.00	-.00	-.00	29.40
22	0	-.00	-.00	.10	.00	.90	1.40	-.00	-.00	-.00	-.00	-.00	-.00	2.40
23	0	-.00	-.00	.10	6.60	11.70	16.20	2.30	-.00	-.00	-.00	-.00	-.00	36.90
24	0	-.00	-.00	1.80	15.10	12.60	8.70	5.40	-.00	-.00	-.00	-.00	-.00	43.60
25	0	-.00	-.00	8.90	17.50	5.00	29.00	4.30	-.00	-.00	-.00	-.00	-.00	65.30

Note: For a description of the operation simulation, refer to Planning Memorandum no. Operation Studies, August 1979.

Planning Memorandum No. 1
Operation Studies
MODEL OUTPUT

MAQARIN RESERVOIR INFLOW (MCM)

YEAR		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	ANNUAL INFLOW
1	0	9.70	14.30	23.60	95.00	148.60	34.20	26.10	8.20	7.20	8.20	8.20	9.20	392.50
2	0	13.70	18.30	22.40	22.10	15.30	15.70	8.80	6.20	4.20	5.20	6.20	7.20	145.40
3	0	9.70	22.30	44.40	69.10	40.10	27.20	14.80	11.20	10.20	12.20	12.20	12.20	285.60
4	0	13.70	17.30	22.80	28.80	45.30	42.70	13.20	11.20	16.20	12.20	12.20	11.20	246.80
5	0	13.70	18.30	27.00	69.10	23.80	15.40	11.20	9.20	9.20	11.20	11.20	10.20	229.50
6	0	11.70	14.30	16.90	19.20	26.10	23.30	9.80	10.20	9.20	9.20	10.20	10.20	170.30
7	0	11.70	14.30	16.80	19.70	15.60	13.40	11.20	11.20	10.20	9.20	10.20	9.20	152.70
8	0	11.70	16.30	18.80	23.00	36.10	18.40	12.20	13.20	10.20	9.20	9.20	10.20	188.50
9	0	14.00	17.20	55.20	37.60	49.20	16.70	7.50	7.70	6.90	7.70	9.30	11.30	240.30
10	0	15.00	14.80	21.30	34.80	35.80	29.50	10.30	9.50	7.60	7.60	9.40	10.40	206.00
11	0	14.20	16.70	27.60	22.30	77.30	53.20	16.40	15.00	14.20	13.70	15.10	14.60	300.30
12	0	15.40	25.70	35.90	86.90	82.10	24.10	18.50	13.80	12.50	13.80	14.50	14.40	357.60
13	0	15.60	17.30	20.50	26.70	29.00	30.00	12.90	10.30	9.90	10.60	12.00	14.30	209.10
14	0	17.90	18.00	52.10	61.30	90.30	136.30	38.90	16.40	17.20	19.50	22.20	22.20	512.30
15	0	5.30	8.40	11.60	69.30	37.00	24.10	6.60	5.40	6.60	6.10	7.40	8.50	196.30
16	0	14.10	16.50	76.60	164.60	93.00	127.40	30.50	13.80	9.30	9.60	10.20	10.00	575.60
17	0	13.30	18.80	17.60	29.20	21.70	47.60	12.20	10.70	8.60	9.00	9.00	8.60	206.30
18	0	13.80	31.30	37.30	20.30	30.50	58.30	46.20	18.40	10.80	17.50	19.40	16.30	319.50
19	0	9.80	13.40	18.70	24.80	37.80	18.20	14.80	14.00	8.80	7.60	8.60	8.40	184.30
20	0	9.70	13.30	16.60	21.70	24.30	36.50	9.50	8.30	7.80	6.70	6.60	6.90	167.90
21	0	14.70	16.10	27.80	60.00	80.50	69.10	15.30	11.60	9.40	8.90	9.40	9.80	332.60
22	0	15.00	7.50	17.20	15.80	22.20	24.10	9.50	9.50	9.70	11.70	8.90	9.50	160.20
23	0	11.50	13.60	16.80	23.70	33.90	45.70	18.60	11.10	9.20	8.70	9.00	9.20	211.00
24	0	13.50	16.30	22.30	38.10	33.30	28.30	17.20	9.50	9.30	9.80	9.10	8.50	215.20
25	0	13.00	14.30	29.20	43.40	28.00	69.20	17.50	14.30	10.20	9.60	8.50	8.40	265.60

THE CONTRIBUTION OF THE SIDE WADIS, KING TALAL, MAI RETURN FLOW FROM IRBID

		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	ANNUAL
1	0	1.665	3.483	4.559	4.679	4.644	4.646	1.885	1.819	1.804	1.791	1.817	1.740	34.532
2	0	1.765	1.811	1.859	4.679	4.113	1.845	1.785	1.619	1.503	1.391	1.417	1.440	25.228
3	0	1.565	1.911	1.959	1.979	1.944	1.946	1.885	1.819	1.703	1.691	1.617	1.740	21.760
4	0	1.765	1.811	1.859	1.979	4.644	4.646	1.885	1.819	1.803	1.691	1.717	1.740	27.360
5	0	1.765	1.911	1.959	3.267	4.644	2.118	1.885	1.719	1.703	1.491	1.517	1.540	25.520
6	0	1.665	1.711	1.759	1.979	4.644	4.646	1.885	1.519	1.403	1.391	1.517	1.440	25.559
7	0	1.465	1.611	1.759	1.879	1.844	1.845	1.685	1.519	1.503	1.491	1.517	1.540	19.659
8	0	1.665	1.911	1.959	1.979	1.944	1.945	1.885	1.619	1.603	1.491	1.517	1.640	21.159
9	0	1.665	1.711	1.959	1.979	4.006	2.918	1.885	1.819	1.603	1.591	1.617	1.640	24.394
10	0	1.865	1.811	1.959	1.979	4.644	2.218	1.685	4.319	1.503	1.491	1.517	1.540	26.532
11	0	1.665	1.911	4.572	4.679	4.644	4.646	2.804	1.819	1.803	1.791	1.717	1.740	33.792
12	0	1.765	1.911	1.959	4.679	4.644	2.218	3.504	1.619	1.703	1.691	1.717	1.740	29.150
13	0	1.765	1.911	1.959	1.679	1.844	1.745	1.785	1.719	1.503	1.591	1.617	1.640	20.760
14	0	1.665	1.711	1.659	1.979	4.644	4.646	1.885	1.819	1.803	1.791	1.717	1.740	27.060
15	0	1.865	1.911	1.959	4.679	4.644	4.646	1.885	1.719	1.603	1.591	1.617	1.640	29.760
16	0	1.665	1.711	1.859	1.879	1.744	4.646	3.604	1.819	1.803	1.791	1.717	1.740	25.978
17	0	1.765	1.911	1.659	1.979	1.944	4.646	1.885	1.719	1.803	1.691	1.717	1.640	24.360
18	0	1.765	1.711	1.959	1.979	1.944	1.946	4.585	1.819	1.804	1.791	1.717	1.640	24.660
19	0	1.765	1.811	1.959	1.979	1.744	1.946	1.885	1.819	1.803	1.791	1.817	1.740	22.060
20	0	1.765	1.811	1.859	1.879	1.844	1.946	1.785	1.719	1.803	1.791	1.717	1.840	21.760
21	0	1.865	1.811	1.859	4.679	4.644	4.646	4.585	1.902	1.703	1.691	1.717	1.740	32.843
22	0	1.765	1.811	1.859	1.879	4.644	4.646	3.104	1.819	1.803	1.791	1.717	1.840	28.679
23	0	1.865	1.911	1.959	1.979	1.944	1.946	1.885	1.819	1.803	1.791	1.817	1.840	22.559
24	0	1.865	1.911	1.959	1.979	1.944	1.946	1.885	1.819	1.803	1.791	1.817	1.840	22.560
25	0	1.865	1.911	1.959	1.979	1.944	1.946	1.885	1.819	1.803	1.791	1.817	1.840	22.560

MODEL OUTPUT

UNREGULATED YARMOUK RIVER FLOW DIVERTED INTO EGMC (MCM)

		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	
1	0	7.200	9.800	9.160	32.000	34.000	9.960	11.480	6.300	4.500	4.500	5.400	5.400	139.700
2	0	5.400	4.500	5.760	6.210	6.570	8.730	6.570	6.300	8.100	8.100	8.100	6.300	80.640
3	0	6.300	5.400	15.720	21.270	13.400	9.960	5.760	7.200	4.500	2.700	2.700	2.700	97.610
4	0	3.600	2.700	1.800	9.960	17.520	10.360	3.600	.900	1.800	.900	1.800	1.800	56.740
5	0	2.700	1.800	7.920	24.270	7.020	3.600	3.600	6.300	4.500	.900	1.800	3.600	68.010
6	0	5.400	4.500	5.310	7.020	14.200	12.280	5.760	2.700	2.700	2.700	2.700	3.600	68.870
7	0	4.500	4.500	4.500	6.570	4.500	4.500	2.700	.900	.900	1.800	.900	2.700	38.970
8	0	1.800	3.600	3.600	4.500	13.400	.900	1.800	6.300	.900	1.800	1.800	.900	41.300
9	0	2.430	4.140	18.360	13.080	18.520	5.850	3.330	3.690	4.050	2.970	1.800	1.530	79.750
10	0	.360	1.800	1.980	15.480	14.200	11.720	3.330	5.130	1.350	1.890	1.530	1.080	59.850
11	0	6.480	6.300	9.880	7.380	22.800	19.840	9.880	9.560	8.910	8.460	7.920	7.470	124.880
12	0	8.640	13.240	11.560	21.600	22.740	10.360	10.600	8.820	7.650	7.740	7.560	7.740	138.250
13	0	8.100	7.920	7.740	12.600	15.000	13.320	9.080	9.080	7.650	7.360	7.830	8.370	114.250
14	0	8.640	11.080	13.320	21.270	21.690	28.770	13.640	11.960	7.740	6.030	3.960	3.780	151.880
15	0	8.640	8.550	3.060	1.530	4.500	17.680	6.660	7.380	5.760	5.940	.900	.900	71.500
16	0	5.220	5.490	12.440	19.760	14.360	17.760	7.380	5.400	3.960	4.050	4.230	4.140	104.190
17	0	4.950	6.210	5.310	6.840	5.940	9.480	4.860	4.410	3.690	3.870	3.870	3.690	63.120
18	0	7.740	18.840	20.600	1.530	11.800	23.700	1.800	10.200	5.490	10.920	11.560	9.560	133.740
19	0	3.690	4.500	9.800	9.480	15.880	6.570	2.880	.900	1.620	3.600	2.700	1.980	63.600
20	0	3.600	4.410	5.220	5.850	6.300	8.010	3.690	3.330	3.150	2.790	2.790	2.880	52.020
21	0	5.760	8.460	8.730	10.600	13.000	11.800	5.310	4.410	3.690	3.510	3.690	3.780	82.740
22	0	5.760	2.610	5.310	4.860	6.030	6.300	3.600	3.600	3.600	4.230	3.330	3.600	52.830
23	0	.990	.270	3.870	9.320	13.080	16.440	5.760	3.870	3.780	2.340	2.340	1.890	63.950
24	0	.360	4.230	6.930	17.000	15.080	12.200	9.800	5.400	3.060	2.160	3.240	4.680	84.140
25	0	.360	.270	9.400	15.720	6.210	20.880	5.580	.900	1.980	.990	.990	1.980	65.260

YARMOUK TRIANGLE REQUIREMENTS (MCM)

		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	
1	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
2	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
3	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
4	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
5	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
6	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
7	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
8	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
9	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
10	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
11	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
12	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
13	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
14	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
15	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
16	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
17	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
18	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
19	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
20	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
21	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
22	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
23	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
24	0	2.800	-.000	-.000	-.000	-.000	-.000	-.000	2.800	3.200	6.500	6.500	3.200	25.000
25	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

MODEL OUTP

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Jordan Valley Irrigation Requirements (MCM)	19.89	12.84	9.54	7.96	10.90	15.98	19.01	20.21	20.28	18.07	18.97	19.77	193.42
Amman Municipal Requirements (MCM)	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.32	8.32	8.32	99.75
Yarmouk Triangle Requiremnts (MCM)	2.80	—	—	—	—	—	—	2.80	3.20	6.50	6.50	3.20	25.00
Total	31.00	21.15	17.85	16.27	19.21	24.29	27.32	31.32	31.79	32.89	33.79	31.29	318.17
IRBID Municipal Requirement (MCM)	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	26.25

