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ZARQA RIVER WATER CONSERVATION AND QUALITY IMPROVEMENT

HWARAT TO ABU ZEIGHAN CONVEYOR PROJECT

ENVIRONMENTAL ASSESSMENT

Harza Engineering Co.

MARCH 1996

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DEFINITION OF TERMS USED IN THIS REPORT

BOD	Biological Oxygen Demand (in mg/L over a 5-day period at 25°C)
DA	Irrigation Development Area
DEA	Draft Environmental Assessment
dS/m	deci-Siemens per meter. Unit of measure of Electro-Conductivity commonly used in agriculture. 1.0 dS/m is equivalent to 1.0 mS/cm (milli-Siemens per centimeter) or 1.0 mmho/cm (milli-mhos per centimeter), which are commonly used in water quality studies.
du	dunum. A unit of area measure equal to 0.1 hectares.
EC	Electro-conductivity. A measure of how readily a medium (e.g., water, soil) will conduct an electrical current. This measure is related to salinity, which is the total concentration of major cations and anions in a medium. Relative to the use of the terms "EC" and "salinity" in this document, they are interchangeable.
ISPAN	Irrigation Support Project for Asia and the Middle East, U.S. Agency for International Development
JVA	Jordan Valley Authority, Ministry of Water and Irrigation
KAC	King Abdullah Canal
KAC-n	KAC north of the confluence with the Abu Zeighan Canal
KAC-s	KAC south of the confluence with the Abu Zeighan Canal
km	kilometer
KTD	King Talal Dam
L/s	Liters per second. Equivalent to 0.001 m^3/s.
m	meter
m^3/s	Cubic meters per second. Equivalent to 1,000 L/s.
mg/L	Milligrams per liter. (equivalent to "parts per million")
Mm^3/yr	Million cubic meters per year.
USAID	United States Agency for International Development
ZC I	Zarqa Carrier I. An irrigation pipeline originating at Thahab Weir.
ZC II	Zarqa Carrier II. An irrigation pipeline originating at Thahab Weir.

FY 1996-2-Jordan

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1. SUMMARY

The Proposed Action is construction of a 3.7 km pipeline to divert water from the Zarqa River at Hwarat Weir and convey that water to the canal that originates at Abu Zeighan Weir, approximately 4.7 km downstream of Hwarat. The pipeline will prevent mixing of irrigation water, released at King Talal Dam (KTD), and saline water originating from springs and seeps along the Zarqa River channel between Hwarat and Abu Zeighan Weirs. Recently, mixing of saline spring water with low-volume irrigation releases from KTD has caused damage to and loss of fruit trees in the Southern and Middle Jordan Valley irrigation districts that are served by the King Abdullah Canal (KAC) south of its confluence with the Abu Zeighan Canal.

The primary, directly-affected area is known as the 18 km Extension Project, which comprises 36,915 dunums (3,692 ha) of irrigated lands in the Southern Jordan Valley. Additional irrigated lands in the Middle Jordan Valley, totalling approximately 5,500 dunums (550 ha), are also directly affected by salinity of water in the KAC south of the Abu Zeighan Canal. The 14.5 km Extension Project, comprising 59,750 du (5,975 ha) in the Southern Jordan Valley will be indirectly affected by the project.

The Proposed Action will affect agricultural lands and dwellings along the 3.7 km pipeline alignment, a 4.7 km segment of the Zarqa River above Abu Zeighan Weir and a 17 km segment of the Zarqa River below Abu Zeighan Weir. Land use and habitations will be affected by construction and operation of the Proposed Action. During construction, up to 16.3 du (1.6 ha) of lands that were under cultivation during 1996 will be disrupted by construction activity. This impact can be mitigated by scheduling construction during the summer and early fall months. Six dwellings are located within 50-100 m of the pipeline construction area. Construction effects on dwellings will be limited to dust generated by construction activities, which will be short-lived. Operation of the Proposed Action will occupy approximately 1.1 du (0.1 ha) of land that was under cultivation during 1996.

Flow in the Zarqa River channel between Hwarat Weir and Abu Zeighan Weir will be reduced by diversion of substantially all streamflow at Hwarat Weir. Operation of a settling basin at the pipeline headworks may result in a small flow (estimated at up to 20 L/s) being released downstream from the weir. The streambed for 1.5 km below Hwarat Weir will be

subject to dessication. The remaining 3.2 km segment between Hwarat Weir and Abu Zeighan Weir will be subject to inflows of 150-300 L/s from saline springs. Saline spring waters have a mixed Electro-conductivity (EC - a measure of salinity) in the 7 - 9 dS/m range. Downstream from Abu Zeighan Weir, flows in the river channel will increase under the Proposed Action because saline spring water, which, at present, is partially mixed with irrigation water from KTD, will no longer be diverted from the Zarqa River channel at the weir.

≠ 7-9 units

Water quality in the areas irrigated from the KAC south of its confluence with Abu Zeighan Canal will be improved by operation of the Proposed Action. An analysis of water quality data for a five year period beginning in September 1990 indicates that the project would have reduced the five-year average salinity of irrigation water by 0.4 dS/m. Substantial improvements in salinity would have occurred in 1994 and 1995 while small improvement would have occurred in 1991 and 1992.

The Proposed Action will affect habitat for aquatic life, vegetation in and adjacent to the stream channel, and, due to its effects on vegetation and aquatic life, habitat for resident and migratory birds. Aquatic life would be virtually eliminated in the 1.5 km "freshwater" river segment below Hwarat Weir due to curtailment of flows; however, the present aquatic fauna is affected by extremely poor water quality and diversity is likely low. The aquatic fauna in the 3.2 km "brackish" segment, affected by saline springs, would likely benefit from project operation because channelization of the streambed for a distance of 2.5 km (a measure intended to partially separate saline inflows from irrigation water) would no longer occur, salinity and flow conditions would be stabilized and nutrient loadings would be substantially reduced. Vegetation in the freshwater segment would also likely be reduced in density and diversity as a result of the loss of flow in the channel; however, conditions in the brackish segment would likely improve because vegetation would not be removed during channel maintenance activities. The area between Hwarat and Abu Zeighan Weirs would likely lose some of its attractiveness as migratory and resident bird habitat as a result of the proposed action. Mitigation in the form of a small continuous minimum flow release (20 L/s) to the channel below Hwarat Weir would likely maintain invertebrate aquatic life in the segment immediately below the weir. A minimum flow would also help maintain vegetation diversity and habitat quality for migratory birds at levels near those available at present.

from effluent

Offset in resident area?

The Proposed Action will affect human uses of the river channel between Hwarat Weir and Abu Zeighan Weir. Project operation will affect two farms that irrigate using water directly from the river channel. Water quality changes potentially will affect water quality for livestock use. There will be little effect on use of Zarqa River water for bathing and washing. The supply of water for irrigation at the farms using water directly from the channel will be unreliable. Water quality for livestock use is typically considered "very satisfactory" (EC < 5.0 dS/m), although periodic reductions in qualtiy to "satisfactory" (EC 5 - 8 dS/m) or "limited use" (EC 8 - 11 dS/m) levels occurs. During project operation, livestock water quality will remain in the borderline area between the "satisfactory" and "limited use" levels. Pastoralists may have to travel approximately one kilometer to reach channel areas with flowing water. Provision of a minimum flow will provide a reliable supply of irrigation water and slightly reduce salinity in the brackish water segment.

At present, it is believed that the project will not affect any areas having antiquities or cultural artifacts. It will be necessary to confirm this on the basis of field reconnaisance.

The Proposed Action will result in substantial economic benefits to the areas irrigated from the KAC south of its confluence with the Abu Zeighan Canal. Based on a retrospective analysis of water quality, cropping and economic data, the impact of the project on the 18 km Extension area would have averaged between 480,000 and 1,100,000 JD/yr during the period 1991 to 1995. The five-year average includes both "wet" years when benefits would have been low, and "dry" years when benefits would have been substantial. The range in economic benefits reflects the effects of data on differences in cropping patterns and economic returns between years during the study period. Benefits to areas outside the 18 km Extension Project that will be directly and indirectly affected by the Proposed Action would likely increase the estimated total project benefit to somewhere in the range of 800,000 to 1,800,000 JD/yr during 1991 to 1995.

2. INTRODUCTION

The United States Agency for International Development (USAID) is supporting investments to assist the Government of Jordan in improving the management and conservation of water resources. As a part of this assistance, the Jordan Water Quality Improvement and Conservation Project (WQIC) was initiated under Contract No. 278-0288-C-00-4026-00, between Development Alternatives, Inc. and USAID. half (see pg 7)

The Zarqa River Conveyance Study was included as a part of the WQIC program to evaluate the potential for improving the conveyance efficiency of water released from King Talal Dam (KTD) and the quality of water diverted from the Zarqa River at Abu Zeighan Weir. The water released at KTD is reclaimed municipal and industrial waste water intended for use in irrigated agriculture in the central and southern Jordan Valley. The objective of this Draft Environmental Assessment (DEA) is to assess the environmental impacts of the proposed project and selected alternatives for improvement of conveyance and water quality. The "no-action" alternative is a member of the set of alternatives considered in this DEA.

Environmental assessment of the project is being carried out under applicable U.S. regulations for USAID funded projects. This has involved conducting a Scoping Session where interested and affected parties were asked to comment on the potential environmental consequences of undertaking the proposed project and to identify issues that require analysis during preparation of the Environmental Assessment. The Scoping Session resulted in a Scoping Statement that identified those environmental issues on which this DEA will focus. For the purposes of the DEA, the term "environment" includes the natural environment, the social environment and the economic environment.

2.1 OBJECTIVES

The objectives of this DEA are the following:

- Provide a brief specification of the need for the project.
- Identify the alternatives being considered in the DEA, including the proposed project and the "no-action" alternative.
- Describe the environment or areas that will be affected by the alternatives under consideration.
- Describe the environmental consequences of undertaking any of the alternatives, including direct and indirect effects, and possible mitigation measures.
- Identify monitoring required to measure changes in environmental quality resulting from implementation of the proposed project.

2.2 PROJECT SETTING

The project is located in the lower part of the Zarqa drainage basin in hilly terrain at the edge of the Jordan Valley at elevations ranging from -115 m (Thahab Weir) to -236 m (Abu Zeighan Weir). The floodplain at the upper end of the project area is narrow with extremely steep slopes rising to elevations of 150 m or more above the river bed on both sides of the river. The floodplain becomes broader downstream, particularly on the right (north) bank of the river. The river generally remains close to the base of the hills on the left (south) bank as it passes through the village of Abu Zeighan at the downstream end of the project area.

The flow in the river is controlled by KTD, approximately 11.5 km upstream of the Thahab Weir. Releases are made from KTD to support irrigated agriculture. The water released is passed through hydroelectric generators at the dam. Hydraulic capacity of the generation facility at KTD is 6,300 liters per second (L/s[1]). At Thahab Weir, flows of up to 2,770 L/s are diverted into irrigation pipelines, referred to as Zarqa Carrier I (ZC I) and Zarqa

[1] Liters per second. Equal to 0.001 cubic meters per second (m^3/s).

Carrier II (ZC II). ZC I and ZC II have design capacities of 1,000 and 1,770 L/s, respectively. ZC I supports irrigation along the river (usually along the right, or north, bank) between Thahab Weir and Abu Zeighan village. Any water remaining after the diversion at Thahab Weir flows downstream about 9.9 km to the Abu Zeighan Weir, where it is diverted into the King Abdullah Canal (KAC) through the Abu Zeighan Canal.

Hwarat Weir is located approximately 5.2 km downstream of Thahab Weir. The weir and a small canal beginning at the weir have been abandoned. Between Hwarat Weir and Abu Zeighan Weir are a number of saline springs that enter the river. Inflow from the springs is approximately 150-300 L/s.

The KAC is considered to comprise two sections, the KAC-s, south of the confluence with the Abu Zeighan Canal, and KAC-s, north of that confluence. The KAC-n carries water from the Yarmouk River in the north, which is a high quality source suitable for irrigation and municipal industrial use. The water in the KAC-s is a mixture of Zarqa River water and Yarmouk River water. The Zarqa water is of lower quality than Yarmouk water. The mixture is usually suitable for irrigation with slight to moderate restriction. During periods of low flow both in the Zarqa River and in the KAC-n , water quality in the KAC-s may be degraded by saline inflows to levels where it is unsuitable for most crops. This project was developed in response to the need to maintain suitable water quality in the KAC-s.

2.3 BACKGROUND

Since the latter part of the 1970's, the Jordan Valley Authority (JVA) has suspected that some portion of the irrigation water released at KTD was not reaching the KAC. Studies by the JVA, and others, were conducted during the 1980's to quantify losses and identify the river reaches in which losses were occurring. The most recent studies were conducted in 1994 by the University of Jordan and ISPAN (Irrigation Support Project for Asia and the Near East - USAID). These studies supported the need for additional study of Zarqa River channel efficiency.

Harza[2] reviewed conveyance and water quality information and conducted water quality and conveyance studies in 1995. Harza concluded that there is no water quality deterioration and that conveyance losses are not appreciable (in fact, some gains may occur) between KTD and Thahab Weir; water quality is unchanged and small losses or gains possibly occur between Thahab Weir and Hwarat Weir; and some conveyance losses are possible and water quality deterioration (due to saline springs) occurs between Hwarat Weir and Abu Zeighan Weir. Water quality deterioration affects the suitability of water for use in irrigated agriculture, the primary use for which the water is intended.

Water quality in the KAC has deteriorated in recent years. This has been due primarily to reduced availability of high quality Yarmouk River water for mixing with water released at the KTD. Yarmouk River water is diverted to Amman for municipal and inducstrial use from the KAC north of the confluence with Abu Zeighan Canal (which conveys KTD water to the KAC from Abu Zeighan Weir). By itself, KTD water is of marginal quality for irrigation use. The source of approximately half of the water released at KTD is partially treated municipial and industrial wastewater from metropolitan Amman and Zarqa. In dry years, when runoff from natural rainfall in the Zarqa River Basin is limited, the monthly average electro-conductivity (EC) of water released at KTD may exceed 2.5 dS/m[3], a level at which growth of moderately tolerant crops may be adversely affected. The quality of KTD water reaching the KAC is further degraded by saline springs and seeps in the reach of the river above Abu Zeighan Weir. Recently, during periods of low releases from KTD, only Zarqa water has been available to the KAC below the Abu Zeighan Canal because Yarmouk water has been completely abstracted for municipal, industrial and upstream irrigation use.

≈250 µmhos/cm

During 1993 and 1994, high salinity of undiluted Zarqa water resulted in reduced crop yields and loss of some 10,000 citrus trees in the southern Jordan Valley. Low releases from KTD mixed with saline spring water in the Zarqa above Abu Zeighan Weir. Diversion of this water to the KAC, when undiluted by Yarmouk water, resulted in high salinities in the KAC

[2] Harza Engineering and Consolidated Consultants. 1996. Zarqa River Conveyance Study, Phase A - Conceptual Study, Part 3 - Selection of Preferred Alternative. Final Report.

MICRO · SIEMENS

[3] dS/m (deci-Siemens per meter) is a measure of conductivity equivalent to mS/cm (milli-Siemens per centimeter) or mmhos/cm (milli-mhos per centimeter). dS/m is generally used to report conductivity in agricultural studies.

µmhos = MICRO-MHOS

— Think the problem w/ the conversion

during summer 1994 (May - October EC 2.02 - 3.67 dS/m; average 2.74 dS/m[4]). The deterioration in quality caused by the salt springs, in combination with the lack of Yarmouk water for mixing, has resulted in water quality in the KAC that has proved detrimental to crops, especially citrus and fruit trees.

[4] Water and Environment Research and Study Center - University of Jordan. 1995. Irrigation management & water quality in the Central Jordan Valley (Baseline Survey). Water Quality Improvement and Conservation Project, Report 3114-95-3b-05.

3. PROJECT PURPOSE

The purpose of the project is to improve the quality of water delivered to the KAC via the Abu Zeighan Canal by separating saline inflows from lower salinity water released at KTD. Improvements in water quality are expected to improve agricultural yields in the area irrigated from the KAC south of the Zarqa River.

4. ALTERNATIVES INCLUDING THE PROPOSED ACTION

During the first phase of the project, a number of conceptual alternatives were originally proposed to improve conveyance and quality of water released at KTD. The focus of the project became water quality and water loss in the area between Hwarat Weir and Abu Zeighan Weir when it was determined that conveyance was acceptable and that deterioration of water quality did not occur in the Zarqa River channel upstream of Hwarat Weir (Figure 4-1). The alternatives originally considered included construction of a pipeline from KTD to Abu Zeighan Canal; construction of a pipeline diversion to bypass certain reaches of the channel; improving the river bed; constructing a deep cutoff wall in the channel; constructing a canal to bypass certain reaches of the channel; and preventing saline spring flow from entering the river channel. In addition, power generation features (construction of a powerhouse and, possibly, a reregulating reservoir) were considered for incorporation into the pipeline alternatives.

Several of the above alternatives were dropped from consideration when information, developed during the conceptual phase of the study, indicated that they were unnecessary, too costly, ineffective or impractical. All alternatives (including the Proposed Action) retained for consideration involve construction of a pipeline or canal-pipeline combination to divert KTD water from the Zarqa River channel at Thahab or Hwarat Weir. Diverted water will be bypassed around the area of saline springs and conveyed to the head of the Abu Zeighan Canal.

Environmental effects of the proposed action and the feasible alternatives on the area irrigated from the KAC-s will be equivalent. Compared to the "no-action" alternative, there will be considerable benefits to irrigated agriculture along the KAC-s. The magnitude of potential negative impacts for the various alternatives is largely dependent on the point of origination of the flow diversion (Thahab or Hwarat Weir) and the amount of construction required for each alternative.

4.1 PROPOSED ACTION

The proposed action involves rehabilitation of Hwarat Weir and construction of a 3.7 km long, 1.4 m diameter, ductile iron pipeline from Hwarat Weir to the head of Abu Zeighan

Canal (Figure 4-2). The pipeline will follow the course of an abandoned canal that originates at Hwarat Weir for approximately 0.5 km to the edge of the river, cross the river on a bridge (the aqueduct for the abandoned canal is occupied by the ZC I pipeline), and continue to follow the canal alignment for approximately 1.3 km. The pipeline will diverge from the canal alignment and continue about 0.7 km alongside an existing roadway to a point just downstream of Abu Zeighan Bridge. The pipeline will cross the river at this point, follow an existing farm road along the foot of the hill on which the village of Abu Zeighan is located and continue in the river floodplain along the base of the escarpment southwest of Abu Zeighan village. The pipeline would terminate at the Abu Zeighan Canal approximately 1.1 km from the river crossing.

Rehabilitation of Hwarat Weir will be required for the Proposed Action, thus requiring disruption of the streambed and use of land for construction lay-down areas in the vicinity of the present weir. Desanding of water conveyed by this alternative will be necessary. Desanding will be accomplished using a settling basin 7 m wide by 34 m long.

The proposed alignment passes within 100 m of six dwellings. The alignment is accessible from existing roads throughout most of its length. Cultivated areas occur within 100 m of the pipeline for most of its length. The proposed alignment will pass within 100 m of three citrus orchards.

Construction will affect areas that are presently being cultivated. The area required for buried pipeline construction will include the trench, a lay-down and work area adjacent to the trench and an area, also adjacent to the trench, for temporary storage of excavated materials during pipeline installation in the trench. Excavated materials will be used to backfill the trench after the pipeline has been installed. The width of the area affected will be about 10 m, typically centered on the axis of the pipeline. This area of 16.3 du[5] may not be available for planting during one cropping season. There are presently no plans to remove fruit trees for pipeline construction.

The canal alignment is generally unoccupied, although it has been filled and planted in a few areas. The canal presently occupies approximately 2.7 du of land in cultivated areas.

[5] du is the abbreviation for dunum. One dunum is equal to 0.1 hectares or 0.247 acres.

Construction of the pipeline alternative would require that approximately 0.9 du land be permanently removed from production beyond that which is presently occupied by the canal.

Dust from construction activity can affect crops by covering leaves and flowers; thus reducing growth and fruit production. The location of the pipeline alignment adjacent to paved roads will help reduce dust generated by construction traffic. Construction will typically require a month from excavation to backfilling for any given segment of the pipeline; thus, dust generation in any specific location will be short-lived.

The Proposed Action will divert water from approximately 4.7 km of river channel between Hwarat and Abu Zeighan Weirs. There are at least two irrigation withdrawals along the left bank of the river in this segment. Approximately 1.5 km can be described as freshwater habitat and the remainder as brackish. The freshwater habitat will be affected significantly by dessication, and appreciable loss of emergent aquatic vegetation (sedges, rushes and cattails) is expected. It is likely that plant species better adapted to periodic wet conditions, such as oleander, tamarix and common reed, will replace the aquatic vegetation.

Note: Not natural w/ flow control

Effects on the brackish habitat will be less pronounced as inflow from saline springs will be maintained; however, transitional freshwater-brackish habitat will be lost and salinity will increase and remain relatively constant in remaining habitat. Compared to the No-Action Alternative, channelization of 2.4 km of the streambed will no longer occur and a more natural riparian and aquatic community, adapted to brackish conditions, may develop.

Dessication in the stream channel and riparian zone will likely result in a general loss of vegetation in the stream channel in the area considered to be freshwater habitat. Emergent aquatic vegetation will likely disappear and this will reduce the habitat value for some types of wading birds and shorebirds. The cover value of the tamarix and oleander will likely be retained and the habitat will remain suitable for migrating and resident songbirds and roosting by many species.

Dessication will eliminate fish populations and most aquatic invertebrates (including crabs) from the freshwater zone. Use of the area by amphibians will be limited. Species able to opportunistically make use of ephemeral pools left after rainfall or high flow events will likely persist. The loss of freshwater aquatic fauna will reduce the suitability of this area for foraging by kingfishers and wading birds. In the brackish area, the springs will maintain

sufficient flows to support a diverse aquatic fauna, including fish, that are adapted to brackish conditions.

All flow from the saline springs will be allowed to pass Abu Zeighan Weir and continue downstream to the Jordan River.

4.2 NO-ACTION ALTERNATIVE

The No-Action Alternative would continue operation of irrigation facilities supporting agriculture in the 18 km Extension Project area of the southern Jordan Valley (Figure 4-1) without reducing the salinity of water delivered to farmers. Flows in the Zarqa River downstream of Thahab Weir, which are presently controlled for agricultural purposes, would not be altered. In the segment between Thahab and Abu Zeighan Weirs flows would vary between near zero and 4.5 m^3/s depending on irrigation requirements along the KAC-s. Complete dessication of 2.3 km of the channel immediately below Thahab weir would occur annually. Minimal flows would enter the river from the settling basin overflow (10-20 L/s) approximately 2.3 km below Thahab Weir during periods when no irrigation water was required. Diversion of most flow from the Zarqa River would occur at Abu Zeighan Weir. The 17 km river reach below Abu Zeighan Weir would receive some diverted saline spring flows from upstream (approximately 80 L/s with an EC of 7-9 dS/m).

4.3 FEASIBLE ALTERNATIVES TO THE PROPOSED ACTION

4.3.1 Canal-Pipeline Combination

This alternative would involve rehabilitation of Hwarat Weir, demolition and reconstruction of the abandoned canal from Hwarat Weir for a distance of approximately and construction of a pipeline from Hwarat Weir to the head of Abu Zeighan Canal (Figure 4-3). The canal would follow the course of the abandoned canal that originates at Hwarat Weir for approximately 2.0 km. At this point a pipeline would be constructed along the same alignment as that of the Proposed Action for the remaining 1.7 km to Abu Zeighan Canal.

The proposed alignment would pass within 100 m of six dwellings. The alignment would be accessible from existing roads throughout most of its length. Cultivated areas occur within

100 m of the canal-pipeline alignment for most of its length. The proposed alignment would pass within 100 m of three citrus orchards.

Construction would affect areas that are presently being cultivated. The area required for buried pipeline construction will include the trench, a lay-down and work area adjacent to the trench and an area, also adjacent to the trench, for temporary storage of excavated materials during pipeline installation in the trench. Excavated materials will be used to backfill the trench after the pipeline has been installed. The width of the area affected will be about 10 m, typically centered on the axis of the pipeline. This area of 16.3 du of land that was under cultivation during winter 1996 might not be available for planting during one cropping season. There would be no plans to remove fruit trees for pipeline construction.

The canal alignment would be generally unoccupied, although it has been filled and planted in a few areas. The abandoned canal presently occupies approximately 2.7 du of land in cultivated areas. Construction of the canal-pipeline alternative would require that approximately 2.9 du land be permanently removed from production beyond that which is presently occupied by the canal.

The impacts from construction and operation of this alternative would be of similar magnitude to those expected for the Proposed Action.

This alternative has the advantage of having a lower construction cost than the Proposed Action; however, maintenance costs will be higher. This open canal construction also has the disadvantage of being more susceptible to adverse effects from various types of accidents such as, spills of pesticides or fertilizers or illegal disposal of waste materials. JVA prefers the use of pipelines for this type of project. Thus the Proposed Action was selected over this alternative despite its lower initial cost.

4.3.2 Pipeline from Thahab Weir to Abu Zeighan Canal

This alternative would involve expansion of the settling basin at ThahabWeir, and construction of a 6.6 km pipeline from Thahab Weir to the head of Abu Zeighan Canal (Figure 4-4). The pipeline would generally parallel the course of ZC 11 for the first 3.9 km. At this point a pipeline would be constructed along the same alignment as that of the Proposed Action for the remaining 1.7 km to Abu Zeighan Canal.

Cultivated areas occur within 100 m of the canal-pipeline alignment for most of its length. The proposed alignment would pass within 100 m of three citrus orchards.

Construction would affect areas that are presently being cultivated. The area required for buried pipeline construction will include the trench, a lay-down and work area adjacent to the trench and an area, also adjacent to the trench, for temporary storage of excavated materials during pipeline installation in the trench. Excavated materials will be used to backfill the trench after the pipeline has been installed. The width of the area affected will be about 10 m, typically centered on the axis of the pipeline. This area of 22.6 du of land that was under cultivation during winter 1996 might not be available for planting during one cropping season. It is likely that 0.3 du of olive trees would be removed during pipeline construction. Construction of the canal-pipeline alternative would require that approximately 7.3 du land be permanently removed from production.

This alternative would affect approximately 9.9 km of river channel between Thahab and Abu Zeighan Weirs. There are at least three irrigation withdrawals along the left bank of the river in this segment. Approximately 6.7 km can be described as freshwater riparian and aquatic habitat and 3.2 km can be described as brackish habitat. The freshwater habitat would be affected significantly by dessication and appreciable reduction of littoral vegetation is expected. Effects on the brackish habitat would be less pronounced as inflow from saline springs would be maintained; however, transitional freshwater-brackish habitat would be lost and salinity would increase in the remaining habitat. Compared to present conditions, channelization of 2.4 km of the streambed would no longer occur and a more natural riparian and aquatic community, adapted to brackish conditions, may develop.

This alternative would affect 5.2 km of freshwater aquatic and riparian habitat in addition to that which would be affected by the proposed alternative. Effects on the area downstream of the Abu Zeighan Weir and in the areas irrigated from the KAC-s would be equivalent to those that will occur with the Proposed Action.

This alternative was retained for consideration in the event that geotechnical or other information developed during the final design stage indicated that Hwarat Weir could not be rehabilitated in a cost-effective manner. This alternative has higher construction costs (which are a function of the pipeline length) and would have greater negative impacts on habitat and biota in the Zarqa River channel without offering any increase in benefits.