****
SHORTAGES OCCUR IN 19 OUT OF 300 MONTHS (6.33 PERCENT OF THE TIME)
TARGET PERCENTAGE = 6.00 TOLERANCE = .50 RESERVOIR ELEV. MAXIMUM/ START= 170.00 / 118.00
IRRIGATED AREA = 17731.0 HECTARES ITERATION NUMBER 0
****

ICOUNT	X	K1	K2	Y	D	S	T	TOL	PCT
0	17731.00	0	0	.33	886.55	1	6.00	.50	6.33

RESERVOIR RELEASES (MCM)

YEAR		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	ANNUAL RELEASE
1	0	22.14	7.86	4.13	.00	.00	9.68	13.95	23.20	25.49	26.60	26.57	24.15	183.78
2	0	23.84	14.84	10.23	5.18	8.53	13.71	18.96	23.40	22.19	23.40	24.28	23.55	212.31
3	0	23.14	13.84	.17	.00	3.87	12.38	19.67	22.30	25.59	28.50	29.48	26.85	205.79
4	0	25.64	16.64	14.19	4.33	.00	9.28	21.83	28.60	28.19	30.30	30.27	27.75	237.03
5	0	26.54	17.44	7.97	.00	7.55	18.57	21.83	23.30	25.59	30.50	30.48	26.15	235.91
6	0	23.94	14.94	10.79	7.27	.37	7.36	19.67	27.10	27.69	28.80	29.58	26.25	223.75
7	0	25.04	15.04	11.59	7.82	12.87	17.94	16.15	8.31	7.22	6.15	7.30	6.43	141.84
8	0	9.08	13.95	12.29	9.79	3.87	21.44	23.63	23.40	20.54	6.15	6.30	7.43	157.87
9	0	11.38	14.85	.00	1.21	.00	15.52	22.10	25.81	26.14	28.33	30.38	28.12	203.84
10	0	17.07	12.45	13.91	.00	.37	10.35	22.30	21.87	28.94	29.51	15.16	7.63	179.55
11	0	11.58	12.94	3.40	4.21	.00	.00	14.63	19.94	21.08	22.64	24.15	22.08	156.66
12	0	20.60	6.00	4.33	.00	.00	11.71	13.21	20.88	22.44	23.46	24.51	21.81	168.93
13	0	21.14	11.32	8.15	1.99	2.37	9.22	16.45	20.52	22.64	23.74	24.34	21.28	183.17
14	0	20.70	8.36	2.87	.00	.00	.00	11.79	17.54	22.25	25.07	28.11	25.77	162.46
15	0	20.50	10.69	12.83	10.06	10.07	1.96	18.77	22.22	24.43	25.36	31.27	28.75	216.92
16	0	24.12	13.95	3.55	.00	3.11	1.88	16.33	24.10	26.03	27.05	27.84	25.41	193.38
17	0	24.29	13.03	10.88	7.45	11.33	10.16	20.57	25.19	26.30	27.33	28.20	25.96	230.70
18	0	21.50	.60	.00	12.76	5.47	.00	20.93	19.30	24.50	20.18	20.51	20.09	165.85
19	0	25.55	14.84	6.09	4.81	1.59	15.77	22.55	28.60	28.37	27.50	29.27	27.57	232.52
20	0	25.64	14.93	10.77	8.54	11.07	14.33	21.84	26.27	26.84	28.31	29.23	26.57	244.40
21	0	23.38	10.88	7.26	.99	1.57	7.84	17.42	25.01	26.40	27.69	28.38	25.77	202.59
22	0	23.48	16.73	10.68	9.53	8.54	13.34	20.61	25.90	26.39	26.87	28.74	25.85	236.67
23	0	28.15	18.97	12.02	4.97	4.19	5.90	19.67	25.63	26.21	28.76	29.64	27.56	231.67
24	0	28.78	15.01	8.96	.00	2.19	10.14	15.63	24.10	26.93	28.94	28.74	24.77	214.19
25	0	28.78	18.97	6.49	.00	11.06	1.46	19.85	28.60	28.01	30.11	30.99	27.47	231.79

$\bar{x} = 202.14$

MODEL OUTPUT

YEAR		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	ANNUAL SPILL
1	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
9	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
13	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
14	0	.00	.00	.00	.00	61.54	134.17	24.06	.00	.00	.00	.00	.00	219.78
15	0	.00	.00	.00	.00	14.23	20.01	.00	.00	.00	.00	.00	.00	34.24
16	0	.00	.00	.00	87.99	87.73	123.39	11.12	.00	.00	.00	.00	.00	310.23
17	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
18	0	.00	.00	.00	.00	.00	.00	1.33	.00	.00	.00	.00	.00	1.33
19	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
20	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
21	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
22	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
23	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
24	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
25	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

MONTHLY AVERAGE WATER SURFACE ELEVATION

YEAR		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	ANNUAL AVERAGE
1	0	116.28	115.01	117.45	128.99	149.08	160.51	162.44	161.85	159.28	156.34	153.40	150.73	144.28
2	0	148.48	147.56	148.40	150.22	151.53	151.82	150.96	148.57	145.40	142.13	138.58	134.72	146.53
3	0	131.34	130.36	134.92	144.14	151.51	154.59	154.91	153.43	151.19	148.40	145.33	142.44	145.21
4	0	139.91	138.40	138.85	141.27	146.19	151.53	152.84	150.68	148.04	145.22	141.97	138.58	144.46
5	0	135.23	133.60	135.05	142.29	148.45	149.11	147.71	145.38	142.57	139.13	134.87	130.92	140.36
6	0	127.47	125.58	125.69	127.16	130.57	134.12	134.24	131.13	126.88	122.21	117.24	112.54	126.24
7	0	108.25	105.61	105.61	107.42	108.88	108.02	105.56	105.02	105.02	105.02	105.02	105.02	106.20
8	0	105.02	105.02	105.63	107.81	112.90	115.73	113.54	110.41	106.14	105.02	105.02	105.02	108.10
9	0	105.02	105.02	111.81	121.74	130.12	134.57	132.85	129.09	124.53	119.61	114.19	108.99	119.80
10	0	105.21	105.02	105.75	110.74	118.35	123.75	123.99	120.84	116.37	110.65	105.85	105.02	112.59
11	0	105.02	105.21	108.45	113.11	123.13	135.74	140.36	139.56	137.79	135.62	133.26	131.09	125.69
12	0	129.26	130.16	134.61	144.25	155.83	161.63	162.40	161.87	160.35	158.55	156.73	155.10	150.89
13	0	153.82	153.47	154.38	156.58	159.68	162.35	163.09	161.83	159.92	157.70	155.50	153.75	157.67
14	0	152.68	152.76	156.33	163.12	169.51	170.00	170.00	169.68	168.80	167.62	166.41	165.37	164.36
15	0	163.80	162.38	161.88	165.20	169.72	170.00	169.07	166.88	164.27	161.49	158.24	154.86	163.98
16	0	152.43	151.57	156.24	167.87	170.00	170.00	170.00	169.13	166.97	164.37	161.73	159.20	163.29
17	0	157.02	156.30	156.82	158.46	160.29	162.95	164.41	162.59	160.12	157.25	154.26	151.38	158.49
18	0	149.16	150.33	154.55	157.25	159.14	164.03	168.80	169.70	168.30	166.78	166.03	165.27	161.61
19	0	163.62	162.18	162.58	164.35	167.55	169.64	169.00	167.21	164.63	161.71	158.64	155.54	163.89
20	0	152.79	151.27	151.24	152.25	153.73	155.78	156.09	153.66	150.71	147.21	143.35	139.52	150.63
21	0	136.34	135.51	137.51	143.68	153.23	162.02	165.32	163.95	161.61	158.84	155.83	153.05	152.24
22	0	151.02	149.41	148.87	149.52	150.60	151.93	151.57	149.23	146.22	143.28	140.02	136.11	147.31
23	0	132.42	129.82	129.30	131.22	135.41	141.18	143.75	142.12	139.01	134.85	130.32	125.67	134.59
24	0	121.56	119.53	120.62	125.57	132.14	136.38	137.78	135.97	132.28	127.96	123.23	118.73	127.64
25	0	114.46	111.56	113.10	120.06	126.01	133.95	139.67	137.52	133.83	129.47	124.33	119.27	125.27

MODEL OUTPUT

MONTHLY POWER PRODUCTION (MW)

YEAR		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	ANNUAL AVERAGE
1	0	6.46	2.35	1.23	-.00	-.00	4.17	6.29	10.06	11.20	11.06	10.81	9.95	6.13
2	0	9.34	5.98	4.02	2.15	3.80	5.53	7.84	9.18	8.77	8.71	8.76	8.49	6.88
3	0	7.83	4.81	.06	-.00	1.73	5.10	8.38	9.09	10.57	11.14	11.24	10.33	6.69
4	0	9.36	6.21	5.15	1.61	-.00	3.74	9.15	11.38	11.35	11.53	11.22	10.33	7.39
5	0	9.30	6.24	2.80	-.00	3.29	7.32	8.79	8.91	9.87	11.03	10.62	9.10	7.27
6	0	7.82	4.96	3.47	2.38	.14	2.57	7.07	9.15	9.27	8.91	8.69	7.58	6.00
7	0	6.67	4.03	3.01	2.08	3.84	4.78	4.33	2.14	1.92	1.59	1.88	1.71	3.17
8	0	2.34	3.71	3.19	2.41	1.21	6.22	6.91	6.40	5.54	1.59	1.63	1.98	3.61
9	0	2.93	3.95	-.00	.38	-.00	5.42	7.84	8.55	8.56	8.54	8.63	7.80	5.22
10	0	4.40	3.31	3.62	-.00	.12	3.27	7.28	6.70	8.70	8.07	3.93	2.03	4.29
11	0	2.99	3.45	.91	1.19	-.00	-.00	5.56	7.27	7.82	7.97	8.32	7.71	4.43
12	0	6.85	2.08	1.52	-.00	-.00	3.08	5.96	9.06	9.94	9.93	10.23	9.30	5.83
13	0	8.64	4.78	3.35	.83	1.12	4.02	7.45	8.90	10.00	9.98	10.07	8.98	6.51
14	0	8.39	3.51	1.20	-.00	-.00	-.00	5.60	8.04	10.46	11.31	12.57	11.82	6.08
15	0	9.02	4.82	5.58	4.48	5.12	.90	8.85	9.98	11.13	10.96	13.17	12.20	8.02
16	0	9.75	5.80	1.48	-.00	1.59	.87	7.76	10.99	12.07	11.92	12.04	11.19	7.12
17	0	10.16	5.62	4.56	3.16	5.39	4.45	9.39	10.97	11.62	11.44	11.54	10.74	8.25
18	0	8.48	.25	-.00	5.36	2.58	-.00	9.85	8.85	11.48	9.06	9.17	9.23	6.19
19	0	11.21	6.67	2.66	2.13	.80	7.23	10.62	12.85	12.94	11.89	12.37	11.77	8.60
20	0	10.38	6.19	4.33	3.46	5.02	5.95	9.38	10.71	11.04	10.96	10.98	9.98	8.20
21	0	8.28	3.96	2.61	.38	.71	3.41	8.01	11.00	11.79	11.72	11.75	10.80	7.04
22	0	9.39	6.83	4.21	3.78	3.78	5.38	8.56	10.20	10.48	10.08	10.49	9.43	7.72
23	0	9.61	6.55	4.01	1.69	1.64	2.19	7.67	9.53	9.80	10.03	9.91	9.12	6.81
24	0	8.85	4.69	2.75	-.00	.83	3.60	5.81	8.31	9.49	9.47	8.98	7.65	5.89
25	0	8.21	5.44	1.84	-.00	3.96	.51	7.48	10.21	10.00	9.99	9.78	8.53	6.33

MONTHLY ENERGY PRODUCTION (GWH)

YEAR		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	ANNUAL ENERGY
1	0	4.81	1.69	.91	.00	.00	3.10	4.53	7.48	8.06	8.23	8.04	7.16	54.02
2	0	6.95	4.30	2.99	1.60	2.56	4.11	5.64	6.83	6.31	6.48	6.52	6.11	60.40
3	0	5.83	3.46	.04	.00	1.16	3.79	6.03	6.76	7.61	8.29	8.36	7.44	58.79
4	0	6.96	4.47	3.83	1.20	.00	2.78	6.59	8.47	8.17	8.58	8.35	7.44	66.84
5	0	6.92	4.49	2.08	.00	2.21	5.45	6.33	6.63	7.10	8.21	7.90	6.55	63.87
6	0	5.81	3.57	2.58	1.77	.09	1.91	5.09	6.80	6.67	6.63	6.47	5.46	52.87
7	0	4.97	2.90	2.24	1.55	2.58	3.56	3.12	1.59	1.39	1.18	1.40	1.23	27.70
8	0	1.74	2.67	2.37	1.94	.81	4.63	4.98	4.76	3.99	1.18	1.21	1.43	31.72
9	0	2.18	2.84	.00	.28	.00	4.03	5.65	6.36	6.16	6.35	6.42	5.61	45.90
10	0	3.28	2.39	2.69	.00	.08	2.43	5.24	4.98	6.27	6.00	2.92	1.46	37.74
11	0	2.22	2.49	.68	.89	.00	.00	4.00	5.41	5.63	5.93	6.19	5.55	38.98
12	0	5.09	1.50	1.13	.00	.00	3.78	4.29	6.74	7.16	7.39	7.61	6.69	51.38
13	0	6.43	3.44	2.50	.62	.76	2.99	5.36	6.62	7.20	7.43	7.49	6.47	57.30
14	0	6.24	2.53	.89	.00	.00	.00	4.03	5.98	7.53	8.41	9.35	8.51	53.49
15	0	6.71	3.47	4.15	3.33	3.44	.67	6.37	7.43	8.01	8.15	9.80	8.79	70.32
16	0	7.25	4.18	1.10	.00	1.07	.64	5.58	8.18	8.69	8.87	8.96	8.03	62.55
17	0	7.56	4.04	3.39	2.35	3.62	3.31	6.76	8.16	8.37	8.51	8.59	7.73	72.40
18	0	6.31	.18	.00	3.99	1.74	.00	7.09	6.58	8.26	6.74	6.82	6.64	54.35
19	0	8.34	4.81	1.98	1.58	.54	5.38	7.65	9.56	9.31	8.85	9.21	8.47	75.67
20	0	7.73	4.46	3.22	2.57	3.37	4.43	6.75	7.97	7.95	8.16	8.17	7.18	71.96
21	0	6.16	2.85	1.94	.28	.48	2.54	5.77	8.18	8.49	8.72	8.74	7.78	61.93
22	0	6.98	4.92	3.13	2.81	2.54	4.01	6.16	7.59	7.55	7.50	7.80	6.79	67.78
23	0	7.15	4.72	2.98	1.26	1.10	1.63	5.53	7.09	7.06	7.46	7.37	6.57	59.9
24	0	6.58	3.38	2.04	.00	.56	2.68	4.18	6.33	6.83	7.05	6.68	5.51	51.8
25	0	6.11	3.92	1.37	.00	2.66	.38	5.39	7.60	7.20	7.43	7.28	6.14	55.40

MODEL OUTPUT

TOTAL ENERGY FOR THE PERIOD OF RECORD IN GWH = 1405.13

SHORTAGES (MCM)

YEAR		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	ANNUAL TOTAL
1	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	0	.00	.00	.00	.00	.00	.00	6.78	20.60	22.17	23.45	24.08	20.62	117.71
8	0	18.46	1.69	.00	.00	.00	.00	.00	.00	8.75	23.45	24.18	21.32	97.85
9	0	15.53	.45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	15.98
10	0	11.71	5.09	.00	.00	.00	.00	.00	.00	.00	.00	15.59	21.04	53.43
11	0	11.28	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	11.28
12	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
13	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
14	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
15	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
16	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
17	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
18	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
19	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
20	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
21	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
22	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
23	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
24	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
25	0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

****

SHORTAGES OCCUR IN 19 OUT OF 300 MONTHS (6.33 PERCENT OF THE TIME)

TARGET PERCENTAGE = 6.00 TOLERANCE = .50 RESERVOIR ELEV. MAXIMUM/ START= 170.00 / 118.00

IRRIGATED AREA = 17731.0 HECTARES ITERATION NUMBER 0

****

APPENDIX H
AIR QUALITY MODEL

In modeling the air quality [carbon monoxide (CO) only] of the Jordan Valley, the HIWAY model, a conservative computerized model developed and sanctioned by the U.S. Environmental Protection Agency was used. This model was chosen because it deals exclusively with automobile emissions and these are the most significant source in the Valley. The parameters used in the model reflect the worst case conditions which, although not documented in Jordan, are meteorologically highly probable. The worst case is the presence of a temperature inversion at about 300 meters about the Valley floor. Such inversions are caused by the nightly flow of cooler, high-altitude air down the slopes of the escarpments to rest on the floor of the valley, below the warmer air. Such temperature profiles have the effect of capping all ground-based emissions below the warm air layer, which causes concentration buildups, until the heat of the sun "burns" the emissions off and upward mixing is again possible.

Because the inversions may occur nightly, even though they are consistently broken up, the local population is exposed to these higher than average concentrations below the inversion. Scorer [H-1][1] states that such inversions are very common in mountain valleys, especially at this latitude.

The Yarmouk-Dead Sea Road was assumed to be a 2 lane, straight-line source, 14 m wide without a center strip, running north-south for 100 km. A northerly wind of 8 m/sec was selected as an average corresponding to 15 knots. The mixing height of 300 m and the Pasquill-Turner air stability class of 4 reflect the type of inversions described above. Emission rates were based upon the factor q_ℓ in grams/meter/sec (equation 1).

---

[1]Numbers in brackets, e.g. [H-1], refer to references listed in Appendix B.

(1)
$$q_\ell = \frac{(\text{grams/vehicle mile}) \times (\text{vehicles/hr})}{(1609.3 \text{ m/mile}) \times (3600 \text{ sec/hr})}$$

Grams/vehicle mile is the emission factor, which must reflect the mixture of vehicles on the road (e.g. percentages of cars, trucks, etc.) and their individual emission rates based on vehicle age. Vehicle mixes for Route 43 were available from the "Master Road Plan". [H-2] Vehicle emission rates by type and age have been established by the Environmental Protection Agency [H-3]. Because of the dry climate, over half of Jordan's vehicles are quite old. The U.S. Environmental Protection Agency data year 1975 was chosen to typify Jordanian emission rates, as pre-1968 vehicles made up 65% of the U.S. total vehicles on the road that year. The overall emission rate was found using equation 2.

(2)
$$\begin{aligned}\text{grams/vehicle mile} = {} & (\%\text{ autos}) \times \left(\begin{matrix}\text{1975 average auto}\\ \text{emission rate}\end{matrix}\right) \\ & + (\%\text{ light trucks}) \times \left(\begin{matrix}\text{1975 average light}\\ \text{truck emission rate}\end{matrix}\right) \\ & + (\%\text{ heavy trucks}) \times \left(\begin{matrix}\text{1975 average heavy truck}\\ \text{emission rate}\end{matrix}\right)\end{aligned}$$

A maximum of 200 vehicles/hr. was selected to reflect the morning traffic to marketing centers and fields; this is about one-fifth of total daily traffic.

The CO concentrations were calculated by the model for a row of "observers" on a line perpendicular to the midpoint of the road at distances of 10, 30, 50, 500, 1000 and 2000 meters.

Results of the run using these modeling assumptions are presented in Table H-1.

The model was run a second time to test concentrations when the winds were less strong (4 m/sec.) and shifted to the west. All other parameters were held constant. These results are presented in Table H-2.

In both analyses, the CO concentration at 10 meters from the road, $0.43 mg/m^3$ and $0.3 mg/m^3$, are a factor of 25 less than the U.S. National Ambient Air Quality 8-hour standard of $10 mg/m^3$. [H-4] It is therefore concluded that there will be no health problems relating to CO in the region, even under worst case conditions.

Table H-1

Analysis of Carbon Monoxide Concentrations

(Case 1)

```
HIWAY VERSION: 73288
ENDPOINTS OF THE LINE SOURCE
      0.    ,       0.    AND       0.    ,      100.000
EMISSION HEIGHT IS    2.000 METERS
EMISSION RATE (GRAMS/SECOND*METER) OF    2 LANE(S)
   .180E-02     .180E-02
WIDTH OF AT-GRADE HIGHWAY IS     14.000 METERS
WIDTH OF CENTER STRIP IS      0.     METERS
WIND DIRECTION IS      0.  DEGREES
WIND SPEED IS     8.0 METERS/SEC
STABILITY CLASS IS     4
HEIGHT OF LIMITING LID IS    300.0 METERS
THE SCALE FACTOR IS      1.0000KM.
```

RECEPTOR LOCATION X	Y	HEIGHT Z (M)	CONCENTRATION UGM/CU METER	PPM
.0100	50.0000	0.	432.715	.376
.0300	50.0000	0.	214.056	.186
.0500	50.0000	0.	153.012	.133
.1000	50.0000	0.	96.561	.084
.5000	50.0000	0.	29.446	.026
1.0000	50.0000	0.	15.032	.013
2.0000	50.0000	0.	5.430	.005

Table H-2

Analysis of Carbon Monoxide Concentrations

(Case 2)

```
HIWAY VERSION: 73288
ENDPOINTS OF THE LINE SOURCE
        0.    ,        0.    AND        0.    ,        2.000
EMISSION HEIGHT IS    1.000 METERS
EMISSION RATE (GRAMS/SECOND*METER) OF    2 LANE(S)
   .180E-02     .180E-02
WIDTH OF AT-GRADE HIGHWAY IS     14.000 METERS
WIDTH OF CENTER STRIP IS      0.     METERS
WIND DIRECTION IS    270.  DEGREES
WIND SPEED IS     4.0 METERS/SEC
STABILITY CLASS IS     4
HEIGHT OF LIMITING LID IS    300.0 METERS
THE SCALE FACTOR IS      1.0000KM.
```

RECEPTOR LOCATION X	Y	HEIGHT Z (M)	CONCENTRATION UGM/CU METER	PPM
.0100	1.0000	0.	305.801	.266
.0300	1.0000	0.	228.477	.199
.0500	1.0000	0.	182.304	.159
.5000	1.0000	0.	37.201	.032
1.0000	1.0000	0.	23.595	.021
2.0000	1.0000	0.	14.813	.013

APPENDIX I

ARCHAEOLOGY

This appendix supplements discussions contained in Chapters 6, 8 and 10 of the EA report. Part I of this appendix concerns the Maqarin Dam and Reservoir area, while Part II deals with the East Jordan Valley. The discussion herein is based on a Stage II project as described in the January 1978 Feasibility Study.

PART I - MAQARIN DAM AND RESERVOIR AREA

I.1 Existing Archaeological Data Base

In 1884 Gottlieb Schumacher surveyed the Yarmouk Valley and other areas east of Lake Tiberius in preparation for the construction of a railway from Haifa to Damascus. In the course of his survey he noted and made drawings of many of the archaeological sites and ruins he encountered in what are today northern Jordan, southern Syria, and the Yarmouk Valley. The descriptions of these sites published in his survey reports [I-1,2,3][1] constitute the first systematic recording of archaeological sites in these areas. Among the archaeological sites discovered by Schumacher were two of the largest within the Maqarin Reservoir area: Tell Jamid (Site 14) and Tell Qurs (Site 28) (Figure 6-3 and Figure I-1).

In the 1930's and 1940's Nelson Glueck carried out extensive archaeological surveys in Palestine and Trans-Jordan, including the Jordanian side of the Yarmouk Valley. Following Schumacher's earlier maps and descriptions of the Yarmouk Valley, Glueck visited the sites of Tell Jamid and Tell Qurs but did not collect artifacts from any additional archaeological sites in the Maqarin Reservoir area. [I-4]

A third archaeological survey of the Maqarin Reservoir area came in 1953, when James Mellaart and Henri de Contenson were commissioned to survey the Yarmouk and Jordan Valleys are part of the Point Four Irrigation Project. [I-5, 6] In the Maqarin Reservoir area they located and described two new archaeological sites (Sites 29 and 32 on Figure 6-3),

[1]Numbers in brackets, e.g. [I-1], refer to references listed in Appendix B.

and collected new material from Tell Jamid and Tell Qurs. During the survey, Mellaart put in a small sounding at Tell Jamid [I-5], but did not publish the materials excavated. This brief excavation at Tell Jamid represents the only archaeological excavation to date within the Maqarin Reservoir area.