4.4 COMPARISON OF ALTERNATIVES

This Section compares the environmental effects of Proposed Action and the feasible alternatives, including the No-Action Alternative, and the Proposed Action with recommended mitigation. The areas of comparison include construction effects, effects on flow in three, potentially-affected segments the Zarqa River, effects on water quality in the Zarqa River and the KAC; effects on aquatic life, channel and riparian vegetation, and migratory/resident bird habitat and effects on human uses in affected areas. No comparison of project benefits is provided because the Proposed Action and all feasible alternatives will have the same level of benefits relative to the No-Action Alternative.

4.4.1 Construction and Operation Effects on Land Use (Table 4-1)

The No-Action Alternative will not affect land use and dwellings. Construction of the Proposed Action could cause a one-season disruption of up the 16.3 du of land that was under cultivation for vegetables during winter 1996. This disruption can be mitigated by scheduling construction outside of the normal growing season (September to May). Cultivation over the pipeline trench area would likely be discouraged after completion of construction (although planting over other pipelines in the area appears to be common practice), resulting in a permanent loss of about 1.1 du of cultivated land. Loss of up to 0.6 du of citrus could occur; however, present plans for pipeline construction call for avoiding this area. Construction in the river channle would be required at two locations. The effects of the Hwarat canal-pipeline alternative are similar to those of the Proposed Action; however, the canal would likely occupy more area and thus would involve a permanent loss of 2.9 du of cultivated land. Due to its greater length, the Thahab pipeline alternative would temporarily affect 22.6 du of land that was under cultivation for vegetables and would result in permanent removal of 7.0 du of land from vegetable cultivation and 0.3 du of olive trees. Construction in the river channel would be required at five locations.

Table 4-1.
Effects of construction of alternatives on land use and dwellings.

Alternative	Loss of Cultivated Land (du)		Total Area for Construction (du)	Pipeline/ Canal River Crossings	Dwellings Affected
	Temporary (One Season)	Permanent (Project Lifetime)			
No-Action	0	0	0	0	0
PROPOSED ACTION: Hwarat Pipeline	16.3 (Vegetables)	1.1 (vegetables) 0 - 0.6 (citrus)	37 =3.7 ha= 9.25 acres	2 1 bridge; 1 buried	6
Proposed Action with Mitigation	0	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action
Hwarat Canal-Pipeline	Same as Proposed Action	2.9 (vegetables) 0 - 0.6 (citrus)	37	2 1 bridge; 1 buried	6
Thahab Pipeline	22.6 (Vegetables); 0.3 (Olives)	7.0 (vegetables) 0 - 0.6 (citrus) 0.3 (olives)	66	5 buried	9

4.4.2 Operation Effects on Streamflow (Table 4-2)

The Proposed Action would divert water from a stream segment that is about 4.7 km long. The lower portion of that segment is affected by saline springs and seeps and appreciable flow would become established within the first 2.5 km below Hwarat Weir. Operation of a settling basin for desanding water delivered to the pipeline (similar to the basin at Thahab Weir) may provide limited year-round flows (up to about 20 L/s) in the 1.5 km segment upstream of the saline springs. With the proposed mitigation a minimum flow of 20 L/s would be released at Hwaret Weir to provide for maintenance of migratory bird and wildlife habitat in the upstream portion of this segment. Under the No-Action Alternative, flows in this segment would fluctuate in response to irrigation demands (from 0 to approximately 2,500 L/s), with limited flows (up to about 20 L/s) in the upstream 1.5 km segment for prolonged periods during the winter months.

The Hwarat canal-pipeline alternative would have be equivalent to the Proposed Action relative to its effects on flow. The Thahab pipeline alternative would affect an additional 5.2 km of stream channel. This segment of channel would experience limited flows (up to about 20 L/s) throughout the year.

At present (No-Action Alternative), the Zarqa River downstream from Abu Zeighan Weir has a flow of approximately 80 L/s from diverted saline spring inflows. These flows were established recently and account for only a portion of the saline spring flows; however, in the absence of other measures, they would be expected to continue. The Proposed Action and feasible alternatives would increase that flow to 150-300 L/s because all spring inflow would be passed at the weir.

Table 4-2.
Effects of alternatives on Zarqa River flow below Thahab Weir

Alternative	Thahab to Hwaret (5.2 km)	Hwaret to Abu Zeighan (4.7 km)	Downstream from Abu Zeighan (17 km)
No-Action	KAC Irrigation[1]	KAC Irrigaition	Partial Saline Spring Inflows (80 L/s)
PROPOSED ACTION: Hwarat Pipeline	Same as No-Action Alternative	No Flow[2] in upstream 1.5 km (0-20 L/s) - Saline Inflows increase downstream[3]	Saline Spring Inflows (150-300 L/s) Increase vs. No-Action
Proposed Action with Mitigation	Same as No-Action Alternative	20 L/s in upstream 1.5 km - Saline Inflows increase downstream	Same as Proposed Action
Hwarat Canal-Pipeline	Same as No-Action Alternative	Same as Proposed Action	Same as Proposed Action
Thahab Pipeline	No Flow[2] (0-20 L/s)	Same as Proposed Action	Same as Proposed Action

Notes:
1. Flow passed at Thahab won't exceed KAC irrigation requirement unless significant runoff from rainfall is occurring. There may be periods of no flow; however, settling basin overflow (10-20 L/s) may be released when there is no KAC requirement, but there is a requirement for ZC I and ZC II.
2. Settling basin overflow (10-20 L/s) may be released nearly continuously when pipeline headworks is operating properly.
3. Spring flow increases from 0 to greater than 100 L/s between 1.5 and 2.5 km downstream from Hwaret Weir.

4.4.3 Operation Effects on Water Quality (Table 4-3)

The Proposed Action would divert slightly brackish (average EC 1.9 dS/m or about 1.3 ‰ salinity), renovated municipal and industrial water intended for irrigation use around an area receiving saline spring inflows of with an EC of 7-9 dS/m. The renovated water is very eutrophic, that is, it is highly enriched with nutrients (NO_3 and NH_4) and Biological Oxygen Demand (BOD) is excessive, thus creating potential problems with maintenance of oxygen for aquatic life. The saline springs have low nutrients and BOD. The Proposed Action will remove renovated water from the stream channel creating conditions much more favorable for aquatic life in the lower 3.2 km of the segment below Hwarat Weir than under the No-Action Alternative. The EC in the area of saline springs will increase to moderately brackish levels; however, this is not as limiting of aquatic fauna diversity and productivity as is consumption of oxygen by high BOD. Low flows in the stream segment upstream of the saline springs will not differ in quality from the No-Action alternative but periods of zero flow will probably occur, thus rendering the area unsuitable for many aquatic fauna. The Proposed Action with recommended mitigation will result in continuing polluted conditions in the stream segment above the saline springs; however, periodic dessication will be reduced. Dilution of nutrients and BOD present in the minimum flow release by the saline spring water will result in conditions not appreciably different from those that would occur with saline inflows alone.

The Hwaret canal-pipeline feasible alternative would have effects on water quality equivalent to those resulting from implementation of the Proposed Action. The Thahab pipeline alternative would divert renovated water around an additional 5.2 km of stream channel, which would be expected to receive low flows and experience periodic dessication.

Table 4-3.
Effects of alternatives on water quality of Zarqa River at sites downstream of Thahab Weir and in the KAC-s

Alternative	Hwaret (5.2 km)	Abu Zeighan (9.9 km)	Below Abu Zeighan (10-27 km)	Irrigated Areas (KAC-s at Maadi)
No-Action	EC: 1.3 - 2.6[1] BOD_5: 20 - 28[2] NH_4: 6 - 8 NO_3 Summer: 32-51 NO_3 Winter: 57	EC: 1.4 - 3.1 BOD_5: 14 - 20 NH_4: 2 - 3 NO_3 Sum.: 38-54 NO_3 Winter: 55	EC: 7 - 9 BOD_5: 1+ NH_4: 1+ NO_3 Sum.: 1-3+ NO_3 Winter: ? (See note 4)	EC: 1.2 - 2.6 BOD_5: 4 - 32 NH_4: 2 - 3 NO_3 Sum.: 39-53 NO_3 Winter: 31
PROPOSED ACTION: Hwarat Pipeline	Same as No-Action Alternative (above weir); No Flow[3] (below weir)	EC: 6 - 9 BOD_5: 1 - 5 NH_4: 1 - 2 NO_3: 1 - 10	EC: 6 - 9 BOD_5: 1 - 5 NH_4: 1 - 2 NO_3: 1 - 10	EC: 1.2 - 2.6 BOD_5: 4 - 28 NH_4: 2 - 8 mg/L NO_3 Sum.: 32-53 NO_3 Winter: 31-57
PROPOSED ACTION with Mitigation	Same as No-Action Alternative (above and below weir)	EC: 6 - 9 BOD_5: 2 - 5 NH_4: 1 - 2 NO_3: 3 - 10	EC: 6 - 9 BOD_5: 2 - 5 NH_4: 1 - 2 NO_3: 3 - 10	Same as Proposed Action
Hwarat Canal-Pipeline	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action
Thahab Pipeline	No Flow	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action

Notes:

1. EC values are in dS/m (= mmhos/cm). Values represent the "typical" range in average monthly EC values for KTD over the period September 1990 - December 1995. Eighty percent of the average monthly values are within this range.
2. Chemical parameter values are in mg/L. Values are the range of seasonal (summer/winter) means[6,7].
3. Due to lack of flow, water quality effects are not considered. If water is present, quality will be equivalent to that of No-Action Alternative.
4. Levels of nutrients will likely increase with distance downstream due to influences of irrigation returns and livestock use.

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[6] Irrigation Support Project for Asia and the Near East and Water and Environment Research and Study Centre, University of Jordan. 1994. Irrigation management and water quality in the Central Jordan Valley, winter cropping season.

[7] Water and Environment Research and Study Center - University of Jordan. 1995. Irrigation management & water quality in the Central Jordan Valley (Baseline Survey). Water Quality Improvement and Conservation Project, Report 3114-95-3b-05.

4.4.4 Operation Effects on Aquatic Life, Vegetation and Migratory and Resident Bird Habitat (Table 4-4)

Aquatic life in the Zarqa River is affected, at present (No-Action Alternative), by flow fluctuations, polluted water and salinity variations. This combination of factors limits the diversity and abundance of aquatic biota to species that are very tolerant of low oxygen, periodic dessication and salinity levels ranging from slightly to moderately brackish. The high BOD and nutrients content of the renovated water released at KTD is likely to result in anoxic conditions on a regular basis. Such conditions probably are the most limiting. The Proposed Action will reduce flows to low levels (0-20 L/s) in the 1.5 km stream segment immediately downstream of Hwarat Weir. The low flows may increase occurrence of anoxic conditions and dessication of the channel would occur frequently; thus, most aquatic biota would likely be extirpated. The low flows would be enough to maintain an area of emergent vegetation in the stream channel (primarily reeds) and support continued presence of a well developed community of tamarix and oleander at the channel margins. The vegetated area will contract somewhat and the existing open water in the center of the channel will become overgrown. The vegetation changes will adversely affect birds that exploit open water in riverine areas, such as larger herons and kingfishers, while habitat for wading birds that prefer cover, such as bitterns, small herons and rails will be maintained. As the vegetated area contracts, there may also be some reduction of the quantity of cover and roosting habitat for songbirds.

In the area affected by saline springs, mixing of low flows of polluted water with saline groundwater will result in much-improved levels of nutrients and BOD. There will be a small reduction in salinity of the spring water (on the order of 0.2-0.5 dS/m) when settling basin overflow is operating; however, salinity will be more stable than under present conditions. Because channelization of the streambed to avoid mixing irrigation water and spring water will no longer be necessary, riparian and aquatic emergent vegetation, primarily halophytic species, will become established. The area should support a greater diversity of aquatic life as conditions will be more stable and disruption of the streambed will no longer occur. Vegetation will probably be limited in diversity by grazing livestock and by salinity. Oleander and reeds are likely to be the most conspicuous plant species. Use of this area by birds will increase as vegetation becomes established. Open water birds and songbirds are most likely to benefit.

Table 4-4.
Effects of alternatives on fish, wildlife and habitat in Zarqa River

Alternative	Fish and Aquatic Life	Vegetation	Migratory and Resident Bird Habitat
No-Action	**Thahab to Abu Zeighan:** Marginal for Fish; OK for invertebrates able to tolerate eutrophic conditions and rapid fluctuations in flow and/or salinity	**Thahab to 2.2 km below Hwaret:** Heavy riparian tamarix and oleander. Thick emergents in channel, reeds at channel margins. **2.5 km above Abu Zeighan:** Channel vegetation removed; sparse riparian oleander.	**Thahab to Abu Zeighan:** Open Water birds - Good, Thick Cover water birds - Good, Songbirds - Excellent, Shorebirds - Fair, Small Raptors - Fair Large Raptors - Poor
PROPOSED ACTION Hwarat Pipeline	**Thahab to Hwaret:** Marginal for Fish; OK for invertebrates able to tolerate eutrophic conditions and rapid fluctuations in flow. **Hwaret to Abu Zeighan:** Upper 1.5 km unsuitable for aquatic life. Lower 3.2 km OK for fish and aquatic life able to tolerate brackish conditions.	**Thahab to Hwaret:** Same as No-Action. **Hwaret to Abu Zeighan:** Tamarix and oleander in upper 1.5 km. Brackish emergents (recovering) and grasses in channel with riparian oleander in downstream 3.2 km.	**Thahab to Hwarat:** Same as No-Action **Hwarat to Abu Zeighan:** Open Water birds - Good, Thick Cover Water birds - Fair, Songbirds - Good, Shorebirds - Poor, Small Raptors - Fair Large Raptors - Poor
PROPOSED ACTION with Mitigation	**Thahab to Hwaret:** Marginal for Fish; OK for invertebrates able to tolerate eutrophic conditions and rapid fluctuations in flow. **Hwaret to Abu Zeighan:** Upper 1.5 km marginal for fish and aquatic life able to tolerate eutrophic conditions and low flow. Lower 3.2 km OK for fish and aquatic life able to tolerate brackish conditions.	**Thahab to Hwaret:** Same as No-Action **Hwaret to Abu Zeighan:** Moderate tamarix and oleander in upper 1.5 km. Brackish emergents (recovering) and grasses in channel with sparse riparian oleander downstream. in 2.5 km above Abu Zeighan.	**Thahab to Hwarat:** Same as No-Action **Hwarat to Abu Zeighan:** Open Water birds - Good, Thick Cover Water birds - Good, Songbirds - Excellent, Shorebirds - Fair, Small Raptors - Fair Large Raptors - Poor
Hwarat Canal-Pipeline	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action
Thahab Pipeline	**Thahab to Hwaret:** Unsuitable for Fish; OK for invertebrates able to tolerate eutrophic conditions and frequent periods of dessication during winter. **Hwaret to Abu Zeighan:** Upper 1.5 km as for Thahab to Hwaret segment. Lower 3.2 km OK for fish and aquatic life able to tolerate brackish conditions.	**Thahab to 2.2 km below Hwaret:** Moderate riparian tamarix and oleander. Reeds in channel. **2.5 km above Abu Zeighan:** Brackish emergents (recovering) and grasses in channel with sparse riparian oleander downstream.	**Thahab to Abu Zeighan:** Open Water birds - Fair, Thick Cover water birds - Fair, Songbirds - Good, Shorebirds - Poor, Small Raptors - Fair Large Raptors - Poor

With the mimimum flow release proposed as a mitigation measure, the Proposed Action would improve the stability of aquatic habitat in the area upstream of the saline inflows. Water quality would not improve over the No-Action Alternative and thus would remain marginal. The minimum flow would maintain greater diversity of mid-channel emergent vegetation and, possibly, denser riparian vegetation than the Proposed Action without mitigation. Effects on the brackish water segment would be similar to the Proposed Action.

The Hwarat canal-pipeline alternative would have the same effects as the Proposed Action. The Thahab pipeline alternative would affect an additional 5.2 km of freshwater stream channel, compared to the Proposed Action. The effects on this area would be similar to those expected to occur in the 1.5 km reach upstream of the saline springs following implementation of the Proposed Action. The greater extent of the effects on aquatic life and vegetation would reduce habitat suitability for birds compared to the Proposed Action.

4.4.5 Operation Effects on Human Uses of Water in the Zarqa River and Irrigated Areas (Table 4-5)

The Zarqa River in the project area is used by pastoralists for grazing and watering livestock, by the local population for various types of washing and bathing and by farmers for irrigation. Most farmers in the area are supplied with irrigation water from taps on the ZC I pipeline. There are three farms on the south side of the river between Thahab and Abu Zeighan Weirs that pump water directly from the river for irrigation purposes. All farms along the river downstream from Abu Zeighan Weir are supplied with water from ZC I, ZC II or the KAC.

Use of the river by pastoralists occurs both upstream and downstream from Abu Zeighan Weir. The water quality for livestock is typically in the "very satisfactory" range[8] upstream from the saline inflows (when there is flow below Thahab Weir) and, depending on the flow past Thahab Weir, may be in the "very satisfactory" or "satisfactory" range above Abu Zeighan Weir. Below Abu Zeighan Weir, water quality for pastoral use is in the "satisfactory" or "limited use" range, depending on the exact EC of the saline spring inflows

[8] Ayers, R. S. and D. W. Westcot. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper No. 29, Rev. 1. United Nations Food and Agriculture Organization, Rome.

Table 4-5.
Effects on human uses of the Zarqa River and in the areas irrigated from the KAC-s

Alternative	Thahab to Hwarat (5.2 river km)	Hwarat to Abu Zeighan (4.7 river km)	Below Abu Zeighan (17 river km)	Irrigated Areas (42,000+ du)
No-Action	**Irrigation:** Moderate Restriction - one user **Pastoralists:** "Very Satisfactory" (Occasional No Flow) **Bathing:** None **Washing:** Limited	**Irrigation:** Moderate-Severe Restriction - two users **Pastoralists:** "Very Satisfactory" or "Satisfactory" **Bathing:** At Springs **Washing:** Limited	**Irrigation:** Not useable **Pastoralists:** "Satisfactory" or "Limited Use" **Bathing:** None? **Washing:** Suitable	**Irrigation:** Moderate-Severe Restriction - 100's of users **Pastoralists:** "Very Satisfactory" **Bathing:** None **Washing:** None
PROPOSED ACTION: Hwarat Pipeline	Same as No-Action	**Irrigation:** No Flow - two users **Pastoralists:** 1.5 km - No Flow; 3.2 km - "Satisfactory" or "Limited Use" **Bathing:** At Springs **Washing:** Suitable	Same as No-Action (flow volume increased)	**Irrigation:** Moderate Restriction - 100's of users **Pastoralists:** "Very Satisfactory" **Bathing:** None **Washing:** None
PROPOSED ACTION: with Mitigation	Same as No-Action	**Irrigation:** Same as No-Action **Pastoralists:** 1.5 km - "Very Satisfactory"; 3.2 km - "Satisfactory" or "Limited Use" **Bathing:** At Springs **Washing:** Suitable (lower 3.2 km)	Same as Proposed Action	Same as Proposed Action
Hwarat Canal-Pipeline	Same as No-Action	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action
Thahab Pipeline	**Irrigation:** No Flow - one user **Pastoralists:** "Very Satisfactory" (Frequent No Flow) **Bathing:** None **Washing:** Limited use	Same as Proposed Action	Same as Proposed Action	Same as Proposed Action

(the likely EC is 8±1 dS/m which lies at the boundary between the two quality ranges). Coliform bacteria levels in the water in the main channel make it of limited suitability for human contact uses. Use of water from the river for bathing occurs at two large thermal springs (Man Spring and Woman Spring). Thus, bathers are not subject to contact with bacteria-contaminated water at the bathing sites. Use of the water for washing clothes, livestock, agricultural vehicles and equipment and gravel washing occurs both upstream and downstream from Abu Zeighan Weir, thus the salinity does not appear to be great enough to restrict those uses.

The Proposed Action would affect two farms that draw water directly from the river channel for irrigation. The flow requirement for those farms is small compared to river flow and would likely be more than satisfied by the settling basin overflow; however, without a minimum flow requirement there would be periods of no flow when irrigation could not be accomplished. The Proposed Action would also affect livestock use in the 1.5 km segment above the saline springs. The loss of flow would be periodic and pastoralists would be required to move flocks 1.5 km downstream to obtain water from the river channel. The quality of water would be in the "satisfactory" to "limited use" range, as discussed above. The 1.5 km segment would also be unavailable for washing; however, river water for washing would be no more than 0.8 km from existing dwellings. Provision of a 20 L/s continuous minimum flow (Proposed Action with mitigation) would be sufficient to meet all use requirements in the 1.5 km segment.

Effects of the Hwarat canal-pipeline alternative are equivalent to those of the proposed action. The Thahab pipeline would affect an additional 5.2 km of river channel. This would affect one additional farm and make access to water for livestock and washing (when there is no flow from the settling basin) more difficult.

4.5 ALTERNATIVES ELIMINATED FROM CONSIDERATION

4.5.1 Construction of a Pipeline from KTD to Abu Zeighan Canal

This alternative was developed before it was determined that any conveyance losses and water quality degradation were occurring only in the lower reach of the river from Hwarat Weir to Abu Zeighan Canal. The benefits derived from this alternative could be obtained at

significantly less cost by construction of a pipeline diversion around the reach of the river where water quality degradation and losses occur; therefore, this alternative was eliminated from consideration.

4.5.2 Improving the River Bed

This alternative originally considered use of a constructed channel (canal) in the river channel or membrane liner for the river bed to reduce seepage losses. Construction of a canal was considered ineffective because of the 38 m drop in head between Hwarat and Abu Zeighan Weirs would necessitate construction of a number of drop structures that would raise the cost of the canal to a level equivalent to a closed conduit. In addition, leakage at expansion joints would likely allow intrusion of saline flows into the canal, thus reducing its effectiveness at maintaining water quality.

A membrane was considered ineffective because it would be subject to cracking or ripping that would allow losses or intrusion of saline water. In addition, because the saline springs are flowing, the impervious barrier might only force springs to discharge up-bank or in another location that might eventually allow saline water to return to the river. Thus performance of this measure could not be guaranteed.

4.5.3 Use of a Deep Cutoff Wall

This alternative was conceived to intercept flow travelling downstream in the gravel and alluvium of the river channel and return it to the surface. This option would potentially be effective in situations where the flow directed to the surface could be diverted for use. Because the only area considered to have potential losses to the streambed is in the area of saline inflows, this alternative would only increase the volume of saline water, thus proving ineffective for improving water quality. In upstream areas, where losses do not appear to be appreciable, construction of such a structure would increase cost without guaranteeing improved performance.

4.5.4 Preventing Saline Spring and Seep Water from Entering the Channel

This alternative was conceived when the nature and extent of springs and seeps in the channel was not completely understood. The sources of saline water are flowing, thus any

structural confinement may simply lead to a shift in the location of inflows as a result of pressure build-up. Given that saline inflows occur throughout the reach between Hwarat Weir and Abu Zeighan Canal, features constructed to intercept and convey saline flows downstream past Abu Zeighan Weir are likely to be ineffective.

4.5.5 Power Generation Alternative

This alternative involved incorporation of a generation facility and re-regulation reservoir at Abu Zeighan Weir into the scheme. The most economically attractive facility would have a pipeline from Thahab Weir and operate in a peaking mode, coordinated with peaking at KTD. This alternative was dropped from consideration during the conceptual stage, primarily because the generation potential and economic return was considered low relative to the cost. In addition, peaking operations would have detrimental effects on natural resources in the entire channel between KTD and Thahab Weir as well as diversion effects on the resources below Thahab Weir.

4.5.6 Off-take from Zarqa Carrier II

This alternative would involve using the existing ZC II pipeline for conveyance from Thahab Weir to a point approximately 2.0 km from Abu Zeighan Weir (about 50 m downstream of the existing branch for a small pumping station serving the Abu Zeighan village area), and construction of a new pipeline from the bifurcation point to Abu Zeighan Weir. The increased volume conveyed through ZC II under this alternative would result in large head losses and water velocities in the pipe at near-maximum levels for safe operation. To make up for head losses that might harm existing ZC II consumers, a booster pumping station would have to be added downstream of the bifurcation. Additional desanding facilities would be required at Thahab Weir to accomodate the additional volume and to protect the lining of the existing cement-lined pipe. Implementation of this alternative would require more time than other alternatives that were retained for consideration. This alternative also involves a potential disruption of service to much of the area served by ZC II during construction and during any extended outage of the pumping station. The alternative involving a new pipeline from Thahab Weir to Abu Zeighan Weir, described in Section 4.3.2, has fewer potential risks of service disruption and greater flexibility if future operation requires conveyance of greater volumes; therefore, the ZC II Off-take alternative was rejected and Thahab to Abu Zeighan pipeline was retained for consideration.

5. AFFECTED ENVIRONMENT

During the scoping process the following general areas were determined to be potentially subject to direct environmental effects of the project:

- The Zarqa River channel from the point of the flow diversion (at Thahab or Hwarat Weir) downstream to Abu Zeighan Weir,

- Areas in and adjacent to the pipeline (or canal) corridor in the Zarqa River valley area from Thahab or Hwarat Weir to Abu Zeighan Weir,

- The Zarqa River channel downstream of Abu Zeighan Weir and areas adjacent to the channel, and

- Areas irrigated from the KAC-s below the intersection of the Abu Zeighan Canal with the KAC. This includes an area of 36,915 du designated by JVA as the "18 km Extension Project" (Figure 4-1), which includes irrigation development areas (DA's) 26, 27 and 28. Also included in the irrigated area are parts of DA 30 and parts of DA 25 that are served by Pump Station 78.

In addition, the project will have indirect effects on an irrigated area known as the "14.5 km Extension Project," which is south of the 18 km Extension. The 59,750 du 14.5 km Extension (Figure 4-1) is presently being developed to store excess flows from the KAC-s and side wadis at Karameh Dam during the winter months and pump back the stored water during late winter and spring to maintain irrigation.

5.1 ENVIRONMENTAL SETTING

5.1.1 Zarqa Basin

The Zarqa River is a major tributary of the Jordan River that originates in the central part of Jordan at an elevation of about 1,600 m above mean sea level and joins the Jordan River at an elevation of about 300 m below mean sea level. The Zarqa drains the eastern escarpment of the Jordan River Valley and the edge of the elevated plains and deserts of the

Arabian and Syrian plateaus. The elevation of the escarpment varies around 700 m while the valley ranges from -200 to -400 m. The area of the drainage basin is approximately 3,540 km^2.

5.1.2 Climate and Precipitation

The general climate of the Zarqa River basin is a transition between Mediterranean and arid climate. Altitude and latitude are the effective factors controlling weather. Average daily maximum and minimum temperatures are 45°C and 5°C, respectively. There is a rapid decrease in relative humidity and precipitation moving east of the Jordanian Highlands. In winter, northeast winds bring continental polar air from the interior of Asia and make the Jordan Valley cool for its latitude. The mean temperature of the plateau of Amman during January is about 8°C compared to about 14°C in the Valley. Ground frosts occur frequently on the plateau during winter nights but are unusual in the Jordan Valley.

A seasonal low pressure trough over the Arabian Gulf, Iraq, Syria and Cyprus during summer causes westerly winds to enter Jordan from the Mediterranean. Fall is associated with a change in the pressure system as the seasonal trough extending from Cyprus to Iraq begins to migrate southeast. Mediterranean depressions start developing with continental air from the Asiatic Steppes and warmer, moist air from the Mediterranean causing a decrease in temperature and the onset of seasonal frontal rains.

Annual precipitation is highest in the highlands and over the elevated edge of the Valley and decreases gradually toward the eastern deserts. Mean annual precipitation over the entire Zarqa River basin is about 235 mm. Average annual rainfall in the Valley is about 200 mm or less while precipitation in the higher elevations at the edge of the escarpment is on the order of 300-400 mm.

5.1.3 Surface Water Hydrology

Present Situation

The Zarqa River is the second largest of the Jordan River tributaries. The base flow yield for the Zarqa Basin has been estimated at 46 million cubic meters per year (Mm^3/yr), flood

flows contribute an additional 46 Mm^3/yr[9]. The average annual flow is on the order of 2.9 m^3/s. Water is abstracted from the upper basin for municipal and industrial use in Amman and other urban areas. Water is also abstracted for irrigation in the uplands. Municipal and industrial return flows are stored at KTD to support irrigation in the Jordan Valley. Harza[10] estimated that the average annual flow entering the reservoir is 2.3 m^3/s. About half of the flow entering the reservoir is derived from municipal and industrial return flows, primarily from the Khirbet as Samra treatment plant, which serves Amman.

Flows in the Zarqa River at the site are controlled by the KTD, which is operated to provide water in support of irrigated agriculture in the central and southern Jordan Valley. Operation of the KTD to satisfy irrigation demands has resulted in profound changes in the annual hydrograph. Under present conditions, flows in the Zarqa River below KTD are typically low during the winter months and high during the summer and early fall.

The "natural" hydrograph would typically have annual maximum flows occurring during the winter and annual minimum flows during summer and early fall. Presently (under the no-action alternative), flows of up to 2.8 m^3/s (maximum combined flow for ZC's I and II) are diverted from the Zarqa at Thahab Weir. Flow in excess of the irrigation requirement for ZC's I and II is passed at Thahab Weir and continues downstream approximately 9.9 km to Abu Zeighan Weir where it is diverted, via Abu Zeighan Canal, to the KAC. The present diversion affects the Zarqa River between Thahab Weir and the Jordan River (a distance of approximately 27 km). Because water is released from KTD to support irrigation, flows in the Zarqa River rarely exceed the quantity required for the irrigation diversions at Thahab and Abu Zeighan Weirs. Thus, the present situation involves diversion of virtually all flows released at KTD from the 17 km river segment below Abu Zeighan Weir.

The river segment from Hwarat Weir to Abu Zeighan Weir is affected by year-round spring inflows, some of geothermal origin. The mixed inflow from springs in this segment has a relatively high salinity (approximately 7-9 dS/m). Appreciable inflows begin to occur approximately 1.3 km below Hwarat Weir. Total flow accumulation at Abu Zeighan Weir is

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[9] Ministry of Municipal, Rural Affairs and the Environment. 1991. National Environment Strategy for Jordan. IUCN - the World Conservation Union, Gland. 231 pp.

[10] Harza Engineering and Consolidated Consultants. 1996. Zarqa River Conveyance Study, Phase A - Conceptual Study, Part 3 - Selection of Preferred Alternative.

150-300 L/s from springs in the segment below Hwarat Weir. Due to their highly saline nature, the springs adversely affect water quality in the KAC during periods when flow below the Thabab Weir is relatively low.

JVA has channelized the streambed, dividing it into two separate channels, for a distance of approximately 2.4 km above Abu Zeighan Weir. This measure partially separates saline spring inflows from the fresh water flowing downstream of KTD. Upstream of the channelized area, the sources of saline inflow are too widely dispersed over the width and length of the channel to separate them from the freshwater flow. Thus, the main channel carries a mixed saline and freshwater flow to the entrance of the Abu Zeighan Canal. The secondary channel diverts approximately 25-40% of the saline inflow (about 80 L/s) over the Abu Zeighan Weir to continue downstream.

Channelization of the river above Abu Zeighan Weir was done in response to problems with salinity in KAC that occurred during 1993 and 1994. Prior to channelization all flow was diverted to KAC at Abu Zeighan Weir. The No-Action Alternatives assumes that channelization would continue, thus a release of approximately 80 L/s of saline water immediately below Abu Zeighan Weir would be continued in the future.

Likely Future Changes

Water supply in Amman exploits a number of sources outside of the Zarqa Basin. It is likely that additional sources will be developed over the next ten years. These sources will affect the quantity and quality of municipal and industrial return flows reaching the Zarqa River. These sources may result in an improvement of the quality of water available for irrigation; however, other factors are likely to offset gains in quality and quantity of return water. Several sources of groundwater serving Amman are overexploited at present and, consequently, the quality of water from those sources is deteriorating. In addition, increased return flows offer an opportunity for increasing the area of land under irrigation in the uplands. JVA has indicated that as additional return flows become available, up to 2 m^3/s will be diverted to irrigation projects in the uplands. Return flows also will be allocated to the 14.5 km Extension Project. At present, it appears that the quality of renovated water will remain relatively unchanged while total volume will increase.

One of the sources that will be developed for municipal-industrial use in Amman is the Yarmouk River. Thus, the volume of water reaching the KAC-s from the KAC-n may decrease in the future. The recently completed peace treaty with Israel increases the amount of Yarmouk water potentially available to Jordan by about 140 Mm^3/yr. Demand projections developed by Harza Group[11] indicate that, even considering the peace treaty water rights, the water supply shortfall for all uses in Jordan will be 429 Mm^3/yr by the year 2000. Thus, it is unlikely that the supply of Yarmouk water for irrigation will increase. There may be an increase in supply during the first year or two of the project; however, that will rapidly be lost and only those (flood) flows in excess of the capacity of municipal-industrial diversion facilities are are likely to be available during winter months in the future. Such flows will be stored in a series of dams in the Jordan Valley and used to support irrigation along the KAC-n; however, renovated water from the Zarqa River is likely to become more important as a source of irrigation in the future.

5.1.4 Groundwater

The aquifer system in North-Central Jordan is classified into two main systems, the Lower Aquifer System and the Upper Aquifer System. The Upper Aquifer System is not represented in the project area. The Lower System is primarily composed of the Kurnub Group of Early Cretaceous sandstones intercalated with shale, limestone, dolomite and marl and the Zarqa Group of Triassic-Jurassic Rocks. The Zarqa Group is sub-divided into the Main Formation of shales, clays, marly limestone, marls, calcareous sandstones, limestones and massive gypsum beds and the Azab Formation of limestone, dolomite, sandstone and shale.

The major recharge area is in the highlands, through the Upper Aquifer System. Because of the topography, there is a groundwater divide in the recharge area. Water that flows west appears as good quality water in springs, seeps and baseflow from the Upper Aquifer System (Kurnub Formation). Most of the water flows eastward in the Upper Aquifer Complex and infiltrates downward. When water finally reaches the Lower Aquifer Complex, it reverses direction and flows westward to be encountered in wells (flowing or nonflowing) or emerge as springs with thermal brackish water in the Jordan Valley. The water quality of wells and

[11] Harza Group. 1995. The Water Conveyance System from Disi-Mudassara to Amman, Draft Conceptual Study Report, Vol. 3, Formulation and Development of System Components.

springs in the project area (Table 5-1) provides an indication of general groundwater quality in the project area[12].

Table 5-1.

Results of chemical analyses of selected parameters from various groundwater sources[13] in the project area.

Location	EC (dS/m)	Ca (mg/L)	Mg (mg/L)	Cl (mg/L)	NO_3 (mg/L)	NH_4 (mg/L)	H_2S (mg/L)
Test Well 1	8.55	37.15	10.4	50	8.27	0.26	0.49
Test Well 2	14.76	46.69	16.6	116.7	3.94	1.02	0.49
Abu Zeighan No. 1	11.85	42.2	11.5	76.92	1.99	25.6	0.25
Man Spring	6.88	25.29	10.8	35.95	.57	1.28	0.25
Woman Spring	8.08	33.43	6.5	42.4	2.61	1.02	<0.10

5.2 WATER QUALITY

Due to its partial origin as municipal and industrial return flows from the Khribet As-Samra wastewater treatment plant, water flowing downstream of KTD is enriched with nutrients and has a relatively high Biological Oxygen Demand (BOD_5). Water quality data collected during 1993[14] and 1994[15] allow a comparison between the quality of water in the KAC near Sawalha, which is representative of water quality in the relatively unpolluted Yarmouk River, and the

[12] Harza Engineering and Consolidated Consultants. 1996. Zarqa River Conveyance Study, Phase A - Conceptual Study, Part 3 - Selection of Preferred Alternative.

[13] Harza Engineering and Consolidated Consultants. 1996. Zarqa River Conveyance Study, Phase A - Conceptual Study, Part 3 - Selection of Preferred Alternative.

[14] Irrigation Support Project for Asia and the Near East and Water and Environment Research and Study Centre, University of Jordan. 1994. Irrigation management and water quality in the Central Jordan Valley, winter cropping season.

[15] Water and Environment Research and Study Center - University of Jordan. 1995. Irrigation management & water quality in the Central Jordan Valley (Baseline Survey). Water Quality Improvement and Conservation Project, Report 3114-95-3b-05.

quality of water from the Zarqa River at Thahab Weir (Table 5-2). The average concentration of ammonia nitrogen (NH4) was 6-8 mg/L at Thahab Weir vs. 0.1-0.3 mg/L in the KAC-n; average nitrate nitrogen (NO3) was 32-57 mg/L in the Zarqa and 11-15 mg/L in

Table 5-2.
Results of water quality analyses (mean and range) for selected parameters in Zarqa River and King Abdullah Canal for 1993[16] and 1994[17]

Parameter	Thahab Weir			KAC-n (Sawalha)			KAC-s (Maadi)		
	Apr '93 to Oct '94	Nov '93 to Apr '94	Apr '94 to Oct '94	Apr '93 to Oct '94	Nov '93 to Apr '94	Apr '94 to Oct '94	Apr '93 to Oct '94	Nov '93 to Apr '94	Apr '94 to Oct '94
EC (dS/m)	1.6 1.4-2.0	2.1 2.0-2.2	2.1 1.9-2.4	0.9 0.8-0.9	0.9 0.8-0.9	0.9 0.9-1.0	2.0 1.6-2.3	1.7 0.9-2.5	2.7 2.0-3.7
Ca (mg/L)	106 85-126	129 110-150	114 88-124	58 53-61	69 59-84	63 50-80	133 119-152	111 48-148	152 84-220
Mg (mg/L)	159 138-197	54 41-66	60 50-75	34 17-45	30 23-40	39 27-70	56 39-76	40 18-58	61 43-112
Cl (mg/L)	264 241-325	327 291-355	382 317-568	104 86-112	106 82-121	148 108-482	350 283-424	278 121-429	464 112-700
BOD_5 (mg/L)	20 6-30	28 15-35	23 4-40	17 7-27	6 3-13	6 0-20	32 11-55	15 8-29	4 0-13
NH_4 (mg/L)	8 5-9	6 3-11	7 0.6-21	0.3 0.1-0.4	0.3 0.1-0.6	0.1 0.0-0.3	2.1 0.1-4.9	2.0 0.1-5.3	3.0 0.1-7.4
NO_3 (mg/L)	51 25-115	57 28-76	32 17-53	11 7-14	15 7-40	13 5-32	53 33-107	31 6-63	39 22-66
Fecal coliform (MPN/100 ml)	$2.8x10^3$	$3.7x10^2$	$3.5x10^2$	$3.8x10^2$	$4.0x10^2$	$3.4x10^3$	$4.8x10^4$	$3.6x10^3$	$7.9x10^3$
Total coliform (MPN/100 ml)	$6.1x10^3$	$6.1x10^3$	$4.0x10^3$	$5.4x10^3$	$4.3x10^3$	$5.3x10^3$	$5.0x10^4$	$5.8x10^3$	$2.6x10^3$

[16] Irrigation Support Project for Asia and the Near East and Water and Environment Research and Study Centre, University of Jordan. 1994. Irrigation management and water quality in the Central Jordan Valley, winter cropping season.

[17] Water and Environment Research and Study Center - University of Jordan. 1995. Irrigation management & water quality in the Central Jordan Valley (Baseline Survey). Water Quality Improvement and Conservation Project, Report 3114-95-3b-05.

the KAC-n, and average BOD5 was 20-28 mg/L in the Zarqa and 6-17 mg/L in the KAC-n. Total coliform bacteria counts were similar in the Zarqa at Thahab Weir and in the KAC near Sawalha.

Enriched water released at KTD is subjected to aeration in the 13 km segment between KTD and Thahab Weir. Additional aeration of water intended for KAC occurs in the 9.9 km between Thahab Weir and Abu Zeighan Weir. The water quality benefit of additional aeration between Thahab and Abu Zeighan Weirs appears to be relatively small. The reduction in average BOD_5 was 0-14 mg/L (0-50%) between Thahab and Abu Zeighan Weirs during 1993-1994. Biological activity and spring inflows (dilution) may further affect nutrient levels. Ammonia was reduced by 3-7 mg/L (50-75%); however, nitrate decreased by 2 mg/L (4%) in winter, but increased by up to 6 mg/L (19%) in summer. Fecal coliform bacteria levels typically increased between Thahab and Abu Zeighan Weirs, possibly due to use of the stream channel for grazing, while total coliform bacteria levels typically decreased.

5.3 VEGETATION

The fauna and flora of this area described here lays in the Deir Alla region with an average rainfall ranging from 150-300 mm/yr. It lies in the Arid Mediterranean and Saharan Mediterranean bioclimate zones. The soil type is mainly sandstone and granite with limestone and lissan marls. The vegetation types found locally derive from both Irano-Turanean and Mediterranean biogeographic ecozones. These biogeographic zones are divided to several sub-biogeographic ecotypes such as Steppe vegetation, saline (halophytic) vegetation and evergreen oak forests.

Plants typical of the steppe vegetation around the Zarqa River include the following:

- *Ziziphus lotus*
- *Tamarix* spp. *(palaestina)*
- *Salsola* spp.
- *Noea muronata*
- *Ferula communis*
- *Crocus* spp.
- *Pistacia atlantica*
- *Anabasis syriaca*
- *Capparis decidua*
- *Asphodelus microcarpus*
- *Gypsophila arabica*
- *Retama raetama*
- *Hammada* spp.
- *Artemisia herba-alba*
- *Ureginia maritimia*
- *Astragalus spinosa*

Plants of the evergreen oak forest on the slopes of the mountains and in the areas around King Talal Dam include the following:

Trees

- *Querqus calliprinus*
- *Ceratonia seliqua*
- *Arbutus andrachue*

Shrubs

- *Crataegus azarolus*
- *Amygdalus spp.*
- *Rhamnus palaestinus*
- *Olea europea*
- *Calycotome villosa*
- *Cistus villosus*
- *Rubia olivieri*
- *Asparagus aphyllus*

Herbaceous Bushes

- *Dactylis glomerata*
- *Anemone coronaria*
- *Poa bulbosa*
- *Adonis palaestina*
- *Orchis anatolica*
- *Euphorbia hierosolymitana*
- *Salvia* spp.
- *Alcea* spp.
- *Tulipa* spp.

The saline (Halophitic) vegetation found in the river channel and along the banks of the Zarqa down to King Abdullah Canal and the Jordan River include the following:

- *Juncus littoralis*
- *Tamarix* spp.
- *Lycium* spp.
- *Nitraria retusia*
- *Limonium meyeri*
- *Suadea* spp.
- *Sonchus maritimus*
- *Frankenia pulverules*

Other plant species that typically occur in wet areas of the Zarqa River channel include:

- *Phragmites communis*
- *Typha* spp.
- *Neruim oleander*

5.4 WILDLIFE

Information on wildlife and aquatic resources of the area is limited to observations and professional judgement of local experts. The Zarqa River channel in the project area has a history of disturbance and degraded water quality; therefore, it is not recognized as a quality resource. However, the project area is in the Dead Sea Rift Valley flyway, thus potential use of riparian habitat by migrating birds is a major interest. The Jordan Valley is described in

"Important Bird Areas in the Middle East"[18] as "A major migration route and a notable wetland site."

5.4.1 Wildlife Habitat

Along the Zarqa River channel, dense riparian vegetation provides cover, water is available and human disturbance is reduced. This type of habitat is relatively rare in Jordan and its distribution is being reduced by expanding agricultural program and water diversions supporting irrigation and municipal and industrial demands. The vegetation in the area that will be affected by project operation reflects existing conditions. There is a clear zonation of plant types ranging from those requiring nearly permanently saturation to those tolerant of prolonged dry conditions.

The channel in the first 2.3 km downstream of Thahab Weir is more often subject to dessication than areas further downstream. In this area oleander and tamarix are the dominant vegetation with scattered patches of common reed. At the point where the overflow from the settling basin for the ZC I and ZC II headworks enters the river, emergent aquatic vegetation such as reeds, rushes and sedges begins to appear along the edges of the low flow channel. Oleander and tamarix are present in areas away from the low flow channel, which may be dry for prolonged periods but that occasionally experience flooding. Acacias occur along the tops of the banks in much of the area.

The channel area downstream of Hwarat Weir has a narrow band of emergent sedges and cattails along the sides of the channel. There are scattered clumps of common reed at the bankside margins of this area. In the high flow channel, oleander dominates with tamarix slightly higher along the bank. Acacias occur at the tops of the banks. Some of the plant species, such as oleander, are highly tolerant of brackish conditions.

In the brackish area, the emergent vegetation is less conspicuous. Rushes predominate and oleander occurs in thickets along the banks in places. Tamarix is present along the banks. The brackish channel is more sparsely vegetated than freshwater areas upstream; however, livestock use of this area appears to be more common than upstream as it is closer to the

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[18] Evans, M. I. 1994. Birdlife Conservation Series No. 2, Important Bird Areas of the Middle East. BirdLife International, Cambridge, UK.

village of Abu Zeighan. Grazing pressure may account for the apparent decrease in density of vegetation.

The vegetated area affected by brackish springs is approximately 1.0 km in length. The 2.4 km of stream channel above Abu Zeighan Weir have been modified using a bulldozer to create two channels separated from each other by a low berm. One channel is used to intercept and separate some of the saline spring inflow from the flow from upstream and divert the intercepted saline flow over Abu Zeighan Weir. The channelization has destroyed much of the natural herbaceous and shrub vegetation in the channel and along the banks. Mature trees growing along the banks and scattered clumps of oleander are the only remaining vegetation. The streambed exposed by the channelization is largely gravel and cobble-sized rocks. Grasses and other herbaceous plants grow along the banks and on the berm. This area is adjacent to Abu Zeighan village, and is frequently used by livestock.

Downstream of Abu Zeighan Weir the channel shows the effects of the long periods of dessication associated with over 10 years of flow diversion from the Zarqa River channel to Abu Zeighan Canal at Abu Zeighan Weir. Wildlife habitat is marginal. Flow presently being diverted over Abu Zeighan Weir (estimated at 80 L/s) is contained in a narrow (2 m-wide), low-flow channel. The normal high-flow channel is approximately 30-60 m wide. The high flow channel is open and grassy with sparsely scattered oleander along the banks. The area along the river from Abu Zeighan downstream to the Yarmouk-Dead Sea Road crossing near Arda is densely populated. The floodplain is used for agriculture where soils are suitable and is open "waste land" in some areas considered unsuitable for agriculture. In the downstream areas of agricultural and waste lands, human disturbance may be low enough to allow occasional use of the area by waterfowl, wading birds and shorebirds.

Wildlife habitat, particularly for birds, along the river channel in the freshwater zone between Thahab Weir and 1.3 km downstream of Hwarat Weir is diverse with a variety of plant growth forms providing cover, foraging area, possible nesting sites and roosting opportunities for a variety of migrating and resident bird species. The river channel itself provides potential foraging habitat for wading birds and kingfishers, several species of which were observed in the area during January 1996. The river also acts as a key water source for mammals and amphibians.

5.4.2 Birds

The Rift Valley is a major migratory flyway for Europen and Eurasian bird species that winter in Africa. The vegetated wadis along the margins of the Rift Valley provide resting and foraging habitat for migrants passing through the Jordan Valley. The wetlands of the Zarqa River have historically attracted a wide variety of migrant birds[19]. Although migratory birds use such areas opportunistically, riparian wetlands along the margin of the Jordan Valley are decreasing due to agricultural development. Vegetated riparian areas, such as those found in the project area, are also important habitat for many seasonal and year-round resident species. Birds use the riparian vegetation for cover, foraging and, for some species, nesting habitat. Kingfishers and herons feed directly on fish, crabs and amphibians. Diversity and density of plant species and the associated bird community may be adversely affected by loss or reduction of streamflow. Annex 1 presents a list of bird species likely to be found in or pass through the project area.

5.4.3 Mammals, Reptiles and Amphibians

Due to overgrazing, agriculture and urban development in the watershed very little information is known about the fauna of this area. Human activities (hunting, agriculture, deforestation, diversion of surface waters for municipal, industrial and agricultural use) have caused the disappearance of many important animal species of the area, particularly larger mammals. The species likely to be present in the area include those that are more more tolerant of human activities or less susceptible to hunting. The list of species that may occur in the Zarqa River Valley area from KTD to the Jordan Valley, including the valley slopes and hillsides, is presented in Annex 2.

One of the reptile species listed in Annex 2, the Mediterranean tortoise is considered endangered[20]. This species is associated with the Mediterranean vegetation on the hillsides

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[19] Anderson, I. J. 1995. The Birds of the Hashemite Kingdom of Jordan. Burns & Harris Ltd. Scotland. 185 pp.

[20] Ministry of Municipal, Rural Affairs and the Environment. 1991. National Environment Strategy for Jordan. IUCN - the World Conservation Union, Gland. 231 pp.

and at higher elevations in the drainage basin and is not expected to occur in the area below Thahab Weir.

5.4.4 Aquatic Fauna

The aquatic animal community present in the river between Thahab Weir and Abu Zeighan Weir may include amphibians (toads, frogs - see Annex 2), a freshwater crab, fish, aquatic insects, microcrustaceans, and algae. The number and diversity of larger aquatic forms, such as fish, is likely limited due to frequent disruptions of flow and eutrophic conditions. Observations of bird activity in the area (kingfishers and herons) indicates that fish and/or amphibians are present. The presence of freshwater crab was also noted. It should be noted that nutrient-enriched water released from KTD may affect the density and types of vegetation and the aquatic community - reducing diversity somewhat and increasing densities of species adapted to eutrophic conditions.

In the area affected by saline inflows, the diversity of the riparian vegetation and aquatic community are restricted to species tolerant of brackish conditions. The aquatic fauna able to tolerate the range of salinities that likely occurs in this area is diverse[21]. Fish populations are likely severely limited by occasional, abrupt interruptions of flow and enriched conditions. There is little information concerning the aquatic invertebrates, but most probably such species are common to flowing wadis and saline springs throughout the Jordan Valley (Annex 3). In this area, channelization of the streambed has occurred, further disrupting the natural communities. The area of saline inflows is also subject to increased human pressure from livestock grazing on vegetation in and adjacent to the stream channel.

5.5 HUMAN ENVIRONMENT

5.5.1 Cultural Resources - Antiquities

The proposed action and feasible alternatives will involve construction-related excavation in areas that have been previously disturbed by installation of ZC I and ZC II and the abandoned canal. No antiquities were reported during construction of those water

[21] Remane, A. and C. Schlieper. 1971. Biology of Brackish Water. John Wiley & Sons, Inc. New York, 372 pp.

conveyance projects. Discussions with the American Center of Oriental Research in Amman[22] have revealed that an Early Bronze Age site, considered potentially highly significant on the basis of a preliminary excavation in 1994, is located on the hillside approximately 300-400 m east-southeast of Abu Zeighan Bridge. The site is at an elevation approximately 10-15 m above the riverbed. No other sites are known in the construction area of the Proposed Action.

On 11 March 1996, a site visit was conducted by Mr. A. Abu Dayyeh, Project Manager, Heritage Resources Project, Department of Antiquities. Mr. Dayyeh found no antiquities along the proposed alignment of the pipeline for the Proposed Action. The Department of Antiquities has stated that they have no objection to construction of the project, "...provided that the Contractor keep this department informed on any antiquities that may be found during construction. A copy of the letter from the Department of Antiquities is included in Attachment 1.

5.5.2 Agricultural Activities

Irrigated agriculture is the main human activity in the area affected by the project. From Thahab Weir to about 0.8 km below Hwarat Weir agricultural activity is restricted largely to cultivation along a narrow floodplain terrace. Three small olive groves (approx. 5 du each) are located on moderate slopes above the floodplain terrace in this area. The area suitable for cultivation is generally restricted to one bank of the river, the river is cutting at the foot of steep slopes on the opposite bank and there is no room for cultivation. The Zarqa Carrier pipelines cross the river at three points between Thahab and Hwarat Weirs thus staying on the side with the broader floodplain terrace. Pressurized drip irrigation of most areas is supported by taps on the ZC I pipeline. The primary crops observed during January 1996 were tomatoes and onions. One farm operation is believed to use a portable irrigation pump to draw irrigation water from the river. There is a plastic greenhouse operation (six greenhouse units) on the left bank of the river about 0.5 km downstream of Hwarat Weir.

From about 0.8 km below Hwarat Weir to Abu Zeighan Weir, the river leaves the foothills and enters the Jordan Valley. The floodplain becomes broader and gently sloping terraces are found along both banks. The areas under cultivation support tomatoes, onions and field

[22] Meeting with Pierre Bikai, Director, American Center of Oriental Research, February 13, 1996.

crops. Citrus orchards (10-20 du) are located to the north of the pipeline corridor and at the western foot of the hill on which Abu Zeighan village is located. A citrus grove is also located on the hillside south of Abu Zeighan village above the edge of a steep riverbank escarpment. Crops are also grown on the hillside south of the river at Abu Zeighan village and about 1.5 km upstream of Abu Zeighan bridge. A pumping station adjacent to Abu Zeighan bridge, situated on a branch from ZC II, pumps water to a reservoir above Abu Zeighan village to support irrigation on the hillside. The hillside farms upstream of the bridge pump water from the river channel (two pumps are visible).

3800 has = 9500 acres = 14.8 mi²

The Proposed Action and feasible alternatives will affect agricultural areas in the central and southern Jordan Valley. The area that will be directly affected by project operation is known as the 18 km Extension Project, an area of approximately 38,000 du comprising JVA Development Areas (DA's) 26, 27 and 28. Additional areas in the Middle Jordan Valley Project's DA 25, served by JVA Pump Station 78 (about 1,000 du), and DA 30 ("Zarqa Zor" - 4,258 du) also use water from the KAC-s. Areas that may be affected during construction include those served by ZC I (DA 29; approximately 10,000 du) and ZC II (DA's 22, 23, 24, and 25; approximately 42,000 du), in the central Jordan Valley. Finally, the area known as the 14.5 km Extension Project will be indirectly affected by project operation. This area of 59,750 du is presently being developed around the Karameh Dam project. When completed in 1997, Karameh Dam will store excess flow from the KAC-s during the winter months. This will include a substantial contribution of flows from KTD and the Zarqa River. This project will pump back stored water during the spring and summer months to support irrigation in the area south of the 18 km Extension Project. Almost all irrigated areas in the central and southern Jordan Valley have been converted from surface irrigation to pressurized drip systems. Plastic greenhouses are widely used for some crops. All irrigation in the Valley will be converted to pressurized drip by 1997[23].

- 250 acres
- 1065 acres
2500 acres
10,500 acres
14,938 acres

The 18 km Extension area presently comprises approximately 70% of the South Shuna (Shuna Janobia) statistical area. This area accounted for about 6.2 percent of the total area under cultivation in Jordan during 1994 (Table 5-3). The Annual Agricultural Statistics for 1994[24] indicate that 34,281 du were cultivated in South Shuna during 1994. This included 15,242 du of fruit (including citrus, bananas, deciduous fruits, grapes, date-palm and olives),

[23] Avedis Serpekian, JVA Operation and Maintenance Department. Personal Communication.