I.2 Completeness of the Archaeological Data Base

In the 1978 survey, [I-7], the entire area of the Maqarin Reservoir, up to an elevation of 220 m, was surveyed by team members walking the terrain on foot at closely spaced intervals so as not to miss any surface remains. In this part of the Near East, ancient sites almost always display surface indications, most often in the form of surface scatters of pot sherds and/or stone tools that can be dated by comparison with similar artifacts from excavated sites elsewhere. In some areas, however, alluviation has buried sites so that they can be found only by systematic subsurface testing or excavation. The buildup of humus topsoil also tends to obliterate surface remains. Such problems are most common in more heavily forested temperate zones such as Western Europe and much of North Aermica. In the Yarmouk Valley, erosion--which tends to bring buried artifacts to the surface--appears to have been more prevalent than alluviation, especially since many of the sites are located on slopes, terraces, and promontories well above the valley floor. Thus, the techniques used in the 1978 survey were highly appropriate to the environmental setting, and were applied in a manner designed to discover the maximum number of sites within the reservoir area. It can be stated with some confidence that no sites of importance remain to be found in the Maqarin Reservoir area, and that the archaeological data base for assessing impacts can be considered complete.

The only drawback to the survey data is that it is difficult in some cases to determine the extent of occupation for any given period on multi-period sites. The numbers of artifacts collected for any given site were small; and within the area of a site, artifacts were not

collected by any systematic sampling technique other than picking up whatever diagnostic, datable artifacts could be found. This technique of artifact collection can lead the surveyer to miss a period of occupation on a site. For example, the absence of Mesolithic stone artifacts, which are difficult to see when walking over a site, might be attributed to the sampling technique used. However, since the primary purpose of the survey was to locate sites, the fact that more sophisticated techniques were not utilized to determine the area and extent of occupation for individual periods on multi-period sites cannot be faulted. To have used such techniques would have been extremely time-consuming and would have made it impossible to cover the reservoir area thoroughly enough in the time available. In any case, because of the way the data were collected, the indications of site size and period of occupation in Tables 6-7 and 7-8 should be taken as very approximate. Only actual excavations will be able to clarify the extent and types of occupation on individual sites in different periods.

I.3 Adverse Impacts of Inundation

Eighteen sites are threatened by inundation. Recent studies of the impact of inundation on archaeological sites in reservoir areas in the United States [I-8] have shown that while some archaeological materials, such as wood, gold, or unpainted pottery with low porosity, are not adversely affected by inundation, most other materials, such as bone, shell, vegetable fibers, iron, bronze, and most types of stone tend to break down or deteriorate more rapidly under conditions of immersion. This type of impact alone would one to recommend mitigation for some of the more important sites within the Maqarin Reservoir area.

I.4 Mitigating Actions

With the possible exceptions of the Roman Period and the time from the Early Islamic Period onward, virtually nothing is known about the ancient history and prehistory of this part of northern Jordan. Moreover, there have been no archaeological excavations in this part of the Yarmouk Valley aside from Mellaart's unpublished sounding at Tell Jamid. The deep-cut

Yarmouk Valley with its perennial river constitutes a very different ecological setting than that of the northern Jordanian plateau, and might therefore reveal very different cultural adaptations or subsistence economies than are found elsewhere. This part of the Near East was one of the primary areas for the emergence of Homo sapiens in the Paleolithic Period and for the so-called "Neolithic Revolution," during which humans first domesticated plants and animals and adopted a sedentary life style. Important clues to the causes and processes involved in these fundamental evolutionary and cultural changes might well be found in the area of the Maqarin Reservoir, which is rich in Paleolithic and Neolithic sites. In later periods this part of the Yarmouk Valley, with its long north-south wadis, may have served as a major crossroads for east-west and north-south travel and trade. This strategic geographical location may, for example, account for the presence of a large Early Bronze Age site (Site 14) at the point of convergence of serveral wadis.

For all these reasons, it can be argued strongly that mitigation should be undertaken on as many of the threatened archaeological sites as possible. The recommended mitigation strategy is excavation. To excavate all the threatened sites would, of course, be the ideal, but such a goal is unrealistic and impractical in the approximately 6 years' lead time available before the reservoir begins to be filled. Consequently, the 28 threatened sites have each been rated and assigned to 1 of 3 categories: Highest Priority, High Priority, Low Priority (Table I-1). This 3-tiered rating system is based on the sites' intrinsic archaeological value, using such criteria as site size, anticipated depth of deposits, richness of material remains on site, and potential for site to answer important questions about the archaeology of the region or more general questions about cultural change in this area of the Near East. Out of 28 threatened sites, 15 are recommended mitigation, 6 labelled Highest Priority category, and 9 labelled High Priority. An attempt has been made to include at least 1 site from every major period.

Table I-1

Archaeological Sites in the Maqarin Dam and Reservoir Area
Recommended for Mitigating Action, Listed in Order of Priority

Highest Priority for Mitigation

Site	3		
	6		
	14		
	18		
	19		
	26		

High Priority

Site	2	17	
	4	27	
	10	31	
	11	32	
	16		

Low Priority

Site	1	20	29
	5	21	30
	12	22	
	13	23	
	15	24	
		25	

Source: Institute for Conservation Archaeology, Harvard University.

Finally, an estimate has been made as to the minimum length of time and number of supervisory personnel needed for the excavation of each of the sites recommended for mitigation. Table I-2 shows these figures arranged according to the urgency of mitigating the sites involved. At the present rate of progress, it is estimated that dam construction can begin about 2 years from now, and within 6 years the reservoir will begin to be filled. Given this timetable, threatened sites within proposed borrow areas will have to undergo mitigation within 2 years, and sites within the reservoir itself within 6 years. This should be sufficient time in which to carry out recommended mitigation if excavations are begun as soon as possible. The recommendations for mitigations made here follow roughly the recommendations of the 1978 survey report [I-7], but with certain modifications based on our own field examination of the Maqarin Reservoir area sites. It should be noted that from an archaeological point of view these are minimal mitigating actions. The proposed excavations will in no case constitute total excavation of a threatened site, but should provide sufficient data to gain a reasonable understanding of the occupational history of the site.

The overall organization of the recommended salvage excavation program should be under the direct control of Jordan's Director of Antiquities. It is also recommended that an experienced archaeologist be found within the Department of Antiquities to coordinate and oversee the excavations and ensure their prompt publication. Although at least 5 individuals are now studying abroad for Ph.D.'s in archaeology and wil return to form the future nucleus of the Department of Antiquities, there are presently not enough trained personnel within the Department to take charge of all the proposed excavations. Where necessary, therefore, foreign archaeologists should be invited to help as supervisory personnel in cooperation with members of the Department of Antiquities.

Table I-2

Mitigation Recommendations for Highest Priority and High Priority Sites in Maqarin Dam and Reservoir Area, Listed According to Urgency

Site No.	No. of Supervisors	Time for Excavation
Sites Threatened by Dam Construction Within 2 Years		
26	4	One 8-week season
27	4	One 8-week season
31	4	One 8-week season
32	4	One 8-week season
Sites Threatened by Inundation Within 6 Years		
2	4	One 8-week season
3	4	Three 8-week seasons
4	4	One 8-week season
6	4	Three 8-week seasons
10	4	Two 8-week seasons
11	4	Two 8-week seasons
14	6	Major excavation, at least 4 8-week seasons
16	4	One 8-week season
17	4	One 8-week season
18	4	One 8-week season
19	6	Major excavation, at least 4 8-week seasons

Source: Institute for Conservation Archaeology, Harvard University.

PART II - THE EAST JORDAN VALLEY

The primary impact of the proposed Stage II actions on archaeological sites will be from the irrigation and cultivation of more than 10,000 hectares of new lands at the south end of the East Jordan Valley. This area hereafter to be referred to as the "South Valley", consists of a strip of land six to eight kilometers wide running from a point just north of the town of South Shuneh and the Wadi Nimrin south to the edge of the Dead Sea near Suweima (Figure 6-4). Other already developed agricultural areas in the East Jordan Valley will be discussed only to demonstrate the type of adverse impacts the planned Stage II development of the South Valley can be expected to have on archaeological sites there.

I.5 Existing Archaeological Data Base

The East Jordan Valley is particularly rich in archaeological remains. At present there are 224 known archaeological sites on the east bank between the Yarmouk River and the Dead Sea. The reason for such a high site density, even at the south end near the Dead Sea where annual rainfall amounts to only 50-100 mm, is that there are several perennial streams flowing down into the Valley from the upland region to the east. Since the Neolithic Period these have served as primary sources of irrigation water.

Although some archaeological sites, particularly the large, highly visible mounds or tells, were noted by nineteenth and early twentieth century geographers and explorers surveying the Jordan Valley [I-9, 10, 11, 12, 13], the first intensive archaeological surveys and detailed publication of surface finds were the work of Nelson Glueck in the 1930's and 1940's. [I-4]. Aside from a brief survey by the French in 1929 [I-14], he was the first to carry out careful archaeological reconnaissances in the South Valley, where he recorded eight sites. The 1953 surveys of James Mellaart and Henri de Contenson, commissioned under the Point Four Irrigation Scheme, raised the total of know sites to ten. [I-5, I-6]

A dramatic change in the data base was brought about by the 1976 survey of James Sauer, Director of the American Center of Oriental Research in Amman. Sauer, working in collaboration with teams from the Department of Antiquities and the University of Jordan, succeeded in tripling the number of known sites, and brought the present known total in the South Valley to 29. (See Figure 6-4.)

The results of this recent survey have not yet been published, but the survey data were made available in Amman. (See Table 6-9.) The sites represent periods of occupation from the Neolithic through the Ottoman Period. (For a chronological chart of the various periods, see Table 3-5.) The south Valley differs from the Maqarin Reservoir in that the Paleolithic Period is not represented here. The absence of occupation in these earliest periods is due to the level of the Dead Sea being substantially higher at various times during the Late Pleistocene, so that the South Valley was totally submerged. Indeed, as late as the Chalcolithic the site of Ghassul (Site 22) appears to have been an island in the midst of a marshy area close to the edge of the Dead Sea. [I-15] Today the level of the Dead Sea is substantially lower, and the shoreline has receded to a point 5.5 km away from Ghassul.

The largest archaeological site (Site 22) is Ghassul which consists of a series of low mounds covering an area of more than 24 hectares. Ghassul also is the only site in the South Valley to have undergone extensive excavations, by a French expedition between 1929 and 1938 [I-16, 17], and in 1960 [I-18], and again since 1967 by the British archaeologist J.B. Hennessey. [I-15] The only other excavations in the South Valley have been at Site 24, where in 1929 the French team from Ghassul excavated several Chalcolithic cairn tombs [I-19], and at Site 11, a Neolithic site where Mellaart put in a small sounding during his 1953 Jordan Valley survey. [I-20]

I.6 Assessment of the Completeness of the Archaeological Data Base

As a result of Sauer's 1976 survey, the archaeological data base for the South Valley has been substantially improved, but it cannot yet be considered complete. Whereas the Maqarin Reservoir survey was commissioned and designed specifically to locate all sites in the area that might be threatened, the strategy of the Sauer survey was different. His approach was that of a macro-survey: attempting to locate as many sites as possible in a large area (from the Zarqa River down to the Dead Sea) within a limited amount of time (six weeks). The most likely locations for archaeological sites--along wadis and at the edges of the Valley--were carefully walked over, but large areas between the wadis, particularly down toward the Jordan River, were poorly covered. Almost certainly no large mound sites were missed, because these are easily spotted from a distance; but many low, flat sites are to be found in the South Valley, and a number of sites of this type probably were missed. Only through further survey will these sites be located. Sauer made a similar estimate, stating that the total number of known sites probably could be increased by 30% over the 29 already found if more intensive survey techniques were used. Therefore, it is strongly recommended that an additional survey be carried out in the areas noted above in close consultation with Sauer, and that the survey be designed as a foot survey to cover the area in the same comprehensive manner achieved at the Maqarin Reservoir.

I.7 Adverse Impacts (see Table 6-10)

With the possible exception of a high, steep mound like Tell Nimrin (Site 5), most of the sites consist of low mounds rising 0.5 to 2 m above the level of the plain. Repeated deep plowing of these sites or the leveling of them to facilitate irrigation will effectively destroy these sites over a period of years. During the March 1979 field reconnaissance, many sites were found in already developed, irrigated areas of the middle and North Valley, as well as in the Kafrein-Heshbon agricultural development, that were being leveled and plowed away at an

alarming rate. (See Figures I-2 and I-3.) On one site, subsurface irrigation piping had been newly laid in across the top of a previously undisturbed site, and about 50% of the site had just been plowed over. (See Figures I-4 and I-5.) Any subsurface irrigation piping or drainage pipes installed below the plow line to leach the soils will seriously disturb and damage any archaeological deposits they cross. At another site (Figure I-2), plowing had churned up so much carved stone entablature and so many column drums and capitals from a buried Byzantine church that the farmer evidently had given up trying to plow.

The proposed sprinkler systems do not require extensive leveling of the land. However, because of the type of crop rotation to be used, it is probably that the sprinkler systems on any given piece of land will be alternated with drip or gravity flow irrigation, for which leveled land is more desirable. In any case, it was found that whatever type of irrigation is being used, farmers prefer their land to be as level as possible. A further incentive for the farmer to level and cultivate archaeological sites is that the deposits tend to be very rich in ash and organic material, and thus extremely fertile.

Archaeological sites in many instances consist of mounds rising above the flat valley floor, and unfortunately, such mounds make excellent defensive positions for the army. During field reconnaissance it was found that army trenches had been cut into Sites 11, 16, and 22. (See Figures I-6 and I-7.) In each case the trenches were no longer being used, which would imply that they served no permanent defensive function and therefore were not particularly necessary.

Finally, an indirect adverse impact of the proposed actions may be an increase in archaeological site looting. Sites were noted during the field reconnaissance which have already been damaged by the trenching operations of site robbers in search of antiquities. (See Figure I-8.) If, as anticipated, the valley population increases significantly, this

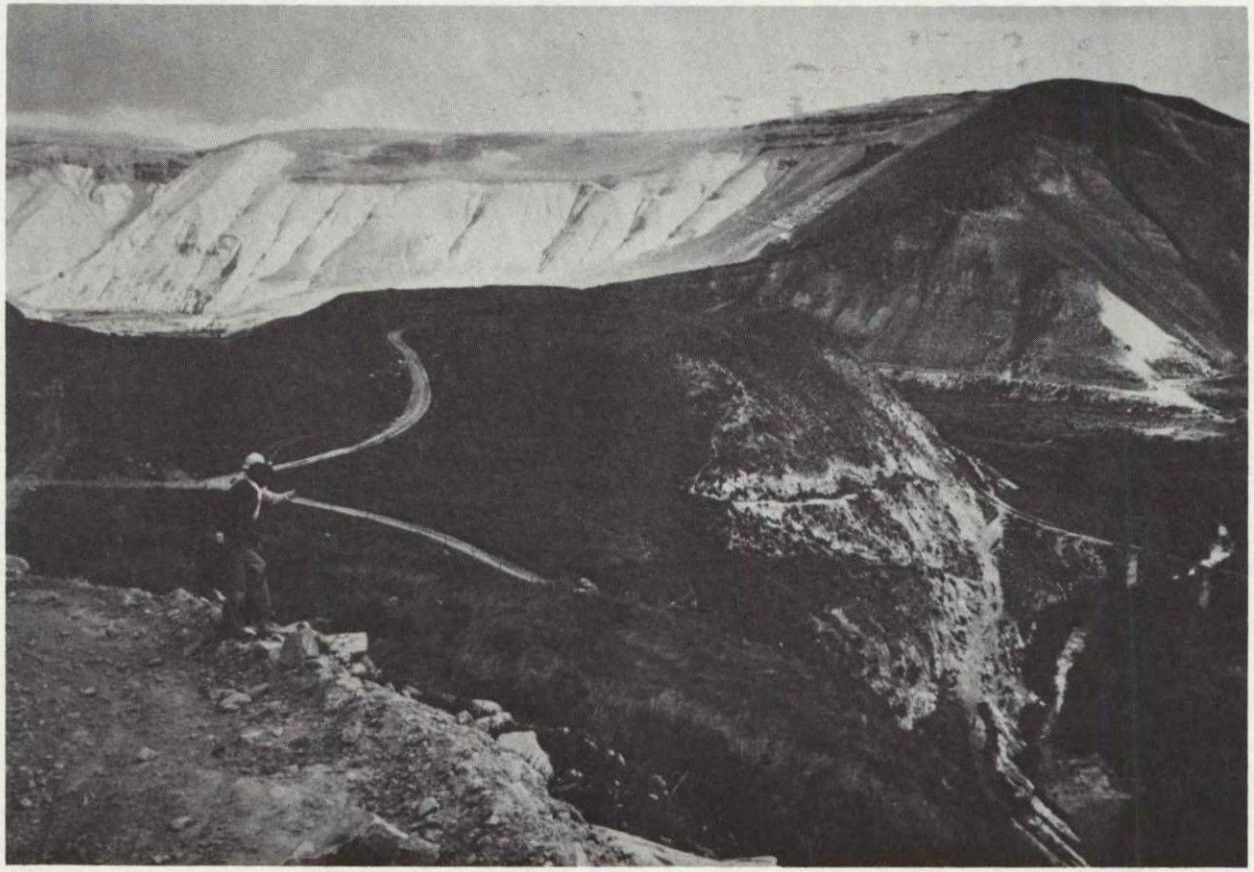

Figure I-1

Site 14 (Tell Jamid), an Early Bronze Age town within the Maqarin Reservoir. Site is visible as a large mound rising above the Valley floor in center foreground.

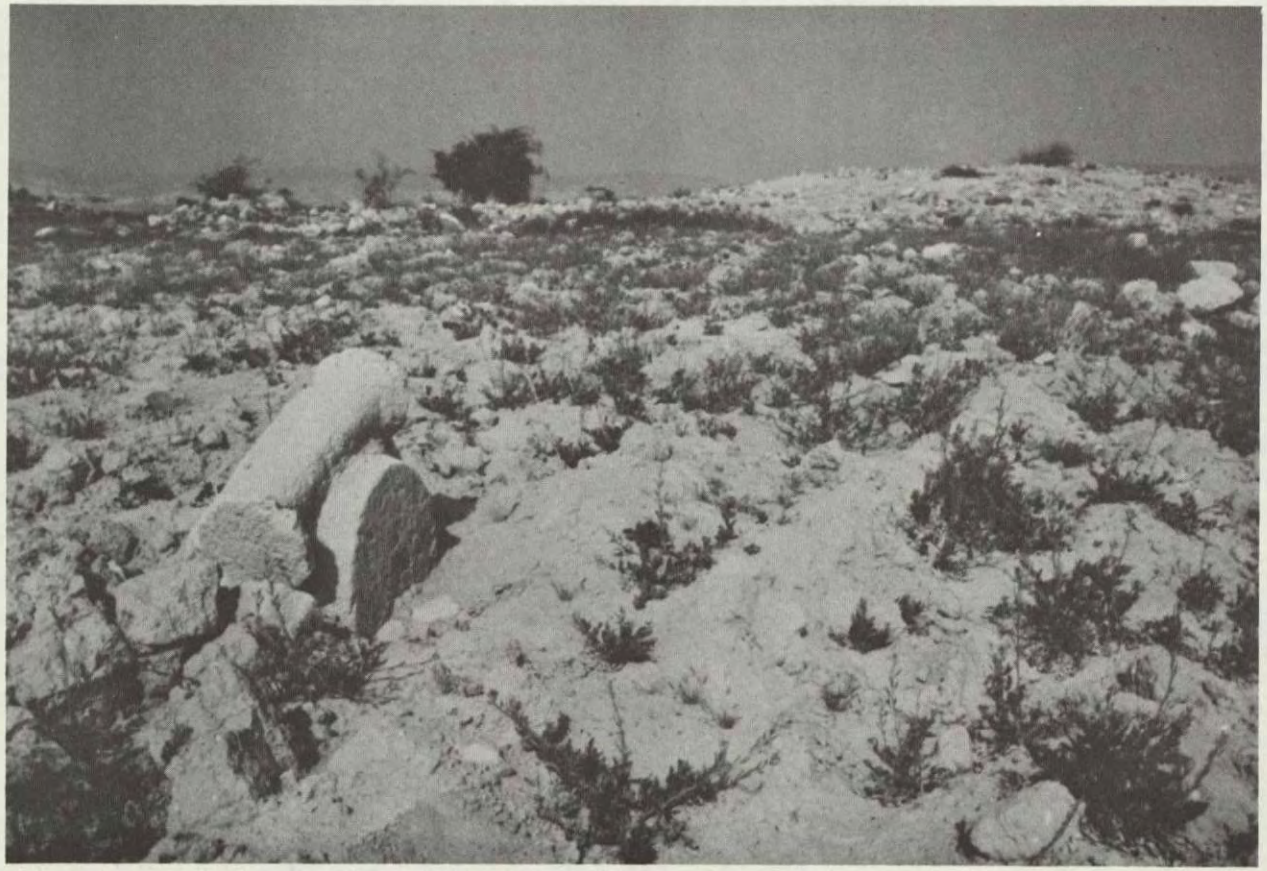

Figure I-2

Tell el-Mazar, a Byzantine site near El Rama in the southern Jordan Valley. In the foreground is a capital from a Byzantine church recently ploughed up at the edge of the site.

Figure I-3

Khirbet el-Buqe'a, a Roman town near the Zarqa River that has already been partially destroyed by encroaching fields.

Figure I-4

Tell el-Maqbarah, a Byzantine town near Karama in the southern Jordan Valley. Much of this site (visible in the photograph as areas of darker soil) has recently been ploughed over.

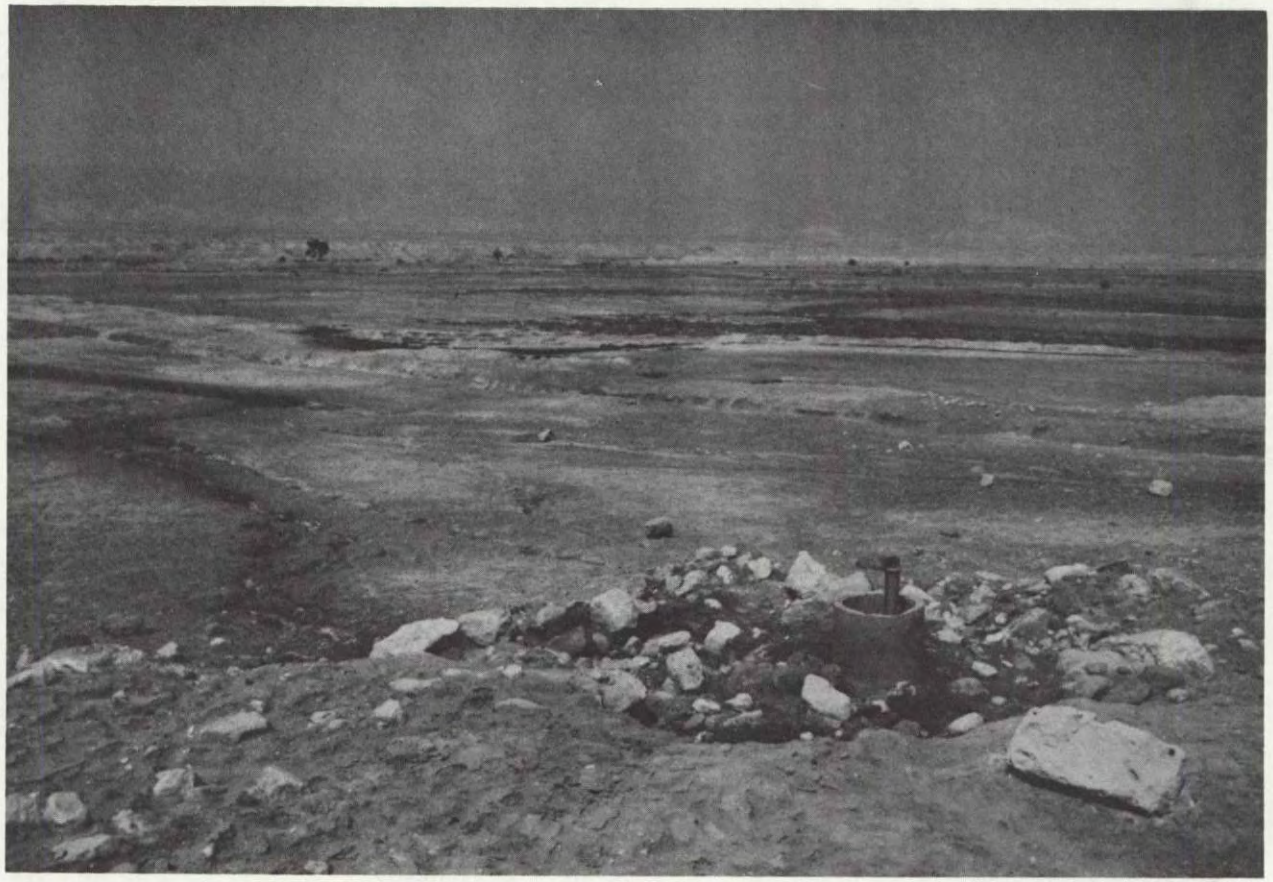

Figure I-5

Tell el-Maqbarah, a Byzantine town near Karama in the southern Jordan Valley. New irrigation outlet (visible in the right foreground) have recently been dug into the top of this site.