[24] Department of Statistics, Hashemite Kingdom of Jordan. 1995. Annual Agricultural Statistics 1994.

5,522 du of field crops (primarily barley, wheat and maize), 12,366 du of autumn (or winter) vegetables (primarily eggplant, lettuce, squash, broad beans and cauliflower), and 1,151 du of summer vegetables (primarily melons, eggplant and tomatoes). Regarding the distribution of various crops, the southern section of the South Shuna area, the Hisban-Kafrein Project, has relatively high water quality and accounted for over 90 percent of the banana production in the area (9,508 du) while about 75 percent of the production of other fruits and 80 percent of the vegetable production is located in the 18 km Extension[25].

Table 5-3.

Areas (du) under cultivation in Jordan during 1994 for various types of crops[26]

Statistical Area	Fruit	Field Crops	Vegetables (Autumn)	Vegetables (Summer)	TOTAL
Al Aghouar	80,525	43,550	110,966	41,586	276,627
Al Aghouar es-Shamalia	51,582	17,502	29,996	20,145	119,225
Dair Alla	12,115	18,890	35,619	10,949	77,573
Shuna Janobia	15,242	5,522	12,366	1,151	34,281
Gur Essafi	1,585	1,636	35,985	9,341	48,547
TOTAL	161,049	87,100	224,932	83,172	556,253

The area under cultivation in the southern Jordan Valley during 1994 (a relatively dry year) was approximately 63 percent of the total area available (summer vegetables excluded as they represent a "double-cropped" area). Data for 1990[27] (a relatively wet year) indicate that 85% of the area was under cultivation. This illustrates annual variability in land utilization that appears to be driven by water availability. Areas not cropped are left fallow.

[25] JVA. Unpublished data for water allotments, May and November 1994.

[26] Department of Statistics, Hashemite Kingdom of Jordan. 1995. Annual Agricultural Statistics 1994.

[27] Department of Statistics, the Hashemite Kingdom of Jordan. 1991. Annual Agricultural Statistics 1990. Data reproduced in: A. Z. Y. Salman. 1994. On the economics of irrigation water use in the Jordan Valley. Ph.D. Dissertation. University of Hohenheim.

Data for the central Jordan Valley indicate that 52 percent of the farms are owner-operated and the remainder are leased. Hired managers operate about 30 percent of the owner-operated farms and 19 percent of the leased farms[28]. Most lease arrangements involve payment of a flat rate per dunum of land. Share cropping is practiced on about 10 percent of the leased farms. Labor in the agricultural sector is largely provided by foreign laborers. Family labor was used on about 22 percent of the farms[29]. In the South Shuna area during 1994, permanent agricultural labor comprised 435 non-Jordanians and 62 Jordanians, while occasional labor was provided by 3,974 non-Jordanians[30].

The Jordan Valley contains relatively low numbers of livestock, predominantly sheep (116,000) and goats (40,000)[31]. Estimates of the number of livestock in the study area are not available; however, one small farm about 0.8 km from Hwarat Weir maintains a small herd of cows (5-10 head) and several large flocks of sheep and goats were observed in the vicinity of Abu Zeighan. Pastoralists make use of the river for grazing and watering livestock. The heaviest use occurs in the area affected by saline springs and downstream of Abu Zeighan Weir. There is considerable use of fallow fields, and crop stubble for grazing.

5.5.3 Population

The project area lies within the Balqa Governorate. The population of the Governorate in 1994 was 273,489, of which 178,056 (65%) lived in urban areas (population of 5,000 or more). Deir Alla is the largest urban area in the vicinity of the project. Salt is the largest urban area in the Governorate. In general, the population in urban areas of Jordan has been increasing faster than that in rural areas due to both migration from rural areas and The Deir Alla and South Shuna Districts, where the project is located , are largely rural with a population of

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[28] Irrigation Support Project for Asia and the Near East and Water and Environment Research and Study Centre, University of Jordan. 1994. Irrigation management and water quality in the Central Jordan Valley, winter cropping season.

[29] Irrigation Support Project for Asia and the Near East and Water and Environment Research and Study Centre, University of Jordan. 1994. Irrigation management and water quality in the Central Jordan Valley, winter cropping season.

[30] Department of Statistics, Hashemite Kingdom of Jordan. 1995. Annual Agricultural Statistics 1994.

[31] Ministry of Municipal, Rural Affairs and the Environment. 1991. National Environment Strategy for Jordan. IUCN - the World Conservation Union, Gland. 231 pp.

72,482[32]. The population growth rate in the Balqa Governorate is projected at 3.46 percent for 1994-2000. The growth rate is expected to decline in the future; however, the population of the Governorate is expected to double by the year 2015.

There is a large component of non-Jordanians in the population of agricultural areas. About 3/4 of the non-Jordanian farm workers are from other Arab countries, particularly Egypt. Wages for farm laborers in Jordan are about three times higher than wages for similar work in Egypt[33]. About 1/4 of the non-Jordanian agricultural labor is from India and other Asian countries.

Approximately 20 percent of the population aged 15 or older is illiterate[34]. The unemployment rate in 1994 was about 8.6 percent[35]. This represents a decrease in unemployment compared to 1991, when the unemployment rate was 17.0 percent[36]. Nearly 95 percent of all homes have electrical service and 96 percent are connected to the public water network.

5.5.4 Public Health

Water supply shortages are chronic during the summer months, with rationing in many areas of Jordan. This may lead to diseases associated with poor sanitation. During 1994, the Deir Alla Health District reported 1,438 cases of diarrhea (1.2% of cases nationwide)[37]. The national incidence of typhoid and paratyphoid in 1994 (a dry year) was higher than that for 1988-1991 (157 cases). Amoebic diarrhea was reported in 517 cases.

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[32] Department of Statistics, the Hashemite Kingdom of Jordan. 1995. Statistical Yearbook 1994, Number 45.

[33] Salman, A. Z. Y. 1994. On the economics of irrigation water use in the Jordan Valley. Ph.D. Dissertation. University of Hohenheim.

[34] Department of Statistics, the Hashemite Kingdom of Jordan. 1994. Demographic survey, Employment Survey 1993, First Phase, Detailed Results.

[35] Department of Statistics, the Hashemite Kingdom of Jordan. 1995. Demographic survey, Employment Survey 1993, Second Phase, Detailed Results.

[36] Ministry of Planning, Hashemite Kingdom of Jordan. 1992. Plan for Economic and Social Development, 1993-1997.

[37] Ministry of Health. 1994. Annual report of the health monitoring department.

Cases of disease associated with water-related vectors were relatively uncommon. Malaria (246 cases) and bilharzia (1,788 cases) were mainly reported among visiting non-nationals. Mosquitos considered potential vectors of malaria are present in Jordan; however, control programs and the scarcity of standing surface water for breeding have virtually eliminated the disease from the resident population. Bilharzia is not a serious problem because potential host populations of aquatic gastropods are very limited in distribution.

6. ENVIRONMENTAL CONSEQUENCES

The Proposed Action involves construction of a 3.5 km long pipeline diversion around a 4.7 km segment of the Zarqa River. The purpose of the pipeline is to avoid mixing of water intended for irrigation use with water from saline spring inflows. The downstream end of the pipeline will be located at a site (Abu Zeighan Weir) at which essentially all flow in the Zarqa River channel is currently diverted from the river (except during flood periods). The project will affect the area in which the pipeline is constructed, the river segment around which the diversion occurs, a segment of the river downstream of the diversion and an area that is presently under irrigation. The Zarqa River segments affected by the project are presently affected by diversions, thus the project will involve changes in the river segment specific flow regimes associated with the current diversions. The project does not involve development of additional lands for irrigation.

6.1 CONSTRUCTION EFFECTS

6.1.1 Proposed Action - IRR3a

The the ~~proposed pipeline will~~ be approximately 3.7 km in length. The actual area required for construction will be about 10 m wide to allow for excavation, lay-down and backfill storage. The pipeline will follow the abandoned canal for the first 0.5 km, which will result in disruption of cultivated land (vegetables) for about 0.1 km, the remaining land adjacent to the canal in the segment below Hwarat Weir was not under cultivation during winter 1995-96. Tomatoes were under cultivation within 20-40 m of the line in this area.

In the next 1.4 km, the pipeline crosses the river (a bridge will likely be required), and follows the canal alignment. The pipeline alignment traverses cultivated land (vegetables) for about 0.8 km of the 1.4 km. The pipeline passes within 100 m of one dwelling (and within 20 m of one outbuilding housing cows) and 30 m of another dwelling along this segment. Because the pipeline will replace the abandoned canal, the area of cultivated land disturbed by construction in this area will be reduced. At the end of this segment, the pipeline passes within about 30-50 m of a citrus grove.

WHOSE'S RHODO?

The pipeline diverges from the canal alignment and follows along the west side of an existing road to the edge of the river just west of the Abu Zeighan Bridge. In the 0.7 km to the edge of the river, the pipeline traverses cultivated land (vegetables and field crops).

After crossing the river (channel width is approximately 100 m), the pipeline follows a farm road at the foot of the hill on which Abu Zeighan village is situated. The road is adjacent to vegetable fields for approximately 0.3 km and a citrus grove for 0.2 km. Four occupied dwellings and a mosque are on the hillside above the farm road, within 100 m of the pipeline.

For the final 0.4 km segment to Abu Zeighan Weir the pipeline would be in the floodplain at the foot of a 10-20 m escarpment. A citrus grove and vegetable fields are located at the top of the escarpment within 100 m of the proposed pipeline route. The closest approach of the pipeline to the known Bronze Age antiquities site near Abu Zeighan village is approximately 0.5 km.

The total area of cultivated land that potentially would be occupied during construction is approximately 16.3 du that were under cultivation for vegetables and field crops during winter 1996 and up to 0.6 du of citrus grove. = 16.9 du = 1.69 ha = 4.3 acres

Depending on the timing of pipeline construction, the area of vegetables and field crops may be realtively unaffected. Summer construction would avoid damage to seasonal crops. Adverse construction effects on the citrus grove will be avoided or minimized by altering construction practice and conducting all laydown and temporary storage of excavated materials to areas at either end of the segment passing the grove. This would limit the impact area to the width of the trench adjacent to the road. Loss of trees, production from which would require a number of years to replace, can probably be avoided.

Construction will take place adjacent to existing, paved roadways. Dust effects from construction traffic will be limited. Dust generated during excavation and backfilling of the pipeline trench will have temporary effects on dwellings near the alignment. About six dwellings could be affected by dust. If construction occurs during the summer season (May-September), effects on crops will be minimal as no vegetables will be under cultivation during that period. At present, construction has not been scheduled.

Operation of the pipeline will require very little land area. An area approximately 2 m in width, directly over the pipeline will be not be available for cultivation. Although JVA discourages planting of crops directly over buried pipelines, this appears to be a common practice in the project area. In some areas crops are planted over the buried existing pipelines (ZC I and ZC II); however, where the existing pipeline alignments are adjacent to roads, the edges of planted fields are typically 3-5 m from the pipeline alignment. Assuming that no planting will occur over the buried line, approximately 3.8 du of cultivated land will be removed from future production. The canal presently occupies 2.7 du of land in cultivated areas; therefore, the Proposed Action will involve removal of an additional 1.1 du from cultivation.

6.1.2 Canal-Pipeline Combination - IRR3b

Construction effects of this alternative will be essentially the same as those described for the Proposed Action. The existing canal would be demolished and a new canal reconstructed along the original alignment for approximately 2.0 km. The new canal would terminate at a pipeline headworks. The pipeline would branch from the existing canal alignment and over the final 1.7 km follow the route described for the Proposed Action. The canal-pipeline alternative will require that more surface area be permanently removed from production than the pipeline described as the Proposed Action. Assuming that no planting will occur within one meter of the new, 2.0 m wide canal, approximately 5.6 du of cultivated land will be excluded from future production. The existing canal presently occupies approximately 2.7 du of land in cultivated areas; therefore, this alternative would result in removal of an additional 2.9 du from production. = .29 ha = 0.725 acres

Operation of the canal, rather than the proposed pipeline, may increase the potential for contamination of irrigation water from irrigation return flows or fertilizer and pesticide spills. The position of the canal adjacent to existing roads also brings about the opportunity for contamination from fuel spills of vehicle accidents.

6.1.3 Pipeline from Thahab Weir to Abu Zeighan Canal - IRR1

The the proposed pipeline will be approximately 6.6 km in length. The actual area required for construction will be about 10 m wide to allow for excavation, lay-down and backfill storage. The pipeline will parallel the alignment for the existing ZC I and ZC II pipelines.

In the first 0.2 km, installation of a new pipeline from the weir to the settling basin and expansion of the settling basin will be necessary. The area around the basin has been stripped to the subsoil by previous construction and there is sufficient room to carry out the expansion within the disturbed area without affecting crops or natural vegetation. There is a small olive grove (young trees) on the hillside south of the settling basin, within about 50 m of the basin.

There are approximately 0.1 km of cultivated areas (onions) near the pipeline alignment (which is along the right, or north, bank) for the next 0.6 km. A small olive grove (mature trees) with grape trellises along the roadside occurs on both sides of the road for the 0.1 km. The section of grove on the north side of the road continues for another 0.1 km. There is no cultivation for the next 0.1 km to the first stream crossing.

The pipeline crosses the river twice at a meander in the channel in the next 0.4 km. There was no cultivation along this segment of the pipeline alignment. Cultivation along the floodplain terrace on the left (south) bank is supported by a tap on the ZC I line between the two crossings.

For the next 1.1 km the pipeline alignment is adjacent to the paved road. There are two cultivated areas (vegetables) alongside the road in this segment (0.6 km total). Cultivation (field crops and vegetables) also occurs on the opposite bank of the river, within 100 m of the alignment, for about 0.3 km along this segment.

The pipeline branches off from the paved road and crosses the river, passes through a cultivated area (vegetables) and past six plastic greenhouses for 1.0 km. Three dwellings are located on the hillside above the pipeline and within 100 m of the proposed alignment in this area. This segment ends at the edge of the river at the crossing point for the abandoned canal.

In the next 1.3 km, the pipeline crosses the river, passes within 20 m of one dwelling (and one outbuilding housing cows) and traverses cultivated land (vegetables) for about 0.8 km of the 1.3 km.

The pipeline diverges from the canal alignment and follows along the west side of an existing road to the edge of the river just west of the Abu Zeighan Bridge. In the 0.7 km to the edge of the river, the pipeline traverses cultivated land (vegetables and field crops).

After crossing the river (channel width is approximately 100 m), the pipeline follows a farm road at the foot of the hill on which Abu Zeighan village is situated. The road is adjacent to vegetable fields for approximately 0.3 km and a citrus grove for 0.2 km. Four occupied dwellings and a mosque are on the hillside above the farm road, within 100 m of the pipeline.

For the final 0.4 km segment to Abu Zeighan Weir the pipeline would be in the floodplain at the foot of a 10-20 m escarpment. A citrus grove and vegetable fields are located at the top of the escarpment within 100 m of the proposed pipeline route. The closest approach of the pipeline to the known Bronze Age antiquities site near Abu Zeighan village is approximately 0.5 km.

The total area of cultivated land that potentially would be occupied during construction is approximately 22.6 du that were under cultivation for vegetables and field crops during winter 1996, 0.3 du of olive grove and up to 0.6 du of citrus grove. =23.2 du = 2.32 ha (5.8 acre)

Depending on the timing of pipeline construction, the area of vegetables and field crops may be realtively unaffected. Summer construction would avoid damage to seasonal crops. Construction of the pipeline will likely involve removal of some trees in the olive grove. Mitigation for this loss will be required. Adverse construction effects on the olive and citrus groves will be avoided or minimized by altering construction practice and conducting all laydown and temporary storage of excavated materials in areas at either end of the segment passing the grove. This would limit the impact area to the width of the trench adjacent to the road. Loss of trees, production from which would require a number of years to replace, can probably be avoided in the citrus grove.

Construction will take place adjacent to existing, paved roadways. Dust effects from construction traffic will be limited. Dust generated during excavation and backfilling of the pipeline trench will have temporary effects on dwellings near the alignment. About nine dwellings could be affected by dust. If construction occurs during the summer season (May-September), effects on crops will be minimal as no vegetables will be under cultivation during that period. At present, construction has not been scheduled.

Operation of the pipeline will require very little land area beyond that occupied by the settling basin (0.25 du) and the weir. An area approximately 2 m in width, directly over the pipeline will be not be available for cultivation. Although JVA discourages planting of crops directly over buried pipelines, this appears to be a common practice in the project area. In some areas crops are planted over the buried existing pipelines (ZC I and ZC II); however, where the existing pipeline alignments are adjacent to roads, the edges of planted fields are typically 3-5 m from the pipeline alignment. Assuming that no planting will occur over the buried line, approximately 7.0 du of cultivated land and 0.3 du of olive grove will be removed from future production.

6.2 EFFECTS ON STREAMFLOW AND WATER QUALITY

6.2.1 No-Action Alternative

Presently (under the no-action alternative), flows of up to 2.8 m^3/s (maximum combined flow for ZC I and II) are diverted from the Zarqa at Thahab Weir. Flow in excess of the irrigation requirement for ZC I and II is passed at Thahab Weir and continues downstream approximately 9.9 km to Abu Zeighan Weir where it is diverted, via Abu Zeighan Canal, to KAC. The present diversion affects the Zarqa River between Thahab Weir and the Jordan River (a distance of approximately 27 km). Because water is released from King Talal Dam (KTD) to support irrigation, flows in the Zarqa River rarely exceed the quantity required for the irrigation diversions at Thahab and Abu Zeighan Weirs. Thus, excepting the diverted saline spring flows of approximately 80 L/s, the present situation involves diversion of virtually all flows from the 17 km river segment below Abu Zeighan Weir.

The river segment from Thahab Weir to Abu Zeighan Weir experiences very variable flows. Based on the maximum irrigation requirement for the KAC-s, the annual range in average monthly flows below Thahab Weir is from 160 L/s to approximately 1.6 m^3/s with peak flows of about 2.5 m^3/s[35]. Natural flood flows are higher, but occur infrequently. Low flows often occur during periods of natural rainfall and there may be no release at Thahab Weir for extended periods during the winter months[36]. Operation of ZC I and II may result in diversion of all flow reaching Thahab Weir except for a small overflow from the settling

[35] Harza and Consolidated Consultants. 1996. *Op. cit.*

[36] JVA, unpublished data.

basin. The settling basin overflow return channel enters the Zarqa about 2.3 km downstream of Thahab Weir, thus the 2.3 km reach below Thahab Weir experiences complete dessication from time to time. The vegetation in the reach between Thahab Weir and the settling basin return is typical of species adapted to periodically saturated conditions, being dominated by oleander and tamarix with scattered clumps of common reed. The settling basin overflow is on the order of 10-20 L/s. This overflow appears to be sufficient to maintain vegetation requiring more or less continuously saturated substrates such as cattails, rushes and sedges, in the reach downstream.

The river segment from Hwarat Weir to Abu Zeighan Weir is affected by year-round spring inflows, some of geothermal origin. The mixed inflow from springs in this segment has a high salinity (EC of approximately 7-9 dS/m). Appreciable inflows begin to occur approximately 1.3 km below Hwarat Weir. Total flow accumulation at Abu Zeighan Weir is 150-300 L/s from springs in the segment below Hwarat Weir. Due to their highly saline nature, the springs adversely affect water quality in the KAC during periods when flow below the Thabab Weir is relatively low.

For several years, JVA has channelized the streambed, dividing it into two separate channels, for a distance of approximately 2.4 km above Abu Zeighan Weir. This measure partially separates saline spring inflows from the fresh water flowing downstream of KTD. Upstream of the channelized area, the sources of saline inflow are too widely dispersed over the width and length of the channel to separate them from the freshwater flow. Thus, the main channel carries a mixed saline and freshwater flow to the entrance of the Abu Zeighan Canal. The secondary channel diverts approximately 25-40% of the saline inflow (about 80 L/s) over the Abu Zeighan Weir to continue downstream.

Channelization of 2.4 km of the river above Abu Zeighan Weir was done in response to problems with salinity in KAC that occurred during 1993 and 1994. Prior to channelization all flow was diverted to KAC at Abu Zeighan Weir. Channelization has had some unanticipated negative benefits on water quality as a "new", relatively high-volume saline spring developed in the channelized reach in 1995. Adoption of the no-action alternative would thus result in a release of approximately 80 L/s of saline water immediately below Abu Zeighan, assuming that the annual channelization program is continued in the future. Although channelization has had a limited effect in improving water quality of the KAC-s, it would be expected to continue under the No-Action Alternative.

6.2.2 Diversion at Hwarat Weir

Both the Proposed Action (IRR3a) and the Canal-Pipeline feasible alternative (IRR3b) would involve a diversion at Hwarat Weir. The existing diversion at Thahab Weir would continue to operate. The reach of the Zarqa River between Thahab Weir and Hwarat Weir would continue to experience fluctuating flows with periods of little or no flow during the winter months, as would occur if the No-Action Alternative were adopted.

Zarqa River between Hwarat Weir and Abu Zeighan Weir

The 4.7 km reach of the Zarqa River between Hwarat Weir and Abu Zeighan Weir will be subject to dessicaton of the streambed for approximately 1.3 km downstream. This area will receive minimal flow from leakage at Hwarat Weir and occasional flood flows during wet periods when the flow from wadis exceeds the irrigation requirements for ZC I, ZC II and the KAC-s.

↓ 1.3 km habitat lost

The remainder of the reach will receive inflows from springs and seeps. The mixed inflows are predominantly brackish in the mesohaline range (EC 7-9 dS/m). This equates to a reduction in the present range in EC which is about 1.5-10 dS/m depending on the flow from KTD which is passed through the reach. Because water originating at KTD typically will not be present in this reach in large quantities compared to the inflows from springs, the water will be relatively free of bacteria contamination and nutrients.

↓ water Q ↑ for bacteria + nutrients; H_2O Vol ↓.

Zarqa River between Abu Zeighan Weir and the Jordan River

Water entering the channel between Hwarat and Abu Zeighan Weirs from seeps and springs will be passed over Abu Zeighan Weir and allowed to continue downstream for approximately 17 km to the Jordan River. This represents a net gain in flow of 70-220 L/s (depending on seasonal variations in spring flow and assuming that channelization continues) in the reach downstream of Abu Zeighan Weir compared to the No-Action Alternative. No information on water quality in the reach below Abu Zeighan Weir was available; however, some springs are known to occur along the river channel below Abu Zeighan Weir. Water quality is likely to be similar to that in the reach above the weir.

↓, Volume ↑.

Irrigated Areas along the KAC-s

Changes in water quantity and water quality in the areas along the KAC-s depend on several factors including the quantity of high quality water from the Yarmouk River that is available to the KAC-s. The recently completed peace treaty with Israel increases the amount of Yarmouk water potentially available to Jordan by about 140 Mm^3/yr. The ultimate destination for this water will be greater Amman, where water shortages are chronic and the gap between municipal and industrial water demand and water availability is increasing. Demand projections developed by Harza Group[37] indicate that the water supply shortfall for all uses will be 429 Mm^3/yr by the year 2000, even considering the peace treaty water rights. Thus, it is unlikely that the supply of Yarmouk water for irrigation will increase. There may be an increase in supply during the first year or two of the project; however, that will rapidly be lost and only excess (flood) flows will be available during winter months in the future.

The quantity of water available in the KAC-s would be expected to decrease somewhat due to the bypassing of 150-300 L/s of saline waters, approximately 70-220 L/s of which are now mixed with KTD water prior to diversion to the KAC-s. However, since the volume of water released at KTD is regulated to meet irrigation requirements, it does not appear that there will be an appreciable change in water delivery. EC of water in the KAC-s will improve compared to that which would occur with the No-Action Alternative.

To assess project effects on EC in the KAC-s, five years of monthly average EC data (1991-1995) were used to compute monthly mixing ratios for water from the Zarqa River at Abu Zeighan with water from the KAC-n (Yarmouk River). The mixing ratios (Annex 4) were applied to KTD EC data to obtain the monthly average EC that would have occurred in the KAC-s had the project been operating. Table 6-1 presents the annual average EC's and the average EC's for typical winter and summer growing periods.

[37] Harza Group. 1995. The Water Conveyance System from Disi-Mudassara to Amman, Draft Conceptual Study Report, Vol. 3, Formulation and Development of System Components.

Table 6-1.

Average EC's (dS/m) in the KAC-s for Various Growing Periods

"Without" represents the average of observed monthly average values; "With" represents the predicted value that would have occurred had the project been in operation.

YEAR	Annual Average EC		SEPT-FEB Average EC (Winter Crops)		MAR-JUN Average EC (Summer Crops)	
	Without	With	Without	With	Without	With
1991	1.90	1.78	2.20	2.17	1.89	1.80
1992	1.20	1.12	1.46	1.38	1.13	1.05
1993	1.97	1.63	1.39	1.33	1.81	1.53
1994	2.44	1.66	2.50	1.86	2.50	1.89
1995	1.99	1.36	1.95	1.55	2.30	1.41

The results presented in Table 6-1 indicate that during 1991 and 1992, the project would have had little effect on water quality in the KAC-s. In 1994 and 1995, the project could have produced agriculturally significant reductions in EC. The mean reduction in average annual EC due to the project would have been 0.39 dS/m from 1991-1995. The project's potential effects on EC in the KAC-s are controlled by interacting factors; however, the volume of water released at KTD has a substantial influence on the magnitude of change observed. Large volumes (greater than 2-3 m^3/s) of KTD water tend to dilute the saline seepages to a point where they effect only a small change in the EC; thus the project has little effect. During periods when flows bypassed at Thahab Weir are substantially less than 2 m^3/s, bypassing the saline springs will be very effective at reducing EC in the KAC-s.

If water from the KAC-n is not available for mixing with Zarqa water, the impact of the Proposed Action on irrigation water quality will depend solely on the quantity of water passed at Thahab Weir. Figure 6-1 illustrates this impact for a saline spring flow of 150-300 L/s; saline spring EC of 8 dS/m and an EC for KTD water of 1.88 dS/m (the average for September 1990 - September 1995; see Annex 4). At flows of up to 1,400 L/s at Thahab Weir, the saline springs could reduce the suitability of water for irrigation to the "Severe Restriction" level. At flows of less than 1,600 L/s at Thahab Weir (the estimated maximum

monthly irrigation requirement for the 18 km Extension), the saline springs cause appreciable salinity degradation of water delivered to the KAC-s. In this case, the Proposed Action would produce a decrease in EC of 0.5-1.0 dS/m, which would be equivalent to a minimum 7.5 percent increase in tomato production or a minimum 11.9 percent increase in citrus (oranges) production[38]. Even at the project design flow of 4,500 L/s, the decrease in EC is greater than 0.3 dS/m.