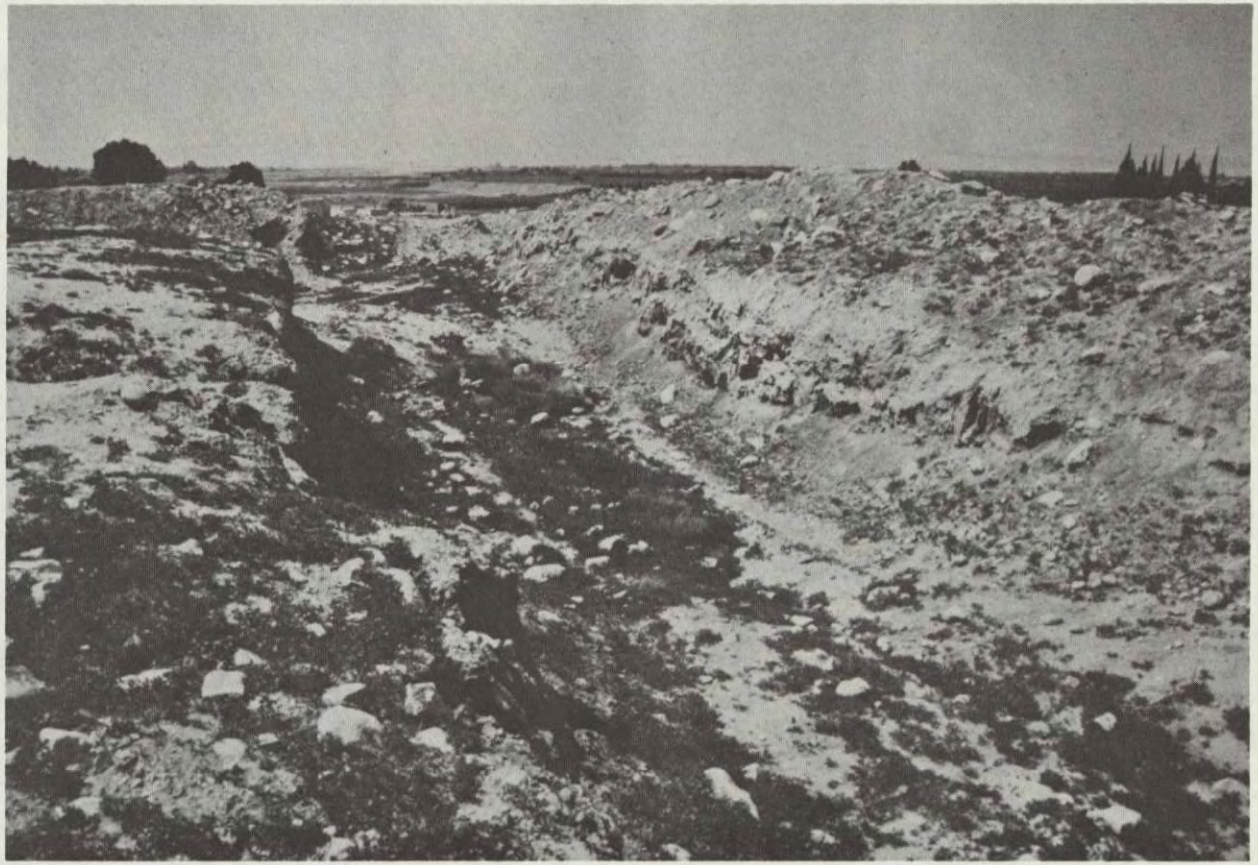

Figure I-6

Tell Nimrin, in the center of South Shuneh, in the southern Jordan Valley. Deep trenches have been dug across the top of the site by the Jordanian army.

Figure I-7

Ghrubba, a Neolithic/Chalcolithic site in the southern Jordan Valley. Trench shown here was dug into the site by the Jordanian army.

Figure I-8

Basset Khalaf, a small Roman site on Wadi Abyad, northwest of Karama in the southern Jordan Valley. Columns can be seen protruding from pit dug by looters.

may accelerate site robbing, especially if there is an increase in the numbers of low-paid foreign farm laborers.

I.8 Mitigation

It is strongly recommended that the adverse impacts noted above be mitigated. The archaeological sites of the East Jordan Valley represent a non-renewable resource critical to the future expansion of Jordan's tourist industry and critical to our understanding of man's cultural evolution in this part of the Near East. The South Valley area is referred to in the Bible as the "Plains of Moab", and is rich in historical tradition during the Iron Age. Indeed, sites mentioned in the Bible are found from one end of the valley to the other. Because of its larger number of perennial streams, the East Jordan Valley from Neolithic times onward always was more densely settled than the West Jordan Valley, so that this is the prime area for archaeological sites in the Jordan Valley, and an area with a higher density of archaeological sites than any other region of comparable size in Jordan.

For the primary impacts of agricultural plowing, leveling, and village expansion, the recommended mitigation is to protect the threatened sites by fencing them in. Table 6-10 shows the twenty sites recommended for mitigation fencing. Sites 7 and 17 are listed as low priorities because they are quite small sites and because there are many other similar sites of the same periods to be found elsewhere in the Jordan Valley.

The most difficult sites to fence will be those lining the Wadi Nimrin from South Shuneh down to the Jordan River. These sites extend almost continuously along the wadi for several kilometers.

Tell Nimrin (Site 5), threatened by the expansion of South Shuneh, has already had a road cut through its north side, leaving two isolated columns of as yet undisturbed archaeological deposits on one side of the road (Figure I-9). Any further road work will almost certainly destroy these deposits, and in their isolated position, they will in any case collapse or erode away within a few years.

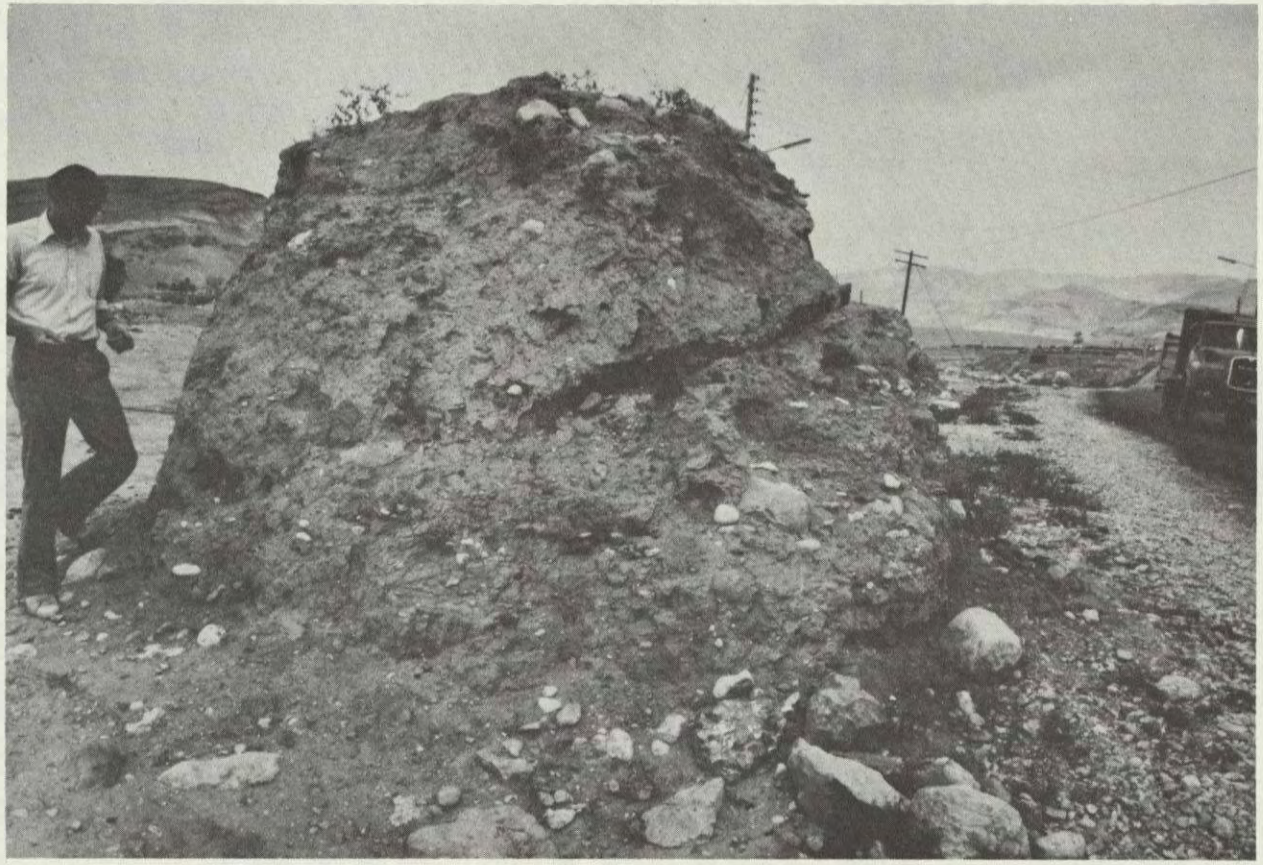

Figure I-9

North edge of Tell Nimrin, in the center of South Shuneh, in the southern Jordan Valley. This isolated column of archaeological deposits is threatened by erosion and road expansion.

For the sites threatened by construction of the EGMC extension (Table 6-10), the preferred mitigation would be avoidance: rerouting the canal slightly so as to avoid these sites. Otherwise, salvage excavations are recommended before canal construction begins, particularly for Site 22 (Ghassul) and Site 27, an important, fortified Early Bronze Age town.

As for the threat of further army trenching across the tops of sites, the easiest mitigation would be to request the army to inform the Department of Antiquities as to where it plans to carry out its trenching exercises, so that alternate trenching areas could be found if archaeological sites are threatened.

The mitigation proposed above will require much time and labor on the part of archaeologists, as well as a significant amount of financial support. The Jordan Valley Authority has expressed an interest in helping with the fencing of sites and has been given maps showing the approximate location of all known archaeological sites in the East Jordan Valley. However, field reconnaissance in March 1979 was not able to locate a single site that had been fenced. Indeed, one site where the area to be fenced had already been agreed upon was found to have been freshly plowed and to have newly laid subsurface irrigation piping across the top of the site (Figures I-4 and I-5). Clearly, the present organizational structure for mitigation has not been entirely effective. Much closer communication is needed between the Jordan Valley Authority and the Department of Antiquities, with trained archaeologists brought in to supervise the whole fencing process.

APPENDIX J

FARM CHEMICALS

J.1 PESTICIDES

Chemical pesticides are already used widely throughout the project area. Fungicides are most common, following by insecticides, acaricides, and nematicides. Herbicides are seldom employed except in plastic houses. No estimates were available on total quantities used in the Valley. However, based on crop budgets prepared by Steitieh, et al. in 1978 [J-1][1] and cropping intensity as presented in the Harza reports, usage in the project area is currently estimated as shown in Table J-1.[2]

Crops typically receive the number of treatments shown in Table J-2.