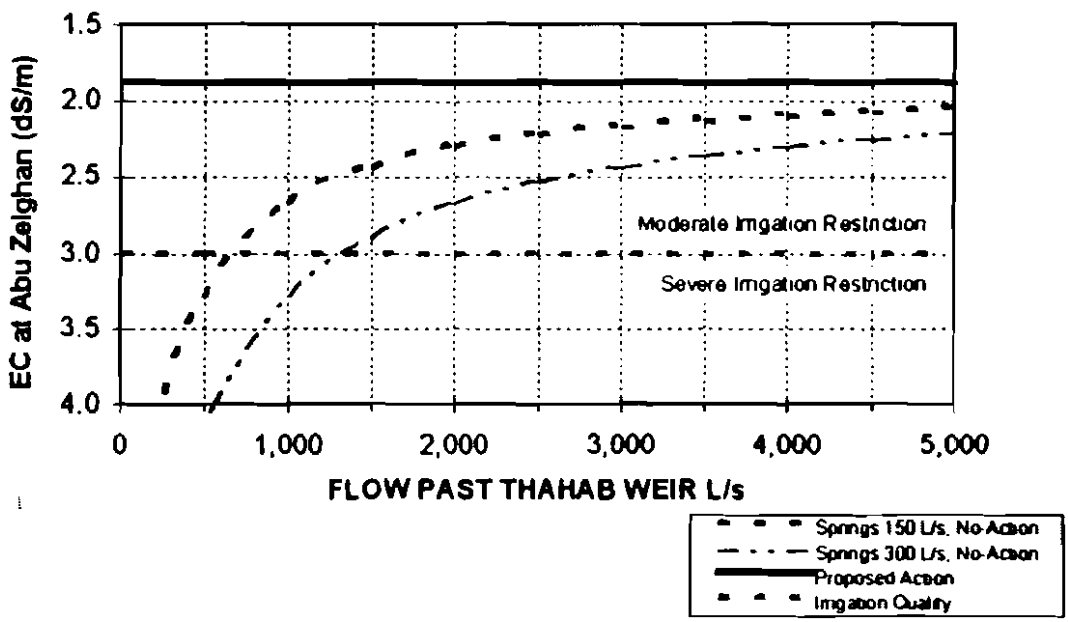

Figure 6-1. Predicted salinity in Abu Zeighan Canal relative to flow at Thahab Weir. For saline spring flows of 150 L/s and 300 L/s under No-Action Alternative. (Saline Springs EC = 8.0 dS/m; KTD EC = 1.88 dS/m)

An additional effect of the project, not readily observed in the long-term average data presented above is the elimination of episodic high salinity events in the KAC-s. For example, during January 1994, the daily average EC in the KAC-s exceeded 3.0 dS/m on 9 of 24 days on which EC was measured (maximum > 7.7 dS/m during one two-day period); however, the monthly average for January 1994 was 2.11 dS/m. Overall, during a two-year period of daily monitoring (Saturday-Thursday) from April 1993 through March 1995, there were nine months during which daily average EC's in the KAC-s exceeded 3.0 dS/m (31 days in 20 separate events). Events occurred during summer (June -September), through autumn

[38] Ayers, R. S. and D. W. Westcot. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper No. 29, Rev. 1. United Nations Food and Agriculture Organization, Rome.

and winter (October - early February) in both 1993 and 1994, with most events occurring in 1994. Had the project been operating, only two separate events totalling 3 days of high salinity would have occurred during the two-year period (in January-February 1994).

The occurrence of high salinity events has serious implications for sensitive vegetable crops, such as string beans, carrots and onions. Even a few days irrigation with very saline water can result in substantially more damage (possibly total loss) than a long-term average for the growing season would suggest. The project will prove very effective in limiting the potential for damage due to periodic high salinity events.

Dilution with saline spring water and assimilation in the reach between Thahab Weir and Abu Zeighan Weir may reduce nutrient concentrations in water reaching the KAC-s. Operation of the project might be expected result in somewhat higher concentrations of ammonia and nitrate in KAC-s waters compared to the No-Action Alternative; however, observed changes in nutrients indicates that such effects may be seasonal and assimilation is not appreciable (Section 5.2). Some small assimilation or dilution of nutrients will be lost by diverting water through the pipeline. This is not necessarily a negative impact as the nutrients in the water can reduce fertilizer applicatons. Water quality data for two irrigation returns in the central Jordan Valley areas served by ZC I and ZC II indicates that farmers do not account for this nutrient enrichment of irrigation water in their fertilizer application[39]. Failure to account for excess nutrients in the source water presently contributes to excessive nutrient enrichment in the Jordan River.

Average concentrations of trace metals in the water released at KTD were found to be well within the suggested guidelines for irrigation waters and not appreciably different from average concentrations in the KAC-n[40]. Project operation is not expected to affect trace metal concentrations.

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[39] Water and Environment Research and Study Center - University of Jordan. 1995. Irrigation management & water quality in the Central Jordan Valley (Baseline Survey). Water Quality Improvement and Conservation Project, Report 3114-95-3b-05.

[40] Water and Environment Research and Study Center - University of Jordan. 1995. Irrigation management & water quality in the Central Jordan Valley (Baseline Survey). Water Quality Improvement and Conservation Project, Report 3114-95-3b-05.

6.2.3 Diversion at Thahab Weir

Thahab Weir to Hwarat Weir

In addition to the having all streamflow and water quality impacts described for the Proposed Action and the canal-pipeline feasible alternative, the feasible alternative involving a pipeline from Thahab Weir to Abu Zeighan Weir (IRR1) would affect flow and water quality in the reach between Thahab Weir and Hwarat Weir. This 5.2 km reach of the Zarqa River will be subject to dessicaton of the streambed for its entire length. This area will receive minimal flow from baseflow and/or leakage at Thahab Weir. Occasional flood flows will occur during wet periods when the flow from upstream side wadis exceeds the irrigation requirements for ZC I, ZC II and the KAC-s. The catchment of this reach is small and steep-sided. The contribution of rainfall runoff from side wadis along the reach to flow in the reach is likely to be short-lived and limited in quantity. The reach was judged to be possibly a gaining or losing reach[41], thus, baseflow may contribute a small continuous flow to the reach. The magnitude of such a contribution to flow, if any, is likely to be small and any springs or seeps are likely to disappear during dry periods.

There is no information available to allow an accurate prediction as to water quality if the project is operating and no KTD water is passed to the reach from upstream. Given that the Upper Aquifer Complex (Kurnub Formation) is exposed along this segment of the river, it is likely that water will be fresh to slightly brackish if groundwater springs and seeps are present. Operation of the settling basin at the headworks to the pipeline may continue to provide a small flow of fresh water in the river downstream. Such flow would be expected to support continued presence of emergent vegetation in the river channel. There would probably be a shift in emergent species toward a predominance of reeds, which are more tolerant of temporary dessication than some of the other species present. Oleander and tamarix at the stream margins may thin out somewhat as competition for water increases in the presence of much-reduced occurrences of innundation of the channel margins; however, this vegetation is expected to remain at moderate to high density.

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[41] Harza Engineering and Consolidated Consultants. 1996. Zarqa River Conveyance Study, Phase A - Conceptual Study, Part 3 - Selection of Preferred Alternative.

Hwarat Weir to Abu Zeighan Weir

Effects of the alternative on this segment of the Zarqa River will be the same as the effects described under Section 6.2.2.

Abu Zeighan Weir to Jordan River

Effects of the alternative on this segment of the Zarqa River will be the same as the effects described under Section 6.2.2.

Irrigated Areas along the KAC-s

Effects of the alternative on irrigated areas will be the same as the effects described under Section 6.2.2.

6.3 GROUNDWATER

Due to its salinity, groundwater in the project area is generally unsuitable for for irrigation, domestic or industrial uses. Wells drilled in the area had EC's ranging from 8 to 15 dS/m. The groundwater is under pressure, as evidenced by the flowing saline springs along the river channel between Hwarat and Abu Zeighan Weirs. Several sources have geothermal origins. Other than pastoralists who may make use of the less saline springs for watering livestock, there are no known users of groundwater in the area that will be affected by the project.

As described in Section 5.1.4, the major area of groundwater recharge is located in the highlands. The groundwater in the project area derives from sources that are spatially and temporally separated from water flowing from springs in the Jordan Valley. In addition, water from test wells has generally been found to be more saline than spring water flowing into the Zarqa River channel. Changes in groundwater quality are not expected as a result of project operation.

In the areas irrigated from the KAC-s, operation of the project will probably result in a small decrease in salinity of irrigation return flows. Monitoring of return flows in the central Jordan Valley in 1993-1994 indicated that these flows typically have average salinities in the

range of 3-6 dS/m. Effects of return water on groundwater won't be appreciable because groundwater salinities are expected to be higher than the 3-6 dS/m observed in return flows[42] and appreciable recharge probably is not occurring.

6.4 WILDLIFE AND AQUATIC RESOURCES

The major impact of project operation will be dessication of the streambed for some distance downstream from the intake structure for each conveyance alternative. At present, the natural riparian and streambed vegetation includes plant species adapted to wet, or frequently wet conditions. These are dominated by, and sedges, rushes, common reed and cattails in the wet areas of the streambed. Oleander and tamarix are also present in areas experiencing occasional innundation.

6.4.1 Diversion at Hwaret Weir

The Proposed Action and the canal-pipeline alternative will divert water from approximately 4.7 km of river channel between Hwarat and Abu Zeighan Weirs. Approximately 1.3 km can be described as freshwater habitat and the remainder as brackish. The freshwater habitat will be affected significantly by dessication, and appreciable loss of emergent aquatic vegetation is expected. It is likely that plant species adapted to periodic wet conditions, particularly oleander and tamarix will replace the sedges and cattails. Common reed is likely to increase in abundance and become more widely distributed because it is more tolerant of fluctuations in water level and dessication.

Structural diversity of the vegetation is likely to be reduced in the absence of continuous flow in the reach. This will, in turn, reduce the suitability of the streamside habitat for some bird species (e.g. wading birds). However, the remaining tamarix and oleander will likely offer acceptable resting habitat for migratory songbirds and related species.

Fish and aquatic animals inhabiting the upstream segment of the reach will likely be lost from that segment due to dessication. In the lower parts of the brackish segment, suitable habitat will remain for fish and aquatic invertebrates. Amphibians are unlikely to reproduce at the salinities found in the brackish segment. Amphibian populations dependent on the

[42] Water and Environment Research and Study Center - University of Jordan. 1995. Irrigation management & water quality in the Central Jordan Valley (Baseline Survey). Water Quality Improvement and Conservation Project, Report 3114-95-3b-05.

freshwater reach for reproduction may be maintained through use of temporary pools left after high flow events.

Effects on the brackish habitat will be less pronounced as inflow from saline springs will be maintained; however, transitional freshwater-brackish habitat will be lost and salinity will increase and remain relatively constant in remaining habitat. Compared to present conditions, channelization of 2.4 km of the streambed will no longer occur and a more natural riparian and aquatic community, adapted to brackish conditions, may develop. Oleander, because it is both salt tolerant and toxic to livestock is likely to become more abundant.

6.4.2 Diversion at Thahab Weir

The diversion at Thahab Weir will divert water from 9.9 km of river channel. Approximately 6.5 km of this reach can be characterized as freshwater riparian habitat. This will constitute a 5.2 km increase in the length of channel subject to dessication and degradation of riparian habitat. Effects on both freshwater and brackish water habitat will be similar to that described above.

6.4.3 Habitat Downstream of Abu Zeighan Weir

Increased flow in the river channel downstream of Abu Zeighan Weir will result from implementation of the Proposed Action or either feasible alternative. The increase in surface water may provide improved opportunity for use of this reach by transient shorebirds, wading birds and ducks. The lack of cover and level of human activity in this area will, however, limit its immediate attractiveness to many species. Habitat for migratory birds and other small wildlife will probably increase over time with the invasion of halophytes such as oleander and common reed that can take advantage of the availability of saline water.

Use of this stream segment by fish and aquatic invertebrates adapted to brackish conditions is likely to increase. Invasion of species from the Jordan River is likely to occur and such species are likely to become established over a period of time. There will be a large net increase in aquatic habitat in this area.

6.4.4 Habitat in Irrigated Areas

The project is not expected to result in any changes in habitat in irrigated areas. Wildlife habitat in irrigated areas will be similar to that found under the No-Action Alternative.

6.5 SUITABILITY OF WATER FOR AGRICULTURE AND OTHER USES

Under the No-Action Alternative, water in the KAC-s is suitable for irrigated agriculture with moderate to severe restrictions due primarily to salinity, chloride and bacterial contamination. Salinity will be variable and may reach levels implying severe restriction for agricultural use (>3.0 dS/m) for short periods of time. Coliform bacteria contamination is frequently greater than 1,000 MPN/100 ml, which indicates that water should be used only for crops that are cooked completely before eating. Adverse salinity and chloride conditions result primarily from the diversion of water from the Zarqa River. Bacterial contamination of water in the KAC-n, while lower than that in the Zarqa, is high enough to restrict irrigation only to crops that will be cooked completely.

6.5.1 Cultivated Areas

The Proposed Action and both feasible alternatives will have identical effects on salinity and chloride in the KAC-s. The average salinity and average chloride concentrations will be reduced. Bacterial contamination levels will not change appreciably. The changes in water quality are expected to benefit agricultural users along the KAC-s (see Section 6.8).

6.5.2 Pastoral Uses

Diversion of KTD water will result in reduced availability of water for livestock use along the river channel between Hwarat Weir (or Thahab Weir in the case of alternative IRR1) and Abu Zeighan Weir. Available water will derive from saline springs an seeps in the area downstream of Hwarat Weir. Water with EC's of less than 5 dS/m are considered "very satisfactory" for livestock use with little chance of economic loss or physiological disturbance

of the animals[43]. Salinities in the 5-8 dS/m range are considered "satisfactory" for livestock use. Water with higher EC's (8-11 dS/m) is suitable for "limited use" with dairy and beef cattle, sheep, swine and horses, but its use should be avoided for pregnant or lactating animals1. EC's above 16 dS/m are "not recommended" for livestock. The groundwater data presented in Section 5.1.4 indicates that saline spring inflows could have EC's on the order of 5-10 dS/m. Daily monitoring at Abu Zeighan Weir reported a maximum EC of 8.7 dS/m with most readings during periods when essentially no water was being passed at Thahab Weir of 8.0 dS/m or less during April 1993 - March 1995. It is likely that EC's in during project operation will be in the "satisfactory" range for livestock use. Livestock use of the Zarqa River channel between Hwarat and Abu Zeighan will not be precluded by diversion of KTD water.

Water from the springs will be relatively uncontaminated by coliform bacteria as compared to KTD water. Although there is no information available on the incidence of water-borne diseases among livestock, this may prove beneficial as livestock will be less exposed to potential disease organisms.

The channel downstream of Abu Zeighan Weir had, for a number of years, received only occasional flow from upstream during high flow periods. The channelization of the Zarqa to divert saline inflows over the weir provides a supplementary water source for use by grazing livestock in the streambed downstream of Abu Zeighan. The quality of this water should be similar to that upstream and is expected to be "satisfactory" for livestock use. Because the channelized condition is considered representative of the No-Action Alternative, the Proposed Action and feasible alternatives will not affect suitability of water for downstream uses; however, the quantity of water available will increase.

6.5.3 Other Uses

Zarqa River water is used for washing clothing, wool, agricultural equipment and vehicles and gravel mined in and adjacent to the channel. The level of salinity in the spring water is not likely to preclude any of those uses. In fact, reduced contamination from fecal coliform

[43] Ayers, R. S. and D. W. Westcot. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper No. 29, Rev. 1. United Nations Food and Agriculture Organization, Rome.

bacteria is expected to occur, thus the quality of the water for any activities involving human contact will improve from the human health standpoint.

6.6 MAINTAINING PRODUCTIVITY OF AFFECTED LANDS

Salinity buildup in soils undergoing irrigation is a concern where the source water has a relatively high salinity, evapotranspiration rates are high and rainfall is scarce. JVA has unpublished data for the central Jordan Valley that have indicated some salinity build-up in soils irrigated with water from KTD during dry years. During years with ample rainfall locally, or availability of excess water from KAC-n, it has been possible to conduct leaching and to maintain soil productivity[44].

By virtue of reducing salinity in water delivered to the areas irrigated from the KAC-s, the project will slightly reduce salinity buildup in soils in the affected area.

6.7 CROP PRODUCTION - PRIMARY BENEFITS OF THE PROJECT

Assessment of the effects of the project on crop production and economic returns in the affected area was based on water quality data collected by JVA at key locations in the irrigation system and on economic data obtained from results of two surveys of randomly selected farms in the central and southern Jordan Valley. Data on cropping patterns for the southern Jordan Valley was obtained from published statistics and from unpublished data provided by JVA. The assessment approach involved estimating EC effects on the percentage yield of individual crops grown in the southern Jordan Valley during the 1990-91 through 1994-95 growing seasons. Observed EC data for the KAC-s were used to estimate what percentage of the theoretical maximum yield was obtained under existing conditions. Predicted EC data (Annex 4) were used to estimate the percentage of maximum yield that would have been obtained had the Zarqa Conveyor Project been in operation during those growing seasons. The ratios of the predicted percentage yields with and without the project were then used to estimate the change in economic returns that could be attributed to the project.

[44] Rassem Anshasi, JVA, Water Quality Laboratory. Personal Communication.

The economic data used in the study came from two sources covering different periods and areas in the Jordan Valley. Two percentage yield estimates were developed for each crop during each of the five growing seasons. These sources provided farm level economic data for the 1991-1992 season in the southern Jordan Valley[45] and for the 1993-1994 season in the central Jordan Valley[46]. Data were available for most of the more widely planted crops and for several technologies (surface irrigation, drip irrigation, drip irrigation in plastic tunnels, and drip irrigation in plastic greenhouses). The 1991-1992 data were collected during a wet period when EC's in the KAC-s were relatively low and the total area of agricultural production was relatively high due to plentiful water from rainfall. During this study, crop production was likely minimally affected by salinity. Predicted yields for most crops were in the 90-100 percent range, based on known salinity vs. crop production relationships[47].

The 1993-94 study in the central Jordan Valley study was conducted in an area that presently receives water that is diverted from the Zarqà River at Thahab Weir. The study was conducted during a period of low rainfall and relatively high EC's. The total area of agricultural production in the southern Jordan Valley during this study was low relative 1990 due to lack of sufficient rainfall to supplement supplies from the irrigation system. Based on known salinity vs. crop production relationships, production of most crops in the study area was in the 60-95 percent range.

In the assessment of crop production, costs were treated as fixed, that is, additional production was not considered to require additional labor for harvesting. In addition, it was assumed that market prices for the crops produced would not be affected by any additional production resulting from improved water quality. The latter assumption appears justified in that the area directly affected by the project is approximately 10 percent of the total agricultural area of the Jordan Valley and the maximum impact of the project on overall yield is on the order of a 10 percent increase. Thus the overall impact on crop production in

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[45] Salman, A. Z. Y. 1994. On the economics of irrigation water use in the Jordan Valley. Ph.D. Dissertation. University of Hohenheim.

[46] Water and Environment Research and Study Center - University of Jordan. 1995. Irrigation management & water quality in the Central Jordan Valley (Baseline Survey). Water Quality Improvement and Conservation Project, Report 3114-95-3b-05.

[47] Ayers, R. S. and D. W. Westcot. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper No. 29, Rev. 1. United Nations Food and Agriculture Organization, Rome.

the Jordan Valley is on the order of 1 percent and would be considered unlikely to have a major impact on market prices of crops.

The assessment approach involved the following analyses:

- Monthly average EC data collected at three key locations (KAC-s, KAC-n and Abu Zeighan) from the beginning of the growing season in the 1991 water year (September 1990) through the end of 1995 were analyzed to determine the average monthly mixing ratio between the KAC-n of the Zarqa River and water from the Zarqa that was diverted through the Abu Zeighan Canal to the KAC-s.

- The mixing ratio was used to predict the maximum monthly average EC's that would have resulted had the project been in operation during the period in question. Monthly average EC data for samples collected at King Talal Dam were used in place of monthly average EC values for samples from Abu Zeighan Weir and "mixed" with KAC-n water assuming that the mixing ratio did not change. This provided estimates of the monthly average EC's in the KAC-s had the project been in operation (i.e., no mixing with saline spring inflows between Hwarat and Abu Zeighan Weirs).

- The observed average monthly EC data for the KAC-s were used to develop average EC's over the irrigation period for each crop (representing growing conditions without the project). The predicted EC's for the KAC-s that would have occurred had the project been operating were used to develop average EC's over the irrigation period for each crop (representing growing conditions with the project).

- The effect of EC on each crop was evaluated using the EC vs. crop yield relationships from the literature[48]. This provided an estimated percentage crop yield for the average EC occurring during the irrigation period. Crop yields were estimated both with and without the project. Where the relationship was not available for a specific crop, the relationship for a related crop was used as a surrogate.

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[48] Ayers, R. S. and D. W. Westcot. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper No. 29, Rev. 1. United Nations Food and Agriculture Organization, Rome.

- Cropping pattern data for individual crops grown in the southern Jordan Valley (Shuna Janobia) were obtained for 1990[49] and for 1994[50].

- The cropping data includes the area of the southern Jordan Valley that will be affected by the Zarqa Conveyance Project, the 18 km Extension, and an area, Hisban-Kafrein, that will not be affected by the Zarqa Conveyance Project. Data provided by JVA for areas of general crop types (e.g., citrus, bananas, fruit trees, "wheat" and vegetables) under irrigation in 1994 in the 18 km Extension and the Hisban-Kafrein areas were used to prorate the cropping data to estimate the acreages in each crop category that were under production in the 18 km Extension area.

- Data estimating average unit production costs (JD/du) and unit economic returns (JD/du) for Jordan Valley farm enterprises were compiled[51,52]. In instances where economic data were not available for a crop appearing in the cropping pattern (all such crops are referred to as "other"), the area-weighted average costs and returns for all drip-irrigated crops were used. Separate area-weighted average unit returns were developed for the 1991-92 and 1993-94 data sets.

- Estimated percentage crop yields for the base period (1991-92 or 1993-94) in which crop economic data were collected were calculated using the observed EC values for those years and for the areas (central or southern Jordan Valley) from which data were obtained. The ratio of the estimated percentage yield for the base period to the estimated percentage yield in the 18 km Extension area, determined using observed EC data for the KAC-s, was multiplied by the unit return (JD/du) in the base period to estimate the unit return for each crop. Estimates of unit returns were developed for

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[49] Department of Statistics, the Hashemite Kingdom of Jordan. 1991. Annual Agricultural Statistics 1990. Data reproduced in: A. Z. Y. Salman. 1994. On the economics of irrigation water use in the Jordan Valley. Ph.D. Dissertation. University of Hohenheim.

[50] Water and Environment Research and Study Center - University of Jordan. 1995. Irrigation management & water quality in the Central Jordan Valley (Baseline Survey). Water Quality Improvement and Conservation Project, Report 3114-95-3b-05.

[51] Water and Environment Research and Study Center - University of Jordan. 1995. Irrigation management & water quality in the Central Jordan Valley (Baseline Survey). Water Quality Improvement and Conservation Project, Report 3114-95-3b-05.

[52] Salman, A. Z. Y. 1994. On the economics of irrigation water use in the Jordan Valley. Ph.D. Dissertation. University of Hohenheim.

each of the years 1991 through 1995. Unit returns were likewise estimated using the estimated EC's that would have occurred in the KAC-s during the years 1991 through 1995 had the Zarqa Conveyance Project been operating. Project unit benefits (JD/du) were calculated as the difference between the "with project" returns and the "without project" returns.

- Two sets of estimates of unit benefits were developed. In cases where 1991-92 and 1993-94 economic data were available for the same crop, two estimates of unit benefits were made for that crop. Where economic data for a specific crop were available from only one source, those data were considered representative of both the 1991-92 and 1993-94 economic sample periods, regardless of the year in which the data were collected. Each set of unit benefit estimates was then multiplied by each set of cropping pattern estimates (1990 and 1994) and summed to produce four estimates of gross project benefits for each year. The four estimates of gross project benefits provide an indication of the range of benefits that might be expected from the project.

- Gross benefit estimates were divided by the total cropped area to obtain estimates of the mean unit benefit (JD/du) provided by the project. Mean unit benefits were averaged over the five year period for which the analysis was conducted.

Table 6-2 summarizes the results of this assessment. Detailed breakdowns of crop production estimates are provided in Annex 5. Depending on the baseline economic and cropping data used, the project would have provided an estimated average annual benefit of approximately 0.48 to 1.10 million JD during 1991 to 1995. When placed in the context of unit returns, the impact of the project could have resulted in an average increase in returns of 20.1 to 28.6 JD per dunum under cultivation.

Table 6-2 illustrates the wide variation in project benefits that might occur between years when water in the KAC-n is relatively plentiful and/or flow releases from KTD are high (1990-1991 and 1991-1992) and years when water in the KAC-n is less available and flow

Table 6-2.

Summary of analysis of estimated farm-level economic returns resulting from project implementation. Two sets of economic data and two sets of cropping pattern data were used to develop an estimated range of potential project impacts (in JD).

Input Data Used for Economic Analysis	Growing Season					Average
	1990-91	1991-92	1992-93	1993-94	1994-95	
1991-92 Economics; 1990 Cropping Pattern	152,396 3.8 JD/du	173,674 4.4 JD/du	328,801 8.3 JD/du	1,924,133 48.4 JD/du	1,408,675 35.4 JD/du	797,644 20.1 JD/du
1991-92 Economics; 1994 Cropping Pattern	109,604 5.1 JD/du	127,099 5.8 JD/du	319,224 14.8 JD/du	987,881 45.8 JD/du	865,302 40.1 JD/du	481,822 22.3 JD/du
1993-94 Economics; 1990 Cropping Pattern	235,291 5.9 JD/du	202,094 5.1 JD/du	439,783 11.5 JD/du	2,744,607 69.0 JD/du	1,880,493 47.3 JD/du	1,100,454 27.7 JD/du
1993-94 Economics; 1994 Cropping Pattern	157,515 7.3 JD/du	160,747 7.5 JD/du	459,244 21.3 JD/du	1,211,431 56.2 JD/du	1,091,100 50.6 JD/du	616,007 28.6 JD/du

releases from the KTD are relatively low (1993-1994 and 1994-1995). Because the five year average includes both "wet" and "dry" years, it is probably a good indication of potential long-term average economic benefits.

The economic analysis does not include direct effects of the project on the areas in the DA's 25 and 30 that receive water directly from the KAC-s, nor does it consider indirect effects of project operation on the 14.5 km Extension Project. Assuming that directly affected areas in DA's 25 and 30 have the same cropping pattern as the 18 km Extension Project, the total economic benefits of the project would increase by approximately 15 percent.

It is more difficult to assess project effects on the 14.5 km Extension Project area. This area is presently under development and; therefore, there is no information on cropping patterns in that area. During the first five to ten years after this irrigation project begins operation, it is expected that crop production would be primarily in the form of vegetables, because fruit trees would require time to come into full production. In addition, the water for the 14.5 km Extension Project will come primarily from storage at Karameh Dam, which will derive partly from the KAC-s and partly from other sources. Filling of Karameh Dam will occur during

winter when water from the KAC-n is plentiful and the project will have less of an impact on the quality of water in the KAC-s (Table 6-1); however, considering the area under development for irrigation in this project (59,750 du), even a small contribution to improved water quality in the 14.5 km Extension area will likely have substantial benefits. The result could be an increase in project benefits equivalent to 50 percent of the estimated benefits for the directly affected area.

Taking into consideration the areas directly and indirectly affected by the project that were not considered in the calculation of benefits in Table 6-2, the estimate of average total benefits of the project would probably fall within the range of 800,000 to 1,800,000 JD/yr.

6.8 ANTIQUITIES

There are several evident ruins in the general vicinity of the project; however, there are no known resources in the pipeline corridor. Construction of both the abandoned canal in the 1960's and the ZC II pipeline along a substantial portion of the proposed pipeline alignment during the mid 1980's did not result in known disruption of antiquities. This suggests that potential effects on antiquities in the project area are not likely to be significant. The American Center for Oriental Studies (ACOR) has indicated that they have no knowledge of important antiquities in the corridor area; although there is a potential site on the hillside east of Abu Zeighan village. ACOR has recommended a reconnaisance of the Zarqa River and pipeline alignment to determine whether antiquities are likely to be affected by the project (see Section 7.1.3).