Hyslop's unpublished survey in 1979 [J-2] of 30 tomato growers indicated farmers using 1 to 4 fungicide applications, 1 to 3 insecticide applications, and 0 to 1 acaricide treatments. The average total number of applications was only 4, only one-third those indicated by Steitieh, et al.

On a per hectare basis, Steitieh, et al. reports pesticide usage by crop as shown in Table J-3.

Obviously on those hectares with more than one crop per year (6% currently), the annual intensity of pesticide application may be considerably greater than that indicated above for any crop.

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[1]Numbers in brackets, e.g., [J-1] refer to references listed in Appendix B.

[2]This is for field production only and does not include pesticides used in plastic houses or the increased quantities used with plastic tunnel field production.

Table J-1

Project Area Pesticide Usage

Compound	Use	LD 50	Total Volume Used (Not A.I.)	
Cosan	Fungicide/ Acaricide	-	29,384	KG
Zenib	Fungicide	5,200	19,279	KG
Tedion	Acaricide	714,700	2,542	KG
Lannate	Insecticide	17	1,807	KG
Afugan	Fungicide	460	1,535	KG
Benlate	Fungicide	10,000	254	KG
Parathion	Insecticide	3	58,538	LT
Hostathion	Insecticide	83	10,040	LT
Gramaxone (Paraquat)[1]	Herbicide	150	7,206	LT
Tamaron (Monitor)	Insecticide	19	1,271	LT
Metasystox	Insecticide	65	1,015	LT
Dimecron	Insecticide	17	635	LT
Perfekthion (Dimethoate)	Insecticide/ Acaricide	371	282	LT

Large quantities of straight sulfur were also used (in addition to Cosan).

[1] Gramaxion in Steitieh's report was assumed to be Gramaxone.

Source: Arthur D. Little, Inc., estimates, based on Streitieh, et al., and Harza data.

Table J-2

Number of Pesticide Treatments by Crop

	Fungicide	Fungicide/ Acaricide	Insecticide or Fungicide	Total
Tomatoes	3	4	5	12
Eggplant	0	4	9	13
Pepper	6	0	1	7
Potatoes	4	3	1	8
Cucumbers	6	0	3	9
Beans	1	0	5	6
Onions	1	0	1	2
Cabbage	0	0	2	2
Cauliflower	0	0	2	2
Squash	4	0	4	8

Source: Streitieh, et al. [J-1]

Table J-3

Pesticide Usage by Crop

Tomatoes:	Sulfur	30.0 KG
	Cosan	8.0 KG
	Zenib	5.4 KG
	Lannate	0.4 KG
	Parathion	2.4 LT
Eggplant:	Cosan	8.0 KG
	Lannate	0.4 KG
	Hostathion	6.3 KG
	Tamaron	1.0 LT
Potatoes:	Cosan	6.0 KG
	Zenib	7.2 KG
	Lannate	0.4 KG
	Gramaxion	5.0 LT
Peppers:	Lannate	0.4 KG
	Zenib	5.4 KG
	Benlate	1.8 KG
Cabbage:	Lannate	0.4 KG
	Perfekthin	1.0 LT
Cauliflower:	Lannate	0.4 KG
	Perfekthin	1.0 LT
Spinach:	Afugan	1.2 KG
	Zenib	2.0 KG
	Tedion	1.5 KG
	Hostathion	1.2 LT
	Parathion	1.4 LT
Cucumber:	Zenib	5.4 KG
	Tedim	1.5 KG
	Afugan	0.8 KG
	Dimecron	1.0 LT
	Hosthation	1.2 LT
Beans: (Broad and Green)	Zenib	2.0 KG
	Lannate	0.4 KG
	Tedion	1.5 KG
	Hosthation	1.2 LT
	Metasystox	2.0 LT

Table J-3 (continued)

Onions:	Zenib	2.0 KG
	Parathion	1.0 LT
Watermelon:	Zenib	1.2 KG
	Hosthation	2.0 LT
Wheat:	None	

Source: Streitieh, et al. [J-1]

While the quantities of compounds used was not indicated, a 1978 report by Steitieh and Abbas [J-1] on production costs under plastic covers indicated a tremendous increase in pesticide usage over field production. Based on costs per dunum reflected in the report, the following table was developed to illustrate this difference in intensity:

	Cucumbers	Tomatoes
Traditional Field	1.0X	1.0X
Plastic or Drip	22.5X	8.2X
Plastic House w/Drip	70.0X	51.0X

In other words, based on cost data, a hectare of cucumbers grown in a plastic house using drip irrigation uses 70 times the amount of pesticides as traditional field production. Tomatoes grown in houses with drip use 51 times the quantities per hectare used in field production.

J.2 FERTILIZER

Fertilizer is employed as widely as pesticides in the East Jordan Valley. Most crops use either chemical or natural fertilizer or a combination of the two. Based on application rates in the 1978 Stietieh and Abbas crop budget study [J-1] and on cropping patterns presented in the Harza reports, total fertilizer usage in the project area is currently estimated as follows:

	Tons
Ammononium Sulfate	3,900
Super Phosphate	4,500
Compound	1,600
Manure	53,000

On a per hectare basis using the same Stiehieh and Abbas report, fertilizer usage by crop was estimated as shown in Table J-4.

The above data vary somewhat from information collected by Hyslop in his survey of tomato growers. He found in 1979 the average usage on tomatoes is 395 kilograms of ammonium sulfate per hectare, 525 kilograms of super phosphate, 490 kilograms of complete, and 265 kilograms of urea.

While production under plastic covers (tunnel or house) tends to use somewhat more fertilizer than field production, this is not always the case, nor is the difference ever as extreme as with pesticides. (See discussion in preceding section.) The following table compares fertilizer usage, using cost data in the Stietieh, et al. study [J-1] on plastic covering production:

	Cucumber		Tomatoes	
	Fertilizer	Manure	Fertilizer	Manure
Traditional	1.0X	0.0X	1.0X	1.0X
Tunnel or Drip	3.3X	23.5X	1.0X	3.4X
Plastic House w/Drip	1.8X	0.0X	1.3X	0.0X

Table J-4

Fertilizer Usage by Crop

Crop	Ammonium Sulfate (KG)	Super Phosphate (KG)	Compound (KG)	Manure (M^3)
Tomato	800	750	500	13
Eggplant	500	850	–	13
Potato	500	1500	–	13
Pepper	500	1000	–	26
Cabbage	500	500	–	–
Cauliflower	500	500	–	–
Squash	500	750	250	–
Cucumber	500	1000	250	–
Bean, Broad	250	–	–	–
Bean, Green	700	–	–	3.5
Onion	375	–	–	–
Watermelon	500	–	–	–
Wheat	–	–	–	–

Source: Streitieh and Abbas. [J-3]

Manure is quite popular for those using plastic tunnels or plastic mulching, since it is felt that the manure's decomposition creates additional soil warmth beneficial to production.

J.3 LAND REDISTRIBUTION

The following information is based on two interviews with Mr. H. Sami, head of the JVA department responsible for land redistribution. The details of the Jordan Valley Development Law will not be repeated here, rather only additional information which relates to the law's implementation.

In areas in which land redistribution is to occur, the JVA first conducts a cadastral survey and then an official land survey. Once this is done, the land is valued and then distributed according to the priority guidelines established in the 1977 Jordan Valley Development Law. Within a priority group, if enough land is not available for all persons within that group, the Distribution Committee[1] generally selects the recipients based on a verbal or other communication that an individual wants the land and on the Committee's perception of the best farms (with the best farmers getting land first). An Evaluation Committee exists consisting of the head of the Department of Land Surveys, a representative of the Ministry of Agriculture to include appropriate experts, and a good farmer in the Valley. An Appeals Committee also exists to settle both distribution and valuation controversies. It is headed by a judge of the High Court and includes a representative of the Ministry of Agriculture and a local farmer. (Both of the latter two are different from the Ministry of Agriculture and farmer representatives on the other two committees.)

Farmers with more than 40 dunums who must give up a portion of their land are allowed to select which land they keep and which they relinquish. This results in the best land (more productive and/or more conveniently located) being retained by current owners. Landowners often farm or have (without farming) non-contiguous parcels. This will

[1]Comprised of H. Sami from JVA; the head of the EGMC; and a representative the farmers.

not be permitted under the redistribution program. A landower cannot be part-owner of two non-contiguous units. Thus, the owner is permitted a choice of which unit he will keep or be part-owner of; generally, he selects the parcel nearest his residence if he lives in the Valley even though this may mean keeping the smallest of his parcels. Occasionally, there has been some movement of farmer/owners to units 10 km to 20 km away if it has meant more and/or better land. Tree crops whenever possible are left intact with the original owner.

Presently, 75% of the survey/valuation/redistribution process is completed in the Zarqa Triangle and 50% in the 8 km extension. In the 18 km extension of the EGMC, only the survey work is in progress; in the 14 km extension, no redistribution-related work has begun. With respect to the 6000 ha reduction in irrigated land due to M&I diversions, Sami is making no special provisions with respect to land distribution. He will appropriate and redistribute land according to the law and current policies; he will then let the "water people" determine which lands receive water and the quantity received. In the redistribution process, all excess government land is kept aside for the landless. However, the quantity available is relatively small: only 30 units (an approximate 100 hectares) from the Yarmouk River to the 8 km extension. In the north, during the first redistribution program prior to 1967, it was difficult to get owners to keep their land; in the south, it is difficult to find any land to allocate to the existing tenant farmers. (There is further discussion on this point in Section 6.4.1.4.2.)

The northern part of the Valley where redistribution has occurred consists of Hod 1-24.[1] Distribution occurred in Hod 1-18 in 1963 and Hod 19-24 in 1967. Tables J-5, J-6, and J-7 summarize the results of this distribution program (Stage I).

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[1]A "hod" is a geographic or administrative zone.

Table J-5

Jordanian Government Purchase and Resale of Lands
In the Northern Valley

Original owner	5,304	
Owners paid for land without receiving any	1,297[1]	
Owners receiving land back		4,007
Farmers/Laborers without land who received land under program		500
Total owners in north now[2]		4,507

[1] Many of these were apparently Bedouins.

[2] Not representative of the number of farms since many owners are absentee landlords.

Table J-6

Allocations of Units[1] in the Northern Valley (Hod 1-24)

Number of Owners Per Holding	Holdings in Category	Number of Units Per Holding	Total Units in Category	% Land in Category
2 owners (Ministries)[2]	-	8	8 or 16	0.3
1 owner	6	7	42	1.3
1 owner	4	6	24	0.8
1 owner	9	5	45	1.4
1 owner	19	4	76	2.4
1 owner	74	3	222	7.0
1 owner	262	2	524	16.4
1 owner	1425	1	1425	44.5
2 owners	455 (910 owners)	1	455	14.2
3 owners	162 (486 owners)	1	162	5.1
5.8 average	225 (1312 owners)	1	225	7.1
	2642 (4507 owners)		3208 (or 3216)	

[1]Unit equals approximately 30 dunums, 3 ha, or 7.41 acres in the north; a unit will equal approximately 40 dunums in the south.

[2]Unclear as to whether two ministries <u>together</u> had 8 units or two ministries <u>each</u> had 8 units.

Table J-7

Land Allocation to Non-Owner Farmers/Laborers
In the Northern Valley, Hod 1-24, Stage I

Owners Per Unit	New Owners In Category	Total Units In Category
1	255	255
2	158	79
3	57	19
4	24	6
5	15	3
	503[1]	362

[1]Equates to the 500 landless persons receiving land in Table J-5. However, data came from two interview sources.

As can be seen from the data, the largest farm in the north was only 21 ha (210 dunums); only 6 holdings fell into this category. Over 90% of the holdings were 9 ha (22.2 acres) or less. Unfortunately, the data do not permit analysis to determine how many of the holdings are owned under separate title by members of the same family. In any event, it is evident that 503 previously landless farmers or farm laborers did receive nearly 1100 ha of land in the redistribution program. While there were some failures among these as farmer-owners, less than 5% of those receiving land in the north were financially forced to give up the lands they had been allocated due to mismanagement, etc.