Antiquities are protected under Jordanian Law. Failure to report the discovery of sites and/or failure to turn cultural artifacts over to the Department of Antiquities carry penalties of both fines and imprisonment. Reporting the discovery of antiquities is a general provision of construction contracts in Jordan.

6.9 HUMAN POPULATION

6.9.1 Employment

Effects of the Proposed Action on the employment sector are difficult to assess. In general, given the large variations in the total number of dunums under cultivation from year to year, it is likely that effects increased agricultural production resulting from improved water quality will be masked by annual changes in the area of land under production. In general, the project will have the greatest positive effect on production during dry years, when the area cropped may be reduced, and a small effect on production during wet years, when a larger area is likely to be under cultivation. Qualitatively, it appears that the project may increase stability in the year to year demand for casual labor.

During the construction period, there will be a requirement for a modest number of laborers. If construction is undertaken during the summer months, when demand for casual farm labor is lower, the project will have a short-term benefit in the Deir Alla area.

6.9.2 Human Health

The effects of water development projects on the incidence of water-borne diseases is often a concern. The Proposed Action is not expected affect the incidence of malaria and bilharzia both because new irrigation areas will be not be developed and because malaria and bilharzia are relatively rare in Jordan. Reduction of coliform bacteria in the Zarqa channel is likely as a result of the diversion. This should reduce the risk of diarrhea and water contact related health problems for that portion of the population that uses the river for washing of clothing, equipment and livestock.

The only known use of the channel for personal bathing occurs at flowing, geothermal springs between Hwaret and Abu Zeighan Weirs. Man Spring and Woman Spring, so-called, are used as bathing areas. The use of springs for bathing probably poses little health risk during normal flow conditions because the spring water does not have bacterial contamination and the springs are isolated from the main channel flow.

7. RECOMMENDED MITIGATION MEASURES

7.1 CONSTRUCTION IMPACTS

7.1.1 Disruption of Cultivated Areas

Construction impacts on cultivation can be reduced by timing construction to occur during a period when little or no cultivation is ongoing in the vicinity of the pipeline alignment. The best time period for this would appear to be June through September. Conclusion of construction activities as late as December would still allow a full growing period for some winter crops and would present minimal disruption of cultivation practices in the project construction area.

Dust generation by construction activities will probably be worst during the summer months due to dry, sunny conditions. However, due to the reduced level of vegetable cultivation during midsummer, there will be little impact on vegetable crops.

Although it is intended that construction be completed without removing any mature fruit trees, it is possible that the final alignment of the pipeline will pass through an orchard or grove. In such case, compensation for lost production should be provided to the affected farmer. Such compensation should ideally replace the lost trees and provide a subsidy or payment for lost production until replacement trees are bearing at full production.

Accidental fuel spills associated with construction activities can damage cultivated areas and cause significant and lasting harm to aquatic life and riparian vegetation. Fuel storage and fueling areas, if any are required, should be located away from cultivated areas and away from areas that drain into cultivated areas or the stream channel. This is particularly important with respect to assuring continuing use of the stream as a source of water for irrigation and livestock during construction. The construction contractor should be responsible for providing spill cleanup materials on-site and properly removing and disposing of any spilled materials promptly.

7.1.2 Dwellings

Dust will affect dwellings in the construction area; however, the effects will be short-lived and the number of dwellings is small. Excavated materials within 50 m of inhabited dwellings should be covered to reduce heavy dust deposition. OK

7.1.3 Stream Channel Construction

Excavation of the streambed for rehabilitation of Hwarat Weir and for buried pipeline crossings should be conducted when flows can be controlled. This will avoid the possibility of washouts due to unanticipated high flows. Measures to prevent siltation of the streambed downstream of crossing sites will also be more effective if flows can be maintained at a low level when the streambed is being trenched. The best period for this activity appears to be June through September. Irrigation demands are particularly low during July and August, thus flows could be reduced to low levels while construction is underway. Excavation of the streambed should be avoided between the months of October and March.

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Materials for cofferdams to protect ongoing work in the channel should be thoroughly washed to remove silt and fines prior to installation. Sump pumps should not discharge directly into the stream but should discharge to a detention facility to allow mud and silt to settle out before water is returned to the stream.

7.1.4 Antiquities ? vs p. 74?

Not later than the Final Design Phase of the project and prior to any construction, an archaeological reconnaissance should be undertaken along the proposed alignment of the pipeline. The purpose of the archaeological reconnaissance will be to identify areas where cultural remains are, or may be present. The reconnaisance will report on any areas along the proposed route where remains are such that:

- consideration should be given to changing the route;
- if the route can not be changed, then mitigation in the form of an archaeological excavation will be conducted prior to construction; or

7.1.2 Dwellings

Dust will affect dwellings in the construction area; however, the effects will be short-lived and the number of dwellings is small. Excavated materials within 50 m of inhabited dwellings should be covered to reduce heavy dust deposition.

7.1.3 Stream Channel Construction

Excavation of the streambed for rehabilitation of Hwarat Weir and for buried pipeline crossings should be conducted when flows can be controlled. This will avoid the possibility of washouts due to unanticipated high flows. Measures to prevent siltation of the streambed downstream of crossing sites will also be more effective if flows can be maintained at a low level when the streambed is being trenched. The best period for this activity appears to be June through September. Irrigation demands are particularly low during July and August, thus flows could be reduced to low levels while construction is underway. Excavation of the streambed should be avoided between the months of October and March.

Materials for cofferdams to protect ongoing work in the channel should be thoroughly washed to remove silt and fines prior to installation. Sump pumps should not discharge directly into the stream but should discharge to a detention facility to allow mud and silt to settle out before water is returned to the stream.

7.1.4 Antiquities

A reconnaisance of the pipeline alignment for the Proposed Action was carried out by a representative from the Department of Antiquities on 11 March 1996. No antiquities were found along the proposed route.

The discovery of antiquities during construction projects is covered under "The Antiquities Law," Law No. 21 for the year 1988. This law places responsibility upon the person discovering the antiquities. The construction contractor will be responsible for reporting any antiquities discovered during construction activities. Under the law, discovery of antiquities must be reported. Destruction of or causing harm to antiquities is punishable under the law

by fines and imprisonment. Rewards are offered to persons discovering antiquities or reporting those who cause harm to antiquities.

If antiquities should be discovered during project construction, they must be reported. A determination must be made by the Department of Antiquities as to whether construction will jeopardize the antiquities and whether excavation or avoidance of the area is necessary. Until such determination is completed, construction must be stopped at that location.

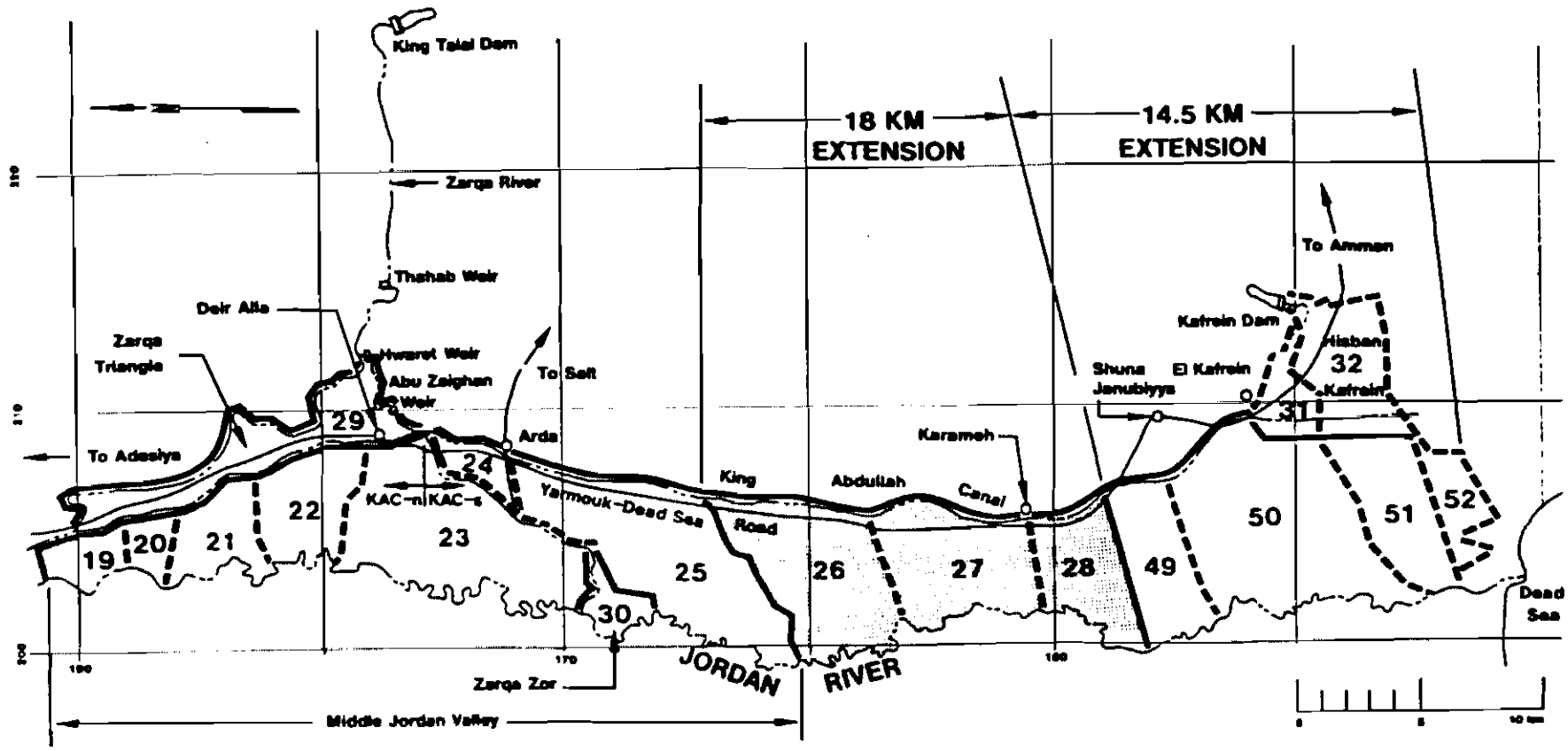
7.2 DIVERSION OF KTD WATER FROM THE RIVER CHANNEL

Diversion of water from the river channel will affect riparian vegetation that represents valuable wildlife habitat; use of river water for irrigation in the river segment between Hwarat Weir, and potential use of the channel as a source of water for livestock. The most suitable form of mitigation for these effects would be to provide a minimum flow release to the channel. This release should be maintained at a level similar to that provided by the settling basin overflow at Thahab Weir. This quantity of flow is often the only flow below Thahab Weir during the winter months and it apparently is sufficient to maintain emergent vegetation in the channel. This measure would maintain vegetation diversity and wildlife habitat quality at satisfactory levels. A small minimum release would also provide enough water for existing irrigation withdrawals along the left bank downstream of Hwarat Weir and provide a source of water for livestock use in 1.3 km of stream channel below Hwarat Weir. The minimum flow would also provide a small reduction in EC of the saline spring water flowing in the channel downstream. Because the water from KTD has a heavy load of nutrients and BOD, a higher flow would not appreciably improve conditions for aquatic life. The mechanism for providing such a flow could be a small diameter pipe located in the headworks of the pipeline at Hwarat Weir.

The provision of a minimum flow below Hwarat Weir on the order of that presently occurring at the Thahab Weir settling basin overflow should not present a major loss to the irrigation system. The estimated flow from the settling basin is 20 L/s or 0.6 Mm^3/yr. "Loss" of this quantity of flow during periods when the Abu Zeighan diversion is not operating is apparently acceptable to the system operators. It also represents less than two percent of the estimated maximum annual irrigation requirement, which is estimated at 1,100 L/s or 35 Mm^3/yr.

9. LIST OF PREPARERS

Name	Expertise	Experience	Discipline
W. Peter Saunders, Jr.	Environmental Science	23	Fisheries Biology
Peter L. Ames	Environmental Assessment	38	Wildlife Management
Khalid Jawed	Hydrology & Water	38	Hydrology
Ross Hagan	Irrigation/Agriculture		Agriculture
Adnan Budieri	Biodiversity of Jordan	9	Biological Engineer



LEGEND

XX Development Areas

Development Area Boundaries

Irrigated Area Affected by Project

Irrigation Project Boundaries

Figure 4-1

OVERALL PROJECT AREA

HARZA ENGINEERING COMPANY CHICAGO

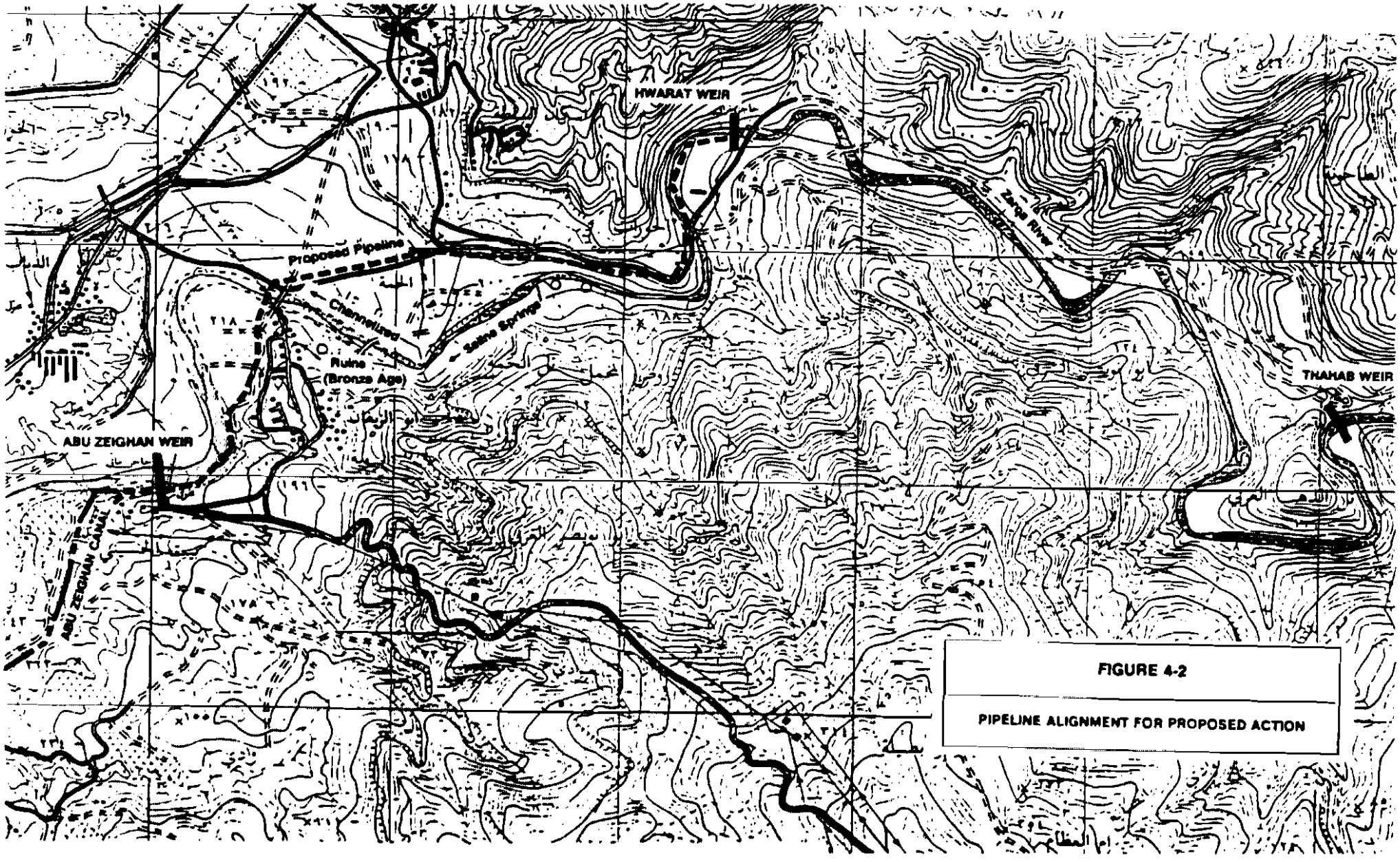


FIGURE 4-2

PIPELINE ALIGNMENT FOR PROPOSED ACTION

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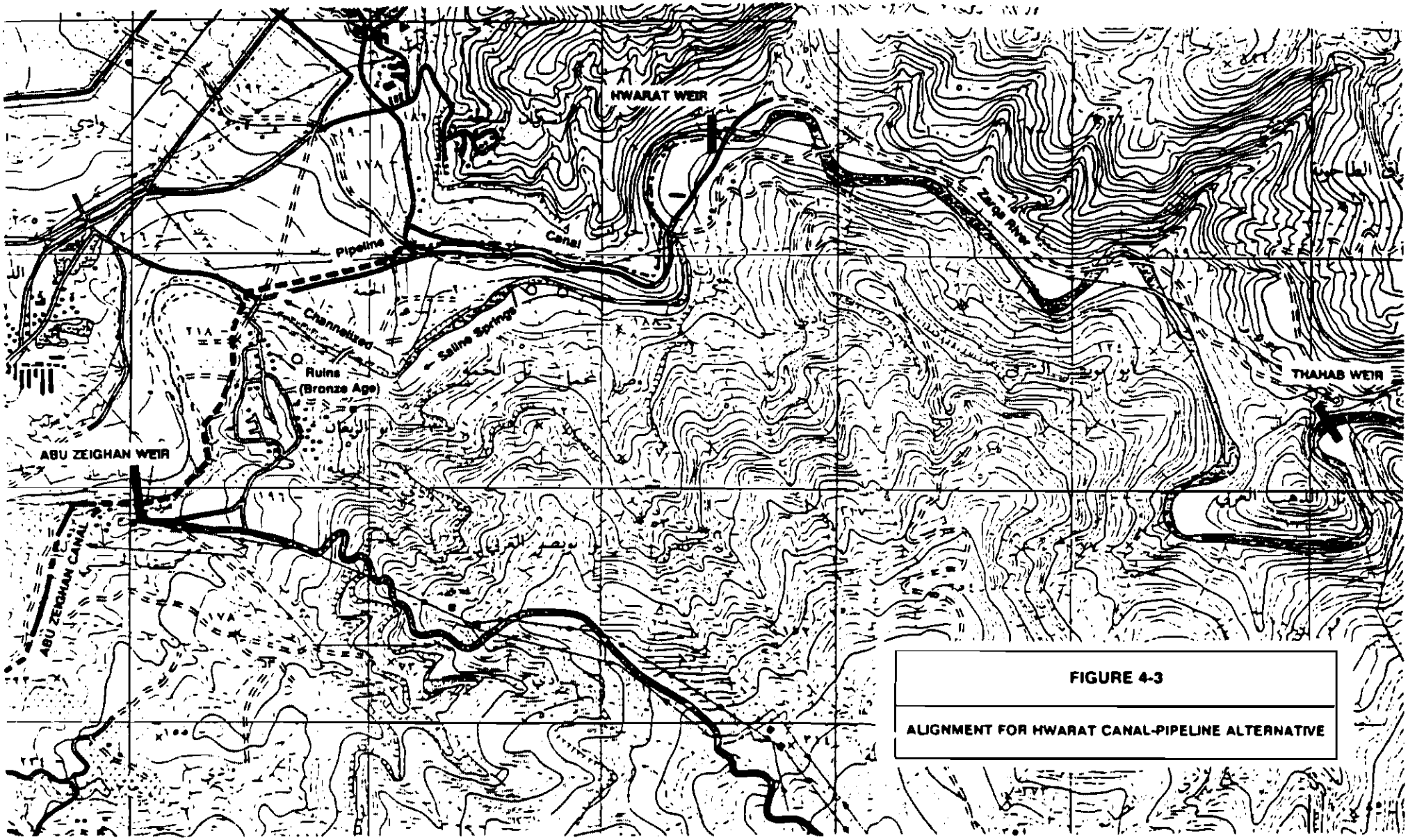

FIGURE 4-3

ALIGNMENT FOR HWARAT CANAL-PIPELINE ALTERNATIVE

BEST AVAILABLE COPY

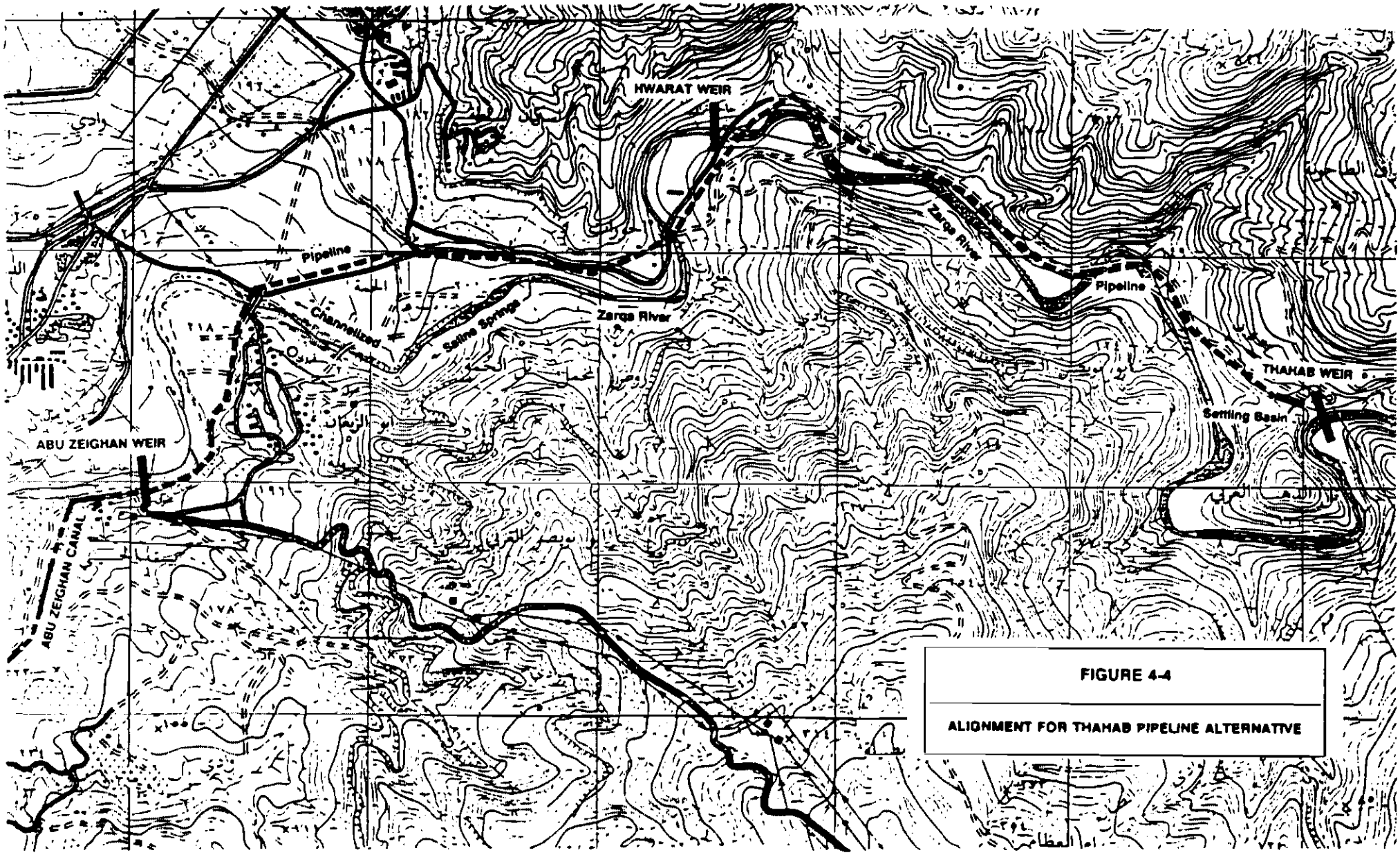

FIGURE 4-4

ALIGNMENT FOR THAHAB PIPELINE ALTERNATIVE

BEST AVAILABLE COPY

ANNEX 1.

Bird Species Likely to be Found in the Zarqa River Area from King Talal Dam to the Jordan Valley

Common Name	Scientific Name	Status	Area
Great White Egret	*Egretta alba*	Wv, Sm	Zarqa R., King Talal Dam
Grey Heron	*Ardea cinerea*	M	King Talal Dam
Purple Heron	*Ardea purpurea*	Sm, Fm	King Talal Dam
White Stork	*Ciconia ciconia*	Sm, Fm	Zarqa River
Mallard	*Anas platyrhynchos*	Wv	King Talal Dam
Pintail	*Anas acuta*	Wv	King Talal Dam
Gargany	*Anas querquedula*	Sm, Fm	King Talal Dam
Ferruginous Duck	*Aythya nyroca*	Sm, Fm	King Talal Dam
Egyptian Vulture	*Neophron percnopterus*	Sm	Zarqa R.
Goshawk	*Accipter gentilis*	Sm	Zarqa R.
Long-legged Buzzard	*Buteo rufinus*	R	Zarqa R., Middle Ghor
Water Rail	*Rallus aquaticus*	Wm	Zarqa R.
Spotted Crake	*Porzana porzana*	Sm, Fm	Zarqa R.
Coot	*Fulica atra*	Wm	King Talal Dam
Green Sandpiper	*Tringa ochropus*	Wm	Zarqa R.
Smyrna Kingfisher	*Halcyon smyrnensis*	R	Zarqa R.
Pied Kingfisher	*Ceryle rudis*	R	King Talal Dam
Woodlark	*Lullula arborea*	Wv	Zarqa R.
White Wagtail	*Motacilla alba alba*	Wv	Zarqa R.
Blackstart	*Cercomela melanura*	R	Zarqa R.
Fan-tailed Warbler	*Cisticola juncidis*	Wv, Sv	Zarqa R.
Olivaceous Warbler	*Hippolais pallida*	M, B	Zarqa R.
Orange Tufffed Sunbird	*Nectarina osea*	R	Zarqa R.
Hooded Crow	*Corvus corone cornix*	R	Zarqa R.
Dead Sea Sparrow	*Passer moabiticus*	R	Middle Ghor
Rock Sparrow	*Petronia petronia*	R	Middle Ghor
Serin	*Serinus serinus*	Wv	Zarqa R.
Green Finch	*Carduelis chloris*	R	Middle Ghor

ANNEX 1.

Bird Species Likely to be Found in the Zarqa River Area from King Talal Dam to the Jordan Valley

Common Name	Scientific Name	Status	Area
Gold Finch	*Carduelis carduelis*	R	Middle Ghor
Linnet	*Carduelis cannabina*	R	Middle Ghor
Trumpter Finch	*Bucanetes githagineus*	R	Middle Ghor, Zarqa R.
House Bunting	*Emberiza striolata*	R	Middle Ghor, Zarqa R.
Corn Bunting	*Miliaria calandra*	Wv	Middle Ghor, Zarqa R.
Kestrel	*Falco tinnunculus*	R	Middle Ghor, Zarqa R.
Lesser Kestrel	*Falco naumanni*	R	Middle Ghor, Zarqa R.
Barbary Falcon	*Falco pelegrinoides*	R	Middle Ghor, Zarqa R.
Chukar	*Alectoris chukar*	R	Middle Ghor, Zarqa R.
Rock Dove	*Columba livia*	R	Middle Ghor, Zarqa R.
Collared Dove	*Streptopelia decaocto*	R	Middle Ghor, Zarqa R.
Little Owl	*Athene noctua*	R	Middle Ghor, Zarqa R.
Alpine Swift	*Apus melba*	Sm	Middle Ghor, Zarqa R.
Little Swift	*Apus affinis*	Sm	Middle Ghor, Zarqa R.
Desert Lark	*Ammonanes deserti*	R	Middle Ghor, Zarqa R.
Crested Lark	*Galerida cristata*	R	Middle Ghor, Zarqa R.
Rock Martin	*Ptyonoprogne fuligula*	R	Middle Ghor, Zarqa R.
Red-rumped Swallow	*Hirundo daurica*	Sv	Middle Ghor, Zarqa R.
Long-billed Pipit	*Anthus similis*	R	Middle Ghor, Zarqa R.
Water Pipit	*Anthus spinoletta*	Wr	Zarqa R.
Yellow-vented Bulbul	*Pycnonotus xanthopygos*	R	Middle Ghor
Rufus Bush Robin	*Cercotrichas galactores*	Sv	Middle Ghor
Mourning Wheatear	*Oenanthe lugens*	R	Middle Ghor
Hooded Wheatear	*Oenanthe monacha*	R	Middle Ghor
White-crowned Black Wheatear	*Oenanthe leucopyga*	R	Middle Ghor
Blue Rock Thrush	*Monticola solitarius*	R	Middle Ghor
Cettis Warbler	*Cettia cetti*	R	Middle Ghor
Gracful Warbler	*Prinia gracilis*	R	Middle Ghor

ANNEX 1.