In Hod 1-24, land was appropriated and then resold at JD 40 per dunum for Class 1 and 2 land (the best agricultural lands) and JD 8 per dunum for Class 6 land (the worst land). Farmers receiving land were able to pay for it over 20 years at 4% interest. (This payment/interest schedule is also contemplated for land in the south.) A farmer/landowner also has to pay JD 20 per dunum for water rights. This may be increased to JD 40 per dunum in the future to help cover water-related investments.

APPENDIX K
TRANSPORTATION

This appendix presents transportation statistics for the seven districts and eighteen major roads within the impact area. Three of the seven districts are essentially urban: Amman, Zarqa-Ruseifa and Irbid City; the remaining four are rural. Population for each district was determined from the 1975 Census by Wilbur Smith Associates, as were the economic figures which were derived from the Department of Statistics. Trip ends, average daily traffic and traffic composition were measured directly by Smith Associates for the Master Road Plan Study.

Statistics representing the present status of factors relevant to transportation planning are given in Table K-1 by district. Car ownership is highly skewed towards the urban districts with 76% of the total. Industrial production is located predominantly in the Zarqa-Ruseifa and Balqa districts. Agricultural production occurs mainly in the Jordan Valley (58%) and Irbid District (29%).

Smith Associates developed a model to predict future transportation demands. The factors they used were based in part on the information from the National Planning Council, the JVA and in part from observed trends and statistics. Future values for the variables given in Table K-1 are presented in Table K-2 as are the increase factors for each by district. Although population is expected to increase by a factor of 2.6, car ownership is expected to increase by 13.7. Automobiles owned in the Jordan Valley will increase to over 20 times the present number. Industrial production is predicted to jump by a factor of 8, while agricultural production will almost double. Road transportation, as represented by trip ends will at least double on most roads.

Average Daily Traffic (ADT) and traffic composition on roads in the impact are shown in Table K-3. It must be emphasized that the ADT's are averaged over the road's length and do not represent the actual travel on each kilometer of a given road.

Table K-1

"Present" Statistics

District	Population (1975)	Trip Ends 1976	Private Cars 1976	Agricultural Production 1975[1]	Industrial Production 1974[1]
North Valley	44,162	1,920	421	104.2	-
South Valley	30,446	3,327	276	91.8	-
Irbid City	127,796	21,490	2,441	4.1	171.6
Irbid District	351,132	20,651	3,760	98.3	24.3
Mafraq District	26,779	3,051	249	3.8	0.4
Balqa District	146,315	31,894	1,713	29.7	719.1
Amman City	654,422	67,566	12,547	7.8	265.2
Zarqa-Ruseifa	283,397	22,778	5,413	1.0	1,088.5
Totals	1,664,449	-	26,820	340.7	2,239.1

[1]In thousands of tons.

Source: Wilbur Smith Associates, 1978.

Table K-2

Projections and Factor of Increase (Fi) for 2000

District	Population	F_1	Trip Ends	F_2	Cars Owned	F_3	Agri. Prod'n[1]	F_4	Ind. Prod'n[1]	F_5
North Valley	117,029	2.65	4,435	2.31	8,546	20.3	176.1	1.69	-	-
South Valley	103,820	3.41	8,318	2.11	7,286	26.4	223.9	2.45	-	-
Irbid City	382,110	2.99	43,194	2.07	32,221	13.2	6.77	1.65	608.4	3.5
Irbid District	863,785	2.46	43,574	2.11	62,416	6.6	162.2	1.65	4,332.3	178.4
Mafraq District	63,820	2.38	7,293	2.39	4,173	16.8	3.5	.92	1.2	3.0
Balqa District	399,439	2.73	71,123	2.23	29,464	17.2	49	1.65	2,545.5	3.5
Amman City	1,662,232	2.54	139,292	2.07	140,526	11.2	12.6	1.62	3,754	14.1
Zarqa-Ruseifa	719,828	2.54	10,393	1.92	60,626	11.2	1.6	1.60	3,720.4	6.36
Totals	4,312,063	2.6			367,905	13.7	635.7	1.87	17,961.9	8.02

[1]In thousands of tons.

Source: Wilbur Smith Associates, 1978.

Table K-3

Average Daily Traffic (ADT) and Traffic Composition
On Roads in the Impact Area

Route #	Name/Description	ADT [2]	Composition - In Percent		
			Autos	Light Trucks	Heavy Trucks
15 [1]	Upland Highway	3227	52.7	18.9	28.4
45 [1]	Yarmouk-Dead Sea Road	1084	54.2	33.9	11.9
16 [1]	North Valley Connector	2850	86.6	26.6	16.8
20 [1]	Mid-Valley Connector	1424	43.2	38.5	18.3
24 [1]	South-Valley Connector	2022	68.8	19.5	11.7
30 [1]	Amman-Jerusalem Highway	1803	46.5	28.8	24.7
48	South Valley Alternate	976	67.1	22.9	10
11 [1]	Irbid-Zarqa Road	1885	52.5	16.6	30.9
12	Yarmouk Road	113	76	20	5
19	Ramtha Road	488	63	21	6
23	Irbid Ajlun Road	1382	62.7	21	5.3
25 [1]	Amman Bypass	3260	60.6	23.6	15.8
26 [1]	Amman-Suweileh Road	5737	74	19.0	7.0
27 [1]	Amman Zarqa Road	8859	60	25	15
33	South Valley Road	377	65	30	5
37	Mid-Valley Road	378	76.7	18.3	5
41	North-Valley Road	1105	78	17	5
70 [1]	Amman Bypass	3453	4.7	23.8	4.5

1 Primary Road, The rest are Secondary Roads
2 Weighted Average

Source: Wilbur Smith Associates, 1978.

APPENDIX L

INSTITUTIONAL ANALYSIS AND DEVELOPMENT

Compared with the amounts of money and talents which have been devoted to planning and building physical structures, little seem to have been directed toward developing the organizations needed to operate, manage, and benefit from them. This oversight is not peculiar to Jordan or the JVA; for example, a recent and comprehensive analysis of development in Arab nations reported a notable lack of published materials on public administration.[1] But as the initial phase of building dams, canals, and villages nears its end, questions of how best to operate, manage, and allocate the benefits of these infrastructure facilities will inevitably grow clearer and more important. As this occurs, policy analysts, planners, and managers will be helped by knowing of recent efforts and resources. A number identified during this Environmental Assessment study are described below.

U.S. AID sponsored in the mid-1960s a three-year "Public Administration Improvement Project in the Hashemite Kingdom of Jordan" by the U.S. firm of Griffenhager-Kroeger, Inc. (Contract AID/NESA-182, Project 278-11-790-083). About 20 studies recommended a multitude of steps, major and minor, to improve the civil service generally and several ministries in particular. These studies focused less on policy issues than on routine, but important, management problems common to government agencies everywhere, such as organization structure, personnel practices, and budget and finance. To what extent the recommendations were adopted, and whether some may still be valid, is not known. However, they may contain benchmark data useful for reviewing and undertaking changes in Jordanian agencies today. The following titles, available through U.S. AID's Office of Development Information and Utilization (General Document Number JO 354.5695 G849), seem most relevant to public administration questions raised by development of the Jordan Valley:

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[1]Sayigh, Yusif A., The Economies of the Arab World: Development since 1945, New York: St. Martin's Press, 1978, p. 157, no. 51.

- Administration of Education in Jordan; July 1966, 103 p.
- Administration Review of the Ministry of Interior, the Ministry of Municipal and Rural Affairs, January 1966, 44 p. Appendix.
- Final Report on the Public Administration Improvement Project in the Hashemite Kingdom of Jordan, 1965-1968, September 1968, 81 p.
- "The Main Thrust" Toward Further Public Administration Improvement in Jordan, August 1966, 56 p.
- Organization and Operation Review of the Ministry of Finance, September 1968, 49 p.
- Organization Review and Recommendations on the Ministry of Information, 1966, 45 p.
- Program for Improving the Civil Service and Personnel System of the Government of Jordan, May 1966, 87 p.
- Recommendations for Efficient Utilization of Current Budget and Accounting Systems of the Government of Jordan, December 1965, 36 p.
- Report on Data Processing in Jordan, 1966, 81 p.
- Review of Organization and Administration of the Ministry of Agriculture, March 1967, 154 p.
- Review of the Organization and Administration of the Ministry of Public Works, July 1966, 84 p.

The Jordanian Institute of Public Administration (JIPA) was established in 1968, with assistance from the Ford Foundation, to provide research, advisory, and training services to Jordanian agencies. Today, JIPA is an independent institution affiliated with and located on the campus of the University of Jordan. Its Board is chaired by the President of the Civil Service Commission, Dr. M. Nuri Shafiq, and includes representatives from the Prime Ministry, Government, and the University. Its Director in recent years has been Dr. Abdulla Zoubi, a specialist in training, who was scheduled in April 1979 to move to Cairo to begin his four-year appointment as Director-General of the Arab Organization of Administrative Sciences. Its Deputy Director is Mr. Abdulla Elyaan. JIPA's staff was generous in responding to the few requests made to it during this environmental assessment study, and would no doubt be a major source of help in further efforts to understand and encourage

improvements in public administration

Several papers which discuss, in Arabic, Jordan's public administration context are:

- Shafiq, M. Nuri, Administrative Ecology of Jordan, Amman: JIPA, 1969, about 50 pp., mimeo.
- Zoubi, Abdulla, Approach Towards Administrative Development in Jordan, Amman: JIPA, May 1977, 28 pp., written for Crown Prince Hassan.
- Rahman, Ahmad Abdul, Tahir Mursi Attiyah, and Abdulla al-Zughbi, A Study of the Jordanian Kingdom, prepared for the Second Arab Conference on Regional Administration to discuss Relations between the Central Government and Local/Regional Authorities, Damascus, September-October, 1972, 50 pp., mimeo, available from JIPA.
- Saub, Abdulla, and Abdulla Zoubi, Administration of Municipal and Village Councils in Jordan, prepared for Third Arab Conference on Regional Administration, Amman, March, 1975, 75 pp., mimeo, available from JIPA.
- Jordan Institute of Public Administration, Present Organization of Public Administration Agencies in Jordan, Amman: JIPA, 1969, ca. 300 pp.; reportedly Jordan's latest government organization manual.
- Arab Organization of Administrative Sciences, Report and Recommendations of the First Annual Conference on Administrative Development in the Arab World, Riyadh, 1978, 17 pp., available from JIPA.

Laws and regulations guiding regional and local administration have been compiled, in Arabic, in:

- Nabeel, Shafeeq, Encyclopedia of Jordanian Legislation, Amman: Jordan Bar Association.
- Ministry of Interior, System of Administrative Divisions, 1972-77, Amman, Ministry of Interior, Dept. of Development, November 1, 1977.

Several publications useful for discussions of generic questions of managing large-scale irrigation projects are:

- American Society of Civil Engineers, "Irrigation's Benefits: Miracle or Mirage?", in Civil Engineering, August 1978, pp. 60-75.

- Fernea, Robert A., Shakh and Effendi: Changing Patterns of Authority Among the El Shabana of Southern Iraq, Cambridge, Mass: Harvard University Press, 1972, 225 pp. Focuses on roles and relationships between a tribal chief and a government irrigation engineer managing the local canal system.
- U.N. Economic Commission for Europe, River Basin Management, New York: U.N., 1971, 101 pp. UN Sales Number E.70.II.E.17. Papers and proceedings of the Seminar of ECE's Committee on Water Problems, London, June 1970; contains substantial discussions of approaches of Eastern and Western European countries and the Unites States, organized under three headings--planning, institutional arrangements and financing, and operational control of water flow and water quality.
- World Bank, Agriculture and Rural Development Department, Management and Organization of Irrigation Projects, Research Study No. 671-34, executed by Overseas Development Institute, London; supervised by Frederick L. Hotes of World Bank; forthcoming.

U.S. AID is reviving its capabilities for helping developing countries improve their public administration, especially in rural areas. The Bureau of Development Support, Office of Rural Development and Development Administration, is preparing to have available, by early 1980, applied research and consulting services in six topics, including administration of public works programs and managing decentralization. Dr. Norman Nicholson is the Office's Deputy Director for Institutional Development.

The United Nations is said to have provided public administration experts on missions of several weeks each occasionally since the mid-1950s. The Ford Foundation has reportedly sponsored assistance projects to develop both public administration and social science research capabilities.