Bird Species Likely to be Found in the Zarqa River Area from King Talal Dam to the Jordan Valley

Common Name	Scientific Name	Status	Area
Scrub Warbler	*Scotocerca inquieta*	R	Middle Ghor
Spectacled Warbler	*Sylvia conspicillata*	R	Middle Ghor
Sardinian Warbler	*Sylvia melanocephalus*	R	Middle Ghor
Great Grey Shrike	*Lanius excubitor*	R	Middle Ghor
Woodchat shrike	*Lanius senator*	Sv	Middle Ghor
Brown-necked Raven	*Corvus ruficollis*	R	Middle Ghor

Key to Status Codes:

B = Breeds M = Migrant all year Fm = Fall migrant R = Resident
Sm = Spring migrant Sv = Spring visitor Wv = Winter visitor

ANNEX 2.

List of Amphibians, Reptiles and Mammals Likely to Occur in the Vicinity of the Project

AMPHIBIANS

Green Tree Frog	Hyla savignyi
March Frog	Rana ridibunda
Green Toad	Bufo virdis

REPTILES

Turtles

Mediterranean Tortoise	Testudo graeca

Lizards

Common Agama	Agama agama
Starred Agama	Agama stelio
Bridled Skink	Mabuya vittatta
Chameleon	Chamaelon chamaelon
Lobe Footed Gecko	Ptyodactylushasselquistii
Elegant Lizard	Opbisopselegans

Snakes

Egyptian Sand Snake	Eryx jaculus
European whip snake	Coluber jugularis
Spotted Whip snake	Coluber ventromaculatus
Tessellated Water Snake	Natrix tessellata
Palestine Viper	Viperapalaestinae
Scaled Viper	Echis coloratus

MAMMALS

ANNEX 2.

List of Amphibians, Reptiles and Mammals Likely to Occur in the Vicinity of the Project

Hedgehogs	
European Hedgehog	Erinaceus europaeaus
Shrews	
Lesser White-toothed Shrew	Crocidura monacha
Bats	
Egyptian Fruit Bat	Rousettusaegypticus
Greater Rat-tailed Bat	Rhinopoma microphylum
Rodents	
Common Mouse	Mus Musculus
Golden Spiny Mouse	Acomys russatus
Common Rat	Rattus rattus
Palestine Mole Rat	Spalax leucodon
Indian Crested Porcupine	Histryxindica
Carnivores	
Egyptian Mongoose	Herpestesichneumon
Marbeld Pole-cat	Vormela peregusnasyriaca
European Badger	Meles meles
Red fox	Vulpesvulpes
Jungle Cat	Felis chaus
Wild Cat	Felis silvestristristramii
Wild Boar	Sus scrofa

ANNEX 3.

List of Fish and Aquatic Fauna Likely to Occur in the Vicinity of the Project

Fish

Barbus canis
Aeanthobrama essneri

Gastropoda -- Snails

Bythinia badiella
Melanoidestuberculata
Lymnea palustris
Psedamnicola solitaria
Hydrobia lactea

Cladocera -- Water Fleas

Ceriodaphnia cormuta

Ostracoda -- Seed shrimps

Hemicyprisaurita

Isopoda

Proaselus coxalis

Decapoda -- Crabs

Freshwater crab (Species not identified)

Odonata -- Dragonflies

Ischnura evansi
Pseudadragon mortoni
Paragomphus genei
Crocothemisarabica
Zygonyxtorrida

Hemiptera -- Water Bugs

Naucoridae
Notonectidae
Veliidae

Annex 4.

Monthly Average EC's and Estimated Mixing Ratios of KAC-n and Zarqa River Water from Abu Zeighan Canal for 1990-1995, Showing Estimated EC if Project had been Operating.

	JVA Monthly Averages								
	Zarqa River		King Abdullah Canal						
Date	KTD King Talal Dam (dS/m)	AZC Abu Zeighan Canal (dS/m)	KAC-s south (Maadi) (dS/m)	KAC-n north (Sawalha) (dS/m)	KTD (corrected)[1] (dS/m)	KAC-s (corrected)[2] (dS/m)	Mixing Ratio (KAC/AZC)[3]	Estimated EC with Project (dS/m)	Project-related change (dS/m)
Sep-90	2.16	2.09	2.21	0.81	2.09	2.09	0.00	2.09	0.00
Oct-90	2.30	2.28	2.42	0.92	2.28	2.28	0.00	2.28	0.00
Nov-90	2.59	2.64	2.49	1.40	2.59	2.49	0.14	2.45	-0.04
Dec-90	2.78	2.80	2.79	0.88	2.78	2.79	0.01	2.77	-0.02
Jan-91	2.73	2.64	2.30	0.92	2.64	2.30	0.25	2.30	0.00
Feb-91	1.76	2.08	1.24	0.91	1.76	1.24	2.55	1.15	-0.09
Mar-91	2.34	2.17	2.15	0.93	2.17	2.15	0.02	2.15	0.00
Apr-91	2.24	1.75	1.83	0.89	1.75	1.75	0.00	1.75	0.00
May-91	1.79	2.04	1.82	0.89	1.79	1.82	0.24	1.62	-0.20
Jun-91	1.74	1.92	1.85	0.91	1.74	1.85	0.07	1.68	-0.17
Jul-91	1.86	2.22	1.92	0.93	1.86	1.92	0.30	1.64	-0.28
Aug-91	2.10	2.28	2.17	0.85	2.10	2.17	0.08	2.00	-0.17
Sep-91	2.35	2.56	2.24	0.93	2.35	2.24	0.24	2.07	-0.17
Oct-91	2.61	2.72	2.27	0.98	2.61	2.27	0.35	2.19	-0.08
Nov-91	2.52	2.79	2.19	0.94	2.52	2.19	0.48	2.01	-0.18
Dec-91	1.50	2.09	0.91	0.77	1.50	0.91	8.43	0.85	-0.06
Jan-92			0.63	0.54		0.63		0.63	0.00
Feb-92	1.15		0.53	0.49		0.53		0.53	0.00
Mar-92	1.03	1.15	0.91	0.51	1.03	0.91	0.60	0.84	-0.08
Apr-92	1.10	1.19	1.17	0.78	1.10	1.17	0.05	1.08	-0.09
May-92	1.12	1.28	1.25	0.93	1.12	1.25	0.09	1.10	-0.15
Jun-92	1.26	1.28	1.20	0.96	1.26	1.20	0.33	1.19	-0.02
Jul-92	1.25	1.42	1.40	0.90	1.25	1.40	0.04	1.24	-0.16
Aug-92	1.23	1.40	1.39	0.92	1.23	1.39	0.02	1.22	-0.17
Sep-92	1.24	1.40	1.36	0.92	1.24	1.36	0.09	1.21	-0.15
Oct-92	1.31	1.39	1.42	0.96	1.31	1.39	0.00	1.31	-0.08
Nov-92	1.77	1.85	1.85	0.93	1.77	1.85	0.00	1.77	-0.08
Dec-92	1.84	1.94	1.34	0.71	1.84	1.34	0.95	1.29	-0.05
Jan-93	2.10	1.76	1.39	0.63	1.76	1.39	0.49	1.39	0.00
Feb-93	1.68	1.71	0.99	0.66	1.68	0.99	2.18	0.98	-0.01
Mar-93	1.60	1.63	1.58	0.75	1.60	1.58	0.06	1.55	-0.03
Apr-93	1.58	1.77	1.58	0.82	1.58	1.58	0.25	1.43	-0.15
May-93	1.57	1.74	1.74	0.88	1.57	1.74	0.00	1.57	-0.17
Jun-93	1.60	2.34	2.32	0.89	1.60	2.32	0.01	1.59	-0.73
Jul-93	1.61	2.33	2.27	0.95	1.61	2.27	0.05	1.58	-0.69
Aug-93	1.58	2.22	2.18	0.85	1.58	2.18	0.03	1.56	-0.62
Sep-93	1.72	2.27	2.32	0.90	1.72	2.27	0.00	1.72	-0.55
Oct-93	1.90	2.25	2.25	0.93	1.90	2.25	0.00	1.90	-0.35
Nov-93	2.13	2.51	2.50	0.94	2.13	2.50	0.01	2.12	-0.38
Dec-93	2.12	2.62	2.71	0.92	2.12	2.62	0.00	2.12	-0.50
Jan-94	2.44	5.62	2.11	0.90	2.44	2.11	2.90	1.29	-0.82
Feb-94	2.62	4.58	3.26	0.88	2.62	3.26	0.55	2.00	-1.26
Mar-94	2.58	4.20	1.88	0.93	2.58	1.88	2.44	1.41	-0.47
Apr-94	1.95	2.55	2.53	0.91	1.95	2.53	0.01	1.94	-0.59
May-94	2.02	2.75	2.79	0.96	2.02	2.75	0.00	2.02	-0.73
Jun-94	2.02	2.89	2.82	0.95	2.02	2.82	0.04	1.98	-0.84
Jul-94	2.01	3.01	2.40	0.92	2.01	2.40	0.41	1.69	-0.71
Aug-94	2.20	2.76	2.71	0.93	2.20	2.71	0.03	2.17	-0.54
Sep-94	2.39	2.89	2.63	0.93	2.39	2.63	0.15	2.20	-0.43
Oct-94	2.43	3.13	2.95	0.93	2.43	2.95	0.09	2.31	-0.64
Nov-94	3.00	3.75	1.82	0.95	3.00	1.82	2.22	1.59	-0.23
Dec-94	2.28	4.02	1.37	0.98	2.28	1.37	6.79	1.15	-0.22
Jan-95	1.90	4.23	1.41	0.81	1.90	1.41	4.70	1.00	-0.41
Feb-95	1.73	2.92	1.52	0.57	1.73	1.52	1.47	1.04	-0.48

Annex 4.

Monthly Average EC's and Estimated Mixing Ratios of KAC-n and Zarqa River Water from Abu Zeighan Canal for 1990-1995, Showing Estimated EC if Project had been Operating.

	JVA Monthly Averages								
	Zarqa River		King Abdullah Canal						
Date	KTD King Talal Dam	AZC Abu Zeighan Canal	KAC-s south (Maadi)	KAC-n north (Sawalha)	KTD (corrected)[1]	KAC-s (corrected)[2]	Mixing Ratio (KAC/AZC)[3]	Estimated EC with Project	Project-related change
Mar-95	1.40	2.28	2.18	0.71	1.40	2.18	0.07	1.36	-0.82
Apr-95	1.40	2.26	2.10	0.83	1.40	2.10	0.13	1.34	-0.76
May-95	1.38	2.63	2.71	0.84	1.38	2.63	0.00	1.38	-1.25
Jun-95	1.55	2.29	2.43	0.84	1.55	2.29	0.00	1.55	-0.74
Jul-95	1.45	2.37	2.15	0.87	1.45	2.15	0.17	1.36	-0.79
Aug-95	1.54	2.15	2.15	0.87	1.54	2.15	0.00	1.54	-0.61
Sep-95	1.57	2.18	1.90	0.90	1.57	1.90	0.28	1.42	-0.48
Oct-95	1.52	2.02	1.92	0.89	1.52	1.92	0.10	1.46	-0.46
Nov-95	2.03	2.79	1.97	0.88	2.03	1.97	0.75	1.54	-0.43
Dec-95	2.08	2.71	1.60	0.85	2.08	1.60	1.48	1.35	-0.25
max	3.00	5.62	3.26	1.40	3.00	3.26	8.43	2.77	0.00
min	1.03	1.15	0.53	0.49	1.03	0.53	0.00	0.53	-1.26
median	1.84	2.28	2.13	0.91	1.78	2.11	0.09	1.58	-0.18
10th percentile	1.25	1.40	1.20	0.71	1.26	1.20	0.00	1.04	-0.77
90th percentile	2.58	3.32	2.71	0.95	2.58	2.64	2.29	2.19	0.00
mean	1.88	2.41	1.95	0.87	1.88	1.94	0.70	1.60	-0.33

Notes:
1. This value is the lesser of the EC at KTD or Abu Zeighan. Lower values at Abu Zeighan likely indicate that high flows were released at KTD and/or there was substantial inflow from side wadis which lowered EC at Abu Zeighan.
2. It is unlikely that EC in the KAC-s is ever higher than EC at Abu Zeighan. The lower of the two values is used. This effectively sets the contribution from KAC-n at zero
3. This ratio is based on the equation:

$$\frac{EC_{(KAC\text{-}n)} \times Q1 + EC_{(AZC)}}{(Q1 + 1)} = EC(KAC\text{-}s)$$

where: Q1 = the ratio of flow in KAC-n to flow in AZC

which implies:

$$Q1 = \frac{EC_{(AZC)} - EC_{(KAC\text{-}s)}}{EC_{(KAC\text{-}s)} - EC_{(KAC\text{-}n)}}$$

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation

INPUT DATA FOR CROP PRODUCTION ESTIMATION MODEL

	Surrogate Species for EC Analysis	Costs (JD/du)	Returns (JD/du)	Margin (JD/du)	Base Cost Year	18 km Extension Project 1990 (du)	18 km Extension Project 1994 (du)	Irrigation Period	Base Year EC	Base Year Est. Yield
		Economic Information				Estimated Areas				
FRUIT TREES										
Citrus						2,125	2,179			
Citrus	Orange	*237*	*643*	*406*	*1993*	*2,125*	2,179	apr-dec	2.00	79%
Lemon	Orange	114	699	585	1991	540	551	apr-dec	1.37	94%
Clementine	Orange	114	519	405	1991	257	267	apr-dec	1.37	94%
Mandarine	Orange	114	638	524	1991	729	730	apr-dec	1.37	94%
Grapefruit	Grapefruit	114	427	313	1991	31	33	apr-dec	1.37	96%
Pummelor	Grapefruit	114	861	747	1991	87	94	apr-dec	1.37	96%
Others	Orange	50	282	233	1991	480	504	apr-dec	1.37	94%
Bananas	Apricot	193	309	116	1993	444	599	jan-dec	2.40	52%
Misc. Trees						1,442	1,936			
Apple	Peach	79	492	413	1991	32	32	apr-sep	1.30	94%
Apple	*Peach*	*162*	*62*	*-99*	*1993*	32	32	apr-sep	2.10	69%
Grape	Grapes	149	279	130	1991	461	461	feb-nov	1.25	96%
Grape	*Grapes*	*241*	*517*	*276*	*1993*	461	461	feb-nov	2.18	83%
Peach	Peach	78	518	440	1991	73	73	apr-sep	1.30	94%
Peach	*Peach*	*274*	*513*	*239*	*1993*	73	73	apr-sep	2.10	69%
Guava	Orange	47	268	221	1991	336	405	jan-dec	1.20	96%
Others	Peach	103	302	199	1991	540	985	apr-dec	1.37	91%
Others	*Peach*	*241*	*491*	*250*	*1993*	876	1,370	apr-dec	2.00	72%
FIELD CROPS						1,739	4,778			
Wheat	Wheat	8	17	9	1993	76	882	dec-may	2.33	100%
Maize	Corn, maize	26	58	32	1991	294	1,031	mar-jun	1.13	99%
Garlic	Onion	101	238	137	1991	-	88	sep-apr	1.38	87%
Garlic	*Onion*	*115*	*123*	*8*	*1993*	-	88	sep-apr	2.18	87%
Others	Barley	22	50	27	1991	1,369	2,797	apr-jul	1.26	100%
Others	*Barley*	*21*	*42*	*21*	*1993*	1,369	2,797	apr-jul	2.10	100%
Autumn						27,899	11,256			
Tomato (PH)	Tomato	508	587	79	1991	2,033	82	oct-may	1.23	100%
Tomato	Tomato	153	330	177	1991	8,460	342	oct-may	1.23	100%
Tomato (PH)	*Tomato*	*1042*	*2607*	*1565*	*1993*	2,033	82	oct-may	2.22	92%
Tomato	*Tomato*	*234*	*280*	*46*	*1993*	6,460	342	oct-may	2.22	92%
Squash	Squash, zucchini	117	275	158	1991	3,324	1,612	sep-dec	1.90	100%
Eggplant	Potato	149	315	166	1991	2,576	1,523	aug-jan	1.74	89%
Eggplant (PH)	Potato	1391	2187	796	1993	2,071	1,223	oct-apr	2.25	79%
Cucumber (PH)	Cucumber	566	1000	434	1991	1,544	165	oct-may	1.23	100%
Cucumber (PH)	*Cucumber*	*1111*	*2107*	*996*	*1993*	1,544	165	oct-may	2.22	90%
Potato	Potato	179	291	113	1991	623	204	oct-jan	1.50	93%
Potato	Potato	179	291	113	1991	118	38	dec-mar	1.03	100%
Potato	*Potato*	*345*	*542*	*197*	*1993*	623	204	oct-jan	2.15	81%
Potato	*Potato*	*345*	*542*	*197*	*1993*	118	38	dec-mar	2.29	79%

TABLE CONCLUDES ON FOLLOWING PAGE

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation

INPUT DATA FOR CROP PRODUCTION ESTIMATION MODEL

		Economic Information				Estimated Areas				
	Surrogate Species for EC Analysis	Costs (JD/du)	Returns (JD/du)	Margin (JD/du)	Base Cost Year	18 km Extension Project 1990 (du)	18 km Extension Project 1994 (du)	Irrigation Period	Base Year EC	Base Year Est Yield
Cabbage	Cabbage	84	165	81	1991	288	375	oct-feb	1.31	98%
Cauliflower	Broccoli	82	273	191	1991	981	857	nov-feb	1.07	100%
Hot Pepper (PH)	Pepper	390	600	210	1991	319	47	aug-dec	1.98	80%
Sweet Pepper (PH)	Pepper	375	692	317	1991	405	69	aug-dec	1.98	80%
Broad Bean	Broadbean	87	77	10	1991	2,118	1,566	sep-dec	1.90	88%
String Bean (PH)	Bean	309	410	102	1991	36	1	jan-apr	0.81	97%
String Bean	Bean	172	315	143	1993	144	4	oct-dec	2.05	81%
Lettuce	Lettuce	79	190	111	1991	2,130	1,811	oct-may	1.23	93%
Spinach	Spinach	115	269	154	1991	150	38	oct-dec	1.79	94%
Onion	Onion	54	124	70	1991	25	197	nov-mar	1.03	94%
Onion	*Onion*	*182*	*417*	*235*	*1993*	25	197	nov-mar	2.31	84%
Turnip	Turnip	46	209	163	1991	18	-	sep-jan	1.85	88%
Carrot	Carrot	80	564	484	1991	27	73	sep-feb	1.48	84%
Carrot	*Carrot*	*55*	*194*	*139*	*1993*	27	73	sep-feb	2.18	69%
Others	Tomato	85	182	97	1991	509	1,029	sep-jan	1.85	100%
Others	*Tomato*	*113*	*234*	*121*	*1993*	509	1,029	sep-jan	2.08	95%
Tomato	Tomato	124	298	174	1991	935	64	jan-may	0.90	100%
Tomato (tun)	Tomato	98	383	285	1991	117	8	dec-may	0.90	100%
Tomato	*Tomato*	*234*	*280*	*46*	*1993*	935	64	jan-may	2.32	91%
Tomato (tun)	*Tomato*	*587*	*1286*	*699*	*1993*	117	8	dec-may	2.33	91%
Squash	Squash, zucchini	60	194	134	1991	116	-	dec-apr	1.06	100%
Cucumber	Cucumber	566	1000	434	1991	-	8	dec-may	0.90	100%
Okra	Bean	30	31	1	1993	-	53	apr-jul	2.10	80%
Cauliflower	Broccoli	82	273	191	1991	-	14	jan-may	0.90	100%
String Bean	Bean	309	410	102	1991	16	2	mar-may	1.11	88%
String Bean	*Bean*	*143*	*209*	*66*	*1993*	18	2	mar-may	2.14	59%
Molokhia	Spinach	35	171	136	1991	7	5	apr-jul	1.26	100%
Molokhia (PH)	Spinach	131	400	269	1993	14	11	apr-jul	2.10	91%
Sweet melon	Squash, scallop	24	93	69	1991	3,254	243	apr-aug	1.28	100%
Eggplant	Potato	149	315	166	1991	684	238	dec-may	0.90	100%
Eggplant	*Potato*	*95*	*77*	*-18*	*1993*	684	238	dec-may	2.33	78%
Others	Tomato	94	188	94	1991	978	166	mar-jun	1.13	100%
Others	*Tomato*	*89*	*137*	*48*	*1993*	978	166	mar-jun	2.28	92%
					AREA TOTAL	39,768	21,560			

Items in italics are used to develop estimates referred to as 1993 data

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation

	1990-1991 Season								
	Without Project			With Project					
	EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Estimated EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Project Benefit (JD/du)	Gross Benefit (1990 Cropping)	Gross Benefit (1994 Cropping)
FRUIT TREES									
Citrus									
Citrus									
Lemon	1.90	81%	862	1.76	84%	890	26.298	60,126	61,850
Clementine	1.90	81%	805	1.76	84%	631	25.853	13,968	14,249
Mandarine	1.90	81%	449	1.76	84%	468	19.198	4,933	5,125
Grapefruit	1.90	83%	552	1.76	84%	576	23.597	17,205	17,220
Pummelor	1.90	83%	371	1.76	87%	386	15.401	462	501
Others	1.90	83%	748	1.76	87%	779	31.055	2,699	2,934
	1.90	81%	244	1.76	84%	255	10.444	5,016	5,261
Bananas	1.90	70%	418	1.78	75%	444	25.646	11,380	15,380
Misc. Trees									
Apple	1.96	73%	383	1.79	78%	410	26.787	853	853
Apple	1.96	73%	66	1.79	78%	71	4.633	148	148
Grape	1.96	86%	249	1.83	88%	255	5.597	2,579	2,581
Grape	1.96	86%	537	1.83	88%	549	12.077	5,564	5,568
Peach	1.96	73%	404	1.79	78%	432	28.181	2,063	2,088
Peach	1.96	73%	546	1.79	78%	584	38.100	2,789	2,795
Guava	1.90	81%	222	1.76	84%	230	7.817	2,558	3,087
Others	1.90	75%	247	1.76	79%	262	14.977	8,087	14,450
Others	1.90	75%	512	1.76	79%	543	31.013	27,181	42,491
						Sub-total 1991 data		71,821	83,686
						Sub-total 1993 data		107,168	128,011
FIELD CROPS									
Wheat	2.01	100%	17	1.96	100%	17	-	-	-
Maize	1.89	86%	50	1.80	87%	51	0.963	283	993
Garlic	2.14	68%	187	2.12	69%	188	1.257	-	85
Garlic	2.14	68%	125	2.12	69%	126	0.841	-	57
Others	1.84	100%	50	1.67	100%	50	-	-	-
Others	1.84	100%	42	1.67	100%	42	-	-	-
						Sub-total 1991 data		283	1,078
						Sub-total 1993 data		283	1,050
Autumn									
Tomato (PH)	2.10	94%	552	2.06	95%	556	3.902	7,931	321
Tomato	2.10	94%	310	2.06	95%	312	2.194	18,558	750
Tomato (PH)	2.10	94%	2,657	2.06	95%	2,675	18.787	38,189	1,544
Tomato	2.10	94%	286	2.06	95%	288	2.019	17,083	691
Squash	2.41	100%	275	2.40	100%	275	-	-	-
Eggplant	2.32	78%	278	2.30	78%	279	0.674	1,738	1,027
Eggplant (PH)	2.14	81%	2,239	2.12	82%	2,250	10.816	22,402	13,232
Cucumber (PH)	2.10	92%	921	2.06	93%	930	8.732	13,481	1,444
Cucumber (PH)	2.10	92%	2,181	2.06	93%	2,182	20.488	31,630	3,387
Potato	2.47	76%	237	2.45	76%	238	0.894	557	182
Potato	2.19	80%	234	2.16	81%	238	1.604	189	62
Potato	2.47	78%	504	2.45	76%	508	1.900	1,184	387
Potato	2.19	80%	554	2.16	81%	557	3.787	446	146

TABLE CONCLUDES ON FOLLOWING PAGE

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation

	1990-1991 Season								
	Without Project			With Project					
	EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Estimated EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Project Benefit (JD/du)	Gross Benefit (1990 Cropping)	Gross Benefit (1994 Cropping)
Cabbage	2.22	85%	143	2.19	86%	144	0.749	215	281
Cauliflower	2.21	96%	261	2.17	96%	263	1.461	1,433	1,252
Hot Pepper (PH)	2.32	73%	543	2.31	73%	545	1.993	635	94
Sweet Pepper (PH)	2.32	73%	627	2.31	73%	629	2.299	931	159
Broad Bean	2.41	61%	71	2.40	61%	71	0.202	426	318
String Bean (PH)	1.86	67%	283	1.84	68%	286	2.729	98	3
String Bean	2.52	46%	246	2.50	49%	249	3.118	450	12
Lettuce	2.10	76%	155	2.06	77%	157	1.775	3,781	3,214
Spinach	2.52	86%	245	2.50	86%	246	0.697	105	26
Onion	2.19	67%	88	2.16	68%	89	0.964	24	190
Onion	2.19	67%	434	2.16	68%	439	4.772	117	940
Turnip	2.39	76%	185	2.38	76%	185	0.420	8	-
Carrot	2.20	68%	459	2.17	69%	462	3.678	100	270
Carrot	2.20	68%	191	2.17	69%	193	1.535	42	113
Others	2.39	90%	163	2.38	90%	163	0.347	178	357
Others	2.39	90%	221	2.38	90%	222	0.471	239	484
						Sub-total 1991 data		73,239	23,190
						Sub-total 1993 data		121,153	27,307
Tomato	1.85	98%	291	1.79	99%	294	2.602	2,432	167
Tomato (tun)	2.01	95%	366	1.96	96%	369	2.978	347	24
Tomato	1.85	98%	302	1.79	99%	305	2.696	2,520	173
Tomato (tun)	2.01	95%	1,353	1.96	96%	1,364	11.023	1,286	88
Squash	2.12	100%	194	2.09	100%	194	-	-	-
Cucumber	2.01	94%	940	1.96	95%	950	10.207	-	79
Okra	1.84	68%	35	1.67	72%	37	2.382	-	127
Cauliflower	1.85	100%	273	1.79	100%	273	-	-	-
String Bean	1.91	68%	304	1.84	67%	313	8.942	145	15
String Bean	1.91	68%	233	1.84	67%	240	6.846	111	12
Molokhia	1.84	94%	160	1.67	96%	164	3.174	21	17
Molokhia (PH)	1.84	94%	413	1.67	96%	422	8.175	114	93
Sweet melon	1.90	100%	93	1.74	100%	93	-	-	-
Eggplant	2.01	84%	264	1.96	85%	266	2.924	2,000	697
Eggplant	2.01	84%	83	1.96	85%	84	0.917	627	218
Others	1.89	97%	182	1.80	99%	185	2.590	2,533	429
Others	1.89	97%	145	1.80	99%	147	2.053	2,008	340
						Sub-total 1991 data		7,593	1,847
						Sub-total 1993 data		6,867	1,147

Items in italics are used to develop estimates referred to as 1993 data

benefit (JD) using 1991 data	152,836	109,604
benefit (JD) using 1993 data	235,291	157,515
unit benefit (JD/du) using 1991 data	3.846	5.064
unit benefit (JD/du) using 1993 data	5.917	7.308
change in crop production -1991 data	0.9%	1.3%
change in crop production -1993 data	0.9%	1.3%
percentage increase in returns - 1991 data	1.0%	1.5%
percentage increase in returns - 1993 data	1.0%	1.9%

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation

	1991-1992 Season								
	Without Project			With Project					
	EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Estimated EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Project Benefit (JD/du)	Gross Benefit (1990 Cropping)	Gross Benefit (1994 Cropping)
FRUIT TREES									
Citrus									
Citrus	1.37	94%	765	1.27	96%	785	20.230	42,984	44,073
Lemon	1.37	94%	699	1.27	96%	717	18.482	9,985	10,187
Clementine	1.37	94%	519	1.27	96%	533	13.723	3,527	3,664
Mandarine	1.37	94%	638	1.27	96%	655	18.870	12,300	12,310
Grapefruit	1.37	96%	427	1.27	98%	438	11.010	344	358
Pummelor	1.37	96%	861	1.27	98%	883	22.201	1,930	2,098
Others	1.37	94%	282	1.27	96%	290	7.466	3,588	3,761
Bananas	1.20	96%	572	1.12	99%	591	18.526	8,221	11,098
Misc. Trees									
Apple	1.30	94%	492	1.17	98%	512	19.742	629	629
Apple	1.30	94%	85	1.17	98%	89	3.418	109	109
Grape	1.25	96%	279	1.15	98%	283	4.018	1,851	1,853
Grape	1.25	96%	602	1.15	98%	611	8.870	3,994	3,997
Peach	1.30	94%	518	1.17	98%	539	20.788	1,521	1,525
Peach	1.30	94%	700	1.17	98%	728	28.101	2,057	2,062
Guava	1.20	98%	268	1.12	100%	274	5.502	1,848	2,230
Others	1.37	91%	302	1.27	95%	313	10.707	5,781	10,330
Others	1.37	91%	825	1.27	95%	647	22.171	19,417	30,376
						Sub-total 1991 data		51,523	60,040
						Sub-total 1993 data		76,782	91,713
FIELD CROPS									
Wheat	0.90	100%	17	0.84	100%	17	-	-	-
Maize	1.13	99%	58	1.05	100%	58	0.339	100	349
Garlic	1.36	87%	238	1.27	89%	243	5.350	-	363
Garlic	1.36	87%	159	1.27	89%	163	3.579	-	243
Others	1.26	100%	50	1.15	100%	50	-	-	-
Others	1.26	100%	42	1.15	100%	42	-	-	-
						Sub-total 1991 data		100	712
						Sub-total 1993 data		100	592
Autumn									
Tomato (PH)	1.23	100%	587	1.15	100%	587	-	-	-
Tomato	1.23	100%	330	1.15	100%	330	-	-	-
Tomato (PH)	1.23	100%	2,826	1.15	100%	2,826	-	-	-
Tomato	1.23	100%	304	1.15	100%	304	-	-	-
Squash	1.90	100%	275	1.78	100%	275	-	-	-
Eggplant	1.74	89%	315	1.62	91%	322	8.988	18,007	10,636
Eggplant (PH)	1.23	98%	2,687	1.16	99%	2,722	34.193	70,819	41,830
Cucumber (PH)	1.23	100%	1,000	1.15	100%	1,000	-	-	-
Cucumber (PH)	1.23	100%	2,346	1.15	100%	2,346	-	-	-
Potato	1.50	93%	291	1.42	94%	298	4.575	2,851	931
Potato	1.03	100%	291	0.97	100%	291	-	-	-
Potato	1.50	93%	619	1.42	94%	629	9.720	6,057	1,976
Potato	1.03	100%	688	0.97	100%	688	-	-	-

TABLE CONCLUDES ON FOLLOWING PAGE

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation

	1991-1992 Season								
	Without Project			With Project					
	EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Estimated EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Project Benefit (JD/du)	Gross Benefit (1990 Cropping)	Gross Benefit (1994 Cropping)
Cabbage	1.31	98%	165	1.24	99%	167	1.586	456	595
Cauliflower	1.07	100%	273	1.00	100%	273	-	-	-
Hot Pepper (PH)	1.96	80%	600	1.82	83%	621	20.650	6,579	972
Sweet Pepper (PH)	1.96	80%	692	1.82	83%	716	23.816	9,647	1,652
Broad Bean	1.90	88%	77	1.78	90%	79	1.564	3,308	2,448
String Bean (PH)	0.81	97%	410	0.77	98%	415	4.856	175	5
String Bean	1.79	69%	353	1.68	72%	369	15.948	2,300	64
Lettuce	1.23	93%	190	1.15	95%	193	3.156	6,722	5,715
Spinach	1.79	94%	269	1.68	96%	273	3.567	536	134
Onion	1.03	94%	124	0.97	96%	126	2.001	49	394
Onion	1.03	94%	614	0.97	96%	624	9.909	244	1,953
Turnip	1.65	86%	209	1.55	87%	212	3.260	59	-
Carrot	1.46	84%	564	1.38	86%	576	11.823	323	887
Carrot	1.46	84%	235	1.38	86%	240	4.936	135	362
Others	1.65	100%	182	1.55	100%	182	-	-	-
Others	1.65	100%	247	1.55	100%	247	-	-	-
						Sub-total 1991 data		121,831	66,243
						Sub-total 1993 data		125,043	68,343
Tomato	0.90	100%	298	0.84	100%	298	-	-	-
Tomato (tun)	0.90	100%	383	0.84	100%	383	-	-	-
Tomato	0.90	100%	309	0.84	100%	309	-	-	-
Tomato (tun)	0.90	100%	1,419	0.84	100%	1,419	-	-	-
Squash	1.06	100%	194	0.99	100%	194	-	-	-
Cucumber	0.90	100%	1,000	0.84	100%	1,000	-	-	-
Okra	1.26	84%	43	1.15	87%	45	1.513	-	81
Cauliflower	0.90	100%	273	0.84	100%	273	-	-	-
String Bean	1.11	88%	410	1.01	91%	424	13.574	220	23
String Bean	1.11	88%	314	1.01	91%	324	10.391	169	18
Molokhia	1.26	100%	171	1.15	100%	171	-	-	-
Molokhia (PH)	1.26	100%	440	1.15	100%	440	-	-	-
Sweet melon	1.28	100%	93	1.17	100%	93	-	-	-
Eggplant	0.90	100%	315	0.84	100%	315	-	-	-
Eggplant	0.90	100%	99	0.84	100%	99	-	-	-
Others	1.13	100%	188	1.05	100%	188	-	-	-
Others	1.13	100%	149	1.05	100%	149	-	-	-
						Sub-total 1991 data		220	103
						Sub-total 1993 data		169	98

Items in italics are used to develop estimates referred to as 1993 data

benefit (JD) using 1991 data	173,674	127,099
benefit (JD) using 1993 data	202,094	160,747
unit benefit (JD/du) using 1991 data	4.367	5.895
unit benefit (JD/du) using 1993 data	5.082	7.456
change in crop production - 1993 data	0.8%	1.2%
change in crop production - 1991 data	0.8%	1.2%
percentage increase in returns - 1991 data	1.0%	1.5%
percentage increase in returns - 1993 data	0.8%	1.6%

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation

	1992-1993 Season								
	Without Project			With Project					
	EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Estimated EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Project Benefit (JD/du)	Gross Benefit (1990 Cropping)	Gross Benefit (1994 Cropping)
FRUIT TREES									
Citrus									
Citrus	2.19	74%	605	1.73	85%	695	89 589	190,357	195,181
Lemon	2.19	74%	553	1.73	85%	635	81 851	44,221	45,112
Clementine	2.19	74%	411	1.73	85%	471	60 773	15,619	16,227
Mandarine	2.19	74%	505	1 73	85%	580	74 708	54,470	54,517
Grapefruit	2.19	76%	340	1.73	87%	389	48.759	1,524	1,585
Pummelor	2.19	76%	686	1.73	87%	784	98.317	8,545	9,289
Others	2.19	74%	223	1.73	85%	256	33 066	15,879	16,657
Bananas	1.97	68%	402	1.63	81%	479	76 642	34,009	45,903
Misc. Trees									
Apple	2.06	70%	367	1.57	85%	446	79.457	2,532	2,532
Apple	2.06	70%	63	1.57	85%	77	13 754	438	438
Grape	1.97	86%	249	1 60	91%	264	15 416	7,102	7,108
Grape	1.97	86%	537	1 60	91%	570	33 261	15,324	15,336
Peach	2.06	70%	386	1.57	85%	470	83.656	6,123	6,138
Peach	2.06	70%	522	1.57	85%	635	113.100	8,279	8,298
Guava	1.97	79%	217	1 63	87%	240	22 783	7,645	9,225
Others	2.19	66%	217	1.73	80%	265	47 416	25,602	45,749
Others	2.19	66%	450	1.73	80%	548	98 185	85,990	134,523
						Sub-total 1991 data		223,272	260,040
						Sub-total 1993 data		334,397	399,679
FIELD CROPS									
Wheat	1.44	100%	17	1.37	100%	17	-	-	-
Maize	1.81	87%	51	1 53	92%	54	2 813	827	2,900
Garlic	1.44	85%	233	1.37	87%	237	4 468	-	303
Garlic	1.44	85%	156	1.37	87%	159	2.988	-	203
Others	1.98	100%	50	1.54	100%	50	-	-	-
Others	1.98	100%	42	1.54	100%	42	-	-	-
						Sub-total 1991 data		827	3,203
						Sub-total 1993 data		827	3,103
Autumn									
Tomato (PH)	1.48	100%	587	1.41	100%	587	-	-	-
Tomato	1.48	100%	330	1.41	100%	330	-	-	-
Tomato (PH)	1.48	100%	2,826	1.41	100%	2,826	-	-	-
Tomato	1.48	100%	304	1.41	100%	304	-	-	-
Squash	1.49	100%	275	1.40	100%	275	-	-	-
Eggplant	1.45	94%	332	1.37	95%	338	5.537	14,274	8,431
Eggplant (PH)	1.45	94%	2,581	1.39	95%	2,610	28.141	58,285	34,426
Cucumber (PH)	1.48	100%	1,000	1 41	100%	1,000	-	-	-
Cucumber (PH)	1.48	100%	2,346	1.41	100%	2,346	-	-	-
Potato	1.49	93%	292	1.44	94%	295	2.959	1,844	602
Potato	1.43	94%	274	1.40	95%	276	1.758	207	68
Potato	1.49	93%	620	1.44	94%	626	6.287	3,917	1,280
Potato	1.43	94%	647	1.40	95%	652	4 151	489	160

TABLE CONCLUDES ON FOLLOWING PAGE

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation

	1992-1993 Season								
	Without Project			With Project					
	EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Estimated EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Project Benefit (JD/du)	Gross Benefit (1990 Cropping)	Gross Benefit (1994 Cropping)
Cabbage	1.39	97%	163	1.35	98%	164	1.072	308	402
Cauliflower	1.39	100%	273	1.36	100%	273	-	-	-
Hot Pepper (PH)	1.47	90%	676	1.36	92%	693	16.369	5,215	770
Sweet Pepper (PH)	1.47	90%	780	1.36	92%	799	18.879	7,647	1,309
Broad Bean	1.49	94%	82	1.40	96%	83	1.130	2,390	1,769
String Bean (PH)	1.39	80%	340	1.34	82%	346	5.736	207	6
String Bean	1.53	76%	392	1.46	78%	402	10.315	1,487	41
Lettuce	1.48	89%	180	1.41	90%	183	2.844	8,058	5,151
Spinach	1.53	97%	278	1.46	98%	280	2.307	346	87
Onion	1.43	85%	112	1.40	86%	113	1.056	26	208
Onion	1.43	85%	553	1.40	86%	558	5.231	129	1,031
Turnip	1.47	88%	215	1.39	89%	217	2.355	43	-
Carrot	1.39	85%	575	1.33	87%	584	8.767	239	643
Carrot	1.39	85%	240	1.33	87%	244	3.660	100	269
Others	1.47	100%	182	1.39	100%	182	-	-	-
Others	1.47	100%	247	1.39	100%	247	-	-	-
						Sub-total 1991 data		98,578	53,914
						Sub-total 1993 data		100,896	55,131
Tomato	1.46	100%	298	1.38	100%	298	-	-	-
Tomato (tun)	1.44	100%	383	1.37	100%	383	-	-	-
Tomato	1.46	100%	309	1.38	100%	309	-	-	-
Tomato (tun)	1.44	100%	1,419	1.37	100%	1,419	-	-	-
Squash	1.46	100%	194	1.40	100%	194	-	-	-
Cucumber	1.44	100%	1,000	1.37	100%	1,000	-	-	-
Okra	1.98	64%	33	1.54	76%	39	6.416	-	341
Cauliflower	1.46	100%	273	1.38	100%	273	-	-	-
String Bean	1.63	73%	341	1.52	77%	356	15.493	251	26
String Bean	1.63	73%	261	1.52	77%	273	11.861	192	20
Molokhia	1.98	92%	158	1.54	97%	166	8.552	56	45
Molokhia (PH)	1.98	92%	406	1.54	97%	428	22.027	307	250
Sweet melon	2.02	100%	93	1.55	100%	93	-	-	-
Eggplant	1.44	94%	296	1.37	95%	300	3.848	2,631	917
Eggplant	1.44	94%	93	1.37	95%	94	1.206	825	287
Others	1.81	98%	185	1.53	100%	188	2.943	2,878	488
Others	1.81	98%	147	1.53	100%	149	2.333	2,281	387
						Sub-total 1991 data		8,124	2,068
						Sub-total 1993 data		3,662	1,331

Items in italics are used to develop estimates referred to as *1993 data*

benefit (JD) using 1991 data	328,801	319,224
benefit (JD) using 1993 data	439,783	459,244
unit benefit (JD/du) using 1991 data	8.268	14.806
unit benefit (JD/du) using 1993 data	11.059	21.300
change in crop production -1993 data	1.6%	3.5%
change in crop production -1991 data	1.7%	3.6%
percentage increase in returns - 1991 data	1.9%	4.2%
percentage increase in returns - 1993 data	1.8%	5.1%

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation

	1993-1994 Season								
	Without Project			With Project					
	EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Estimated EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Project Benefit (JD/du)	Gross Benefit (1990 Cropping)	Gross Benefit (1994 Cropping)
FRUIT TREES									
Citrus									
Citrus	2.44	68%	557	1.91	81%	661	104.129	221,252	226,859
Lemon	2.44	68%	509	1.91	81%	604	95.135	51,398	52,433
Clementine	2.44	68%	378	1.91	81%	448	70.637	18,154	18,860
Mandarine	2.44	68%	464	1.91	81%	551	86.833	63,310	63,385
Grapefruit	2.44	70%	314	1.91	83%	370	58.873	1,772	1,843
Pummelor	2.44	70%	632	1.91	83%	747	114.274	9,932	10,797
Others	2.44	68%	205	1.91	81%	244	38.432	18,457	19,360
Bananas	2.44	51%	300	1.66	79%	471	170.783	75,782	102,285
Misc. Trees									
Apple	2.64	52%	272	2.00	72%	377	104.998	3,348	3,348
Apple	2.64	52%	47	2.00	72%	65	18.178	579	579
Grape	2.58	77%	223	1.79	89%	256	32.956	15,184	15,195
Grape	2.58	77%	482	1.79	89%	553	71.107	32,761	32,785
Peach	2.64	52%	286	2.00	72%	397	110.547	8,092	8,111
Peach	2.64	52%	387	2.00	72%	536	149.455	10,940	10,966
Guava	2.44	68%	167	1.66	87%	238	50.722	17,035	20,556
Others	2.44	58%	192	1.91	75%	247	55.111	29,757	53,174
Others	2.44	58%	397	1.91	75%	511	114.120	99,946	156,357
						Sub-total 1991 data		312,218	369,324
						Sub-total 1993 data		441,261	529,830
FIELD CROPS									
Wheat	2.53	100%	17	1.81	100%	17	-	-	-
Maize	2.50	75%	44	1.89	86%	50	6.276	1,846	6,470
Garlic	2.43	81%	168	1.81	76%	208	40.102	-	2,724
Garlic	2.43	61%	112	1.81	76%	139	26.831	-	1,822
Others	2.63	100%	50	2.00	100%	50	-	-	-
Others	2.63	100%	42	2.00	100%	42	-	-	-
						Sub-total 1991 data		1,846	9,194
						Sub-total 1993 data		1,846	8,293
Autumn									
Tomato (PH)	2.49	88%	518	1.85	98%	574	55.618	113,461	4,568
Tomato	2.49	88%	291	1.85	98%	323	31.360	265,482	10,735
Tomato (PH)	2.49	88%	2,494	1.85	98%	2,763	268.771	546,328	22,091
Tomato	2.49	88%	268	1.85	98%	297	28.886	244,385	9,882
Squash	2.41	100%	275	1.97	100%	275	-	-	-
Eggplant	2.32	78%	277	1.79	88%	311	33.943	87,493	51,879
Eggplant (PH)	2.45	76%	2,088	1.83	87%	2,395	306.494	634,806	374,955
Cucumber (PH)	2.49	85%	846	1.85	97%	971	124.923	192,863	20,851
Cucumber (PH)	2.49	85%	1,984	1.85	97%	2,277	293.098	452,500	48,452
Potato	2.37	77%	243	1.86	88%	271	28.619	17,833	5,825
Potato	2.47	75%	220	1.80	88%	255	35.239	4,153	1,357
Potato	2.37	77%	516	1.86	88%	576	60.801	37,867	12,378
Potato	2.47	75%	519	1.80	88%	602	83.200	9,805	3,203

TABLE CONCLUDES ON FOLLOWING PAGE

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation

	1993-1994 Season								
	Without Project			With Project					
	EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Estimated EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Project Benefit (JD/du)	Gross Benefit (1990 Cropping)	Gross Benefit (1994 Cropping)
Cabbage	2.55	80%	135	1.89	90%	151	16.046	4,616	6,019
Cauliflower	2.62	90%	246	1.88	100%	273	27.395	26,862	23,461
Hot Pepper (PH)	2.36	72%	536	1.88	82%	611	74.887	23,859	3,524
Sweet Pepper (PH)	2.36	72%	619	1.88	82%	705	86.370	34,987	5,991
Broad Bean	2.41	81%	71	1.97	87%	76	5.812	11,872	8,785
String Bean (PH)	2.45	50%	212	1.73	71%	298	88.216	3,108	86
String Bean	2.46	50%	255	2.05	62%	315	59.952	8,644	240
Lettuce	2.49	69%	140	1.65	81%	185	25 391	54,084	45,981
Spinach	2.46	87%	247	2.05	91%	261	13 407	2,014	503
Onion	2.47	80%	79	1 81	76%	100	20 640	507	4,068
Onion	2.47	80%	391	1.81	76%	493	102 208	2,512	20,143
Turnip	2.35	76%	186	1.83	83%	203	17 062	311	-
Carrot	2.50	62%	415	1.86	75%	507	91 976	2,512	6,746
Carrot	2.50	62%	173	1.86	75%	212	38.397	1,049	2,817
Others	2.35	90%	164	1.83	98%	178	14 075	7,162	14,478
Others	2.35	90%	223	1.83	98%	242	19 107	9,723	19,654
						Sub-total 1991 data		1,498,650	589,694
						Sub-total 1993 data		2,196,865	659,863
Tomato	2.51	88%	262	1.93	97%	288	25 650	23,975	1,644
Tomato (tun)	2.53	88%	336	1.81	98%	377	40 825	4,764	327
Tomato	2.51	88%	272	1.93	97%	298	26 577	24,842	1,704
Tomato (tun)	2.53	88%	1,244	1.81	98%	1,395	151.111	17,632	1,209
Squash	2.48	100%	194	1.81	100%	194	-	-	-
Cucumber	2.53	84%	838	1.81	98%	978	139 925	-	1,086
Okra	2.63	45%	23	2.00	63%	32	9 238	-	492
Cauliflower	2.51	92%	250	1.93	100%	272	21 859	-	310
String Bean	2.39	52%	241	1 84	68%	314	72.931	1,184	124
String Bean	2.39	52%	184	1.84	68%	240	55 833	906	95
Molokhia	2.63	85%	145	2.00	92%	157	12.310	80	65
Molokhia (PH)	2.63	85%	373	2.00	92%	405	31 705	442	360
Sweet melon	2.84	87%	81	2 04	100%	93	12.001	39,049	2,912
Eggplant	2.53	75%	235	1.81	87%	275	40 090	27,412	9,550
Eggplant	2.53	75%	74	1 81	87%	86	12 569	8,594	2,994
Others	2.50	88%	166	1.89	97%	182	16 884	16,513	2,799
Others	2.50	88%	131	1.89	97%	145	13.363	13,089	2,216
						Sub-total 1991 data		113,416	19,669
						Sub-total 1993 data		104,635	13,446

Items in italics are used to develop estimates referred to as 1993 data

benefit (JD) using 1991 data	1,924,133	987,861
benefit (JD) using 1993 data	2,744,807	1,211,431
unit benefit (JD/du) using 1991 data	46.384	45 819
unit benefit (JD/du) using 1993 data	69 016	56 188
change in crop production -1993 data	11.4%	11.1%
change in crop production -1991 data	11.4%	11 0%
percentage increase in returns - 1991 data	13.2%	15.2%
percentage increase in returns - 1993 data	13.1%	15 8%

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation

	1994-1996 Season								
	Without Project			*With Project*					
	EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Estimated EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Project Benefit (JD/du)	Gross Benefit (1990 Cropping)	Gross Benefit (1994 Cropping)
FRUIT TREES									
Citrus									
Citrus	2.08	77%	627	1.44	92%	752	124.857	265,294	272,018
Lemon	2.08	77%	573	1.44	92%	687	114.073	61,629	62,870
Clementine	2.08	77%	426	1.44	92%	510	84.698	21,767	22,615
Mandarine	2.08	77%	523	1.44	92%	627	104.118	75,913	75,978
Grapefruit	2.08	79%	352	1.44	94%	420	67.954	2,125	2,210
Pummelor	2.08	79%	710	1.44	94%	847	137.021	11,910	12,946
Others	2.08	77%	232	1.44	92%	278	46.083	22,130	23,214
Bananas	1.99	67%	400	1.36	90%	537	137.294	60,922	62,228
Misc. Trees									
Apple	2.20	66%	343	1.43	90%	469	126.217	4,022	4,022
Apple	2.20	66%	59	1.43	90%	81	21.849	696	696
Grape	2.08	84%	244	1.40	94%	273	28.591	13,173	13,182
Grape	2.08	84%	526	1.40	94%	588	61.689	28,421	28,443
Peach	2.20	66%	361	1.43	90%	494	132.887	9,727	9,750
Peach	2.20	66%	489	1.43	90%	668	179.659	13,151	13,182
Guava	1.99	79%	217	1.36	94%	258	40.776	13,695	16,525
Others	2.08	69%	229	1.44	89%	295	66.081	35,680	63,758
Others	2.08	69%	474	1.44	89%	611	136.837	119,841	167,461
						Sub-total 1991 data		332,692	389,298
						Sub-total 1993 data		488,326	584,045
FIELD CROPS									
Wheat	1.87	100%	17	1.21	100%	17	-	-	-
Maize	2.30	79%	46	1.41	95%	55	9.318	2,741	9,607
Garlic	2.00	71%	198	1.50	83%	229	32.708	-	2,221
Garlic	2.00	71%	131	1.50	83%	153	21.884	-	1,486
Others	2.29	100%	50	1.41	100%	50	-	-	-
Others	2.29	100%	42	1.41	100%	42	-	-	-
						Sub-total 1991 data		2,741	11,828
						Sub-total 1993 data		2,741	11,093
Autumn									
Tomato (PH)	2.00	96%	561	1.39	100%	587	26.085	52,981	2,142
Tomato	2.00	96%	315	1.39	100%	330	14.653	123,967	5,013
Tomato (PH)	2.00	96%	2,701	1.39	100%	2,826	125.504	255,109	10,315
Tomato	2.00	96%	290	1.39	100%	304	13.469	114,118	4,614
Squash	2.19	100%	275	1.81	100%	275	-	-	-
Eggplant	2.15	61%	268	1.73	69%	315	26.255	67,677	39,974
Eggplant (PH)	1.91	86%	2,355	1.40	95%	2,606	251.024	519,918	307,085
Cucumber (PH)	2.00	94%	942	1.39	100%	1,000	58.333	90,058	9,643
Cucumber (PH)	2.00	94%	2,209	1.39	100%	2,346	136.863	211,296	22,625
Potato	1.89	86%	270	1.51	93%	291	21.123	13,162	4,300
Potato	1.66	90%	262	1.23	98%	285	22.584	2,661	869
Potato	1.89	86%	573	1.51	93%	618	44.877	27,964	9,135
Potato	1.66	90%	619	1.23	98%	673	53.321	6,284	2,053

TABLE CONCLUDES ON FOLLOWING PAGE

ANNEX 5.

Analysis of Estimated Farm-Level Economic Returns (JD)
Resulting from Project Implementation

	1994-1995 Season								
	Without Project			With Project					
	EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Estimated EC (dS/m)	Est. % Yield	Estimated Returns (JD/du)	Project Benefit (JD/du)	Gross Benefit (1990 Cropping)	Gross Benefit (1994 Cropping)
Cabbage	1.81	91%	153	1.42	97%	162	9.660	2,779	3,624
Cauliflower	1.53	100%	273	1.19	100%	273	-	-	-
Hot Pepper (PH)	2.30	73%	547	1.88	82%	612	64.850	20,661	3,052
Sweet Pepper (PH)	2.30	73%	631	1.88	82%	706	74.794	30,297	5,168
Broad Bean	2.19	84%	73	1.81	90%	78	4.839	10,236	7,575
String Bean (PH)	1.80	69%	290	1.18	86%	365	74.912	2,700	75
String Bean	2.05	62%	315	1.68	72%	369	53.671	7,739	215
Lettuce	2.00	78%	160	1.39	90%	184	24.044	51,216	43,542
Spinach	2.05	91%	261	1.68	96%	273	12.003	1,803	450
Onion	1.66	80%	104	1.23	90%	118	13.570	334	2,674
Onion	1.66	80%	517	1.23	90%	584	87.196	1,652	13,243
Turnip	2.04	81%	196	1.65	86%	209	12.776	233	-
Carrot	1.95	73%	494	1.55	82%	552	57.820	1,579	4,242
Carrot	1.95	73%	206	1.55	82%	230	24.138	659	1,771
Others	2.04	95%	173	1.65	100%	182	9.120	4,641	9,381
Others	2.04	95%	234	1.65	100%	247	12.381	6,300	12,735
						Sub-total 1991 data		1,004,642	449,054
						Sub-total 1993 data		1,336,639	487,280
Tomato	1.97	98%	286	1.22	100%	296	11.924	11,145	784
Tomato (tun)	1.87	97%	374	1.21	100%	383	9.630	1,124	77
Tomato	1.97	98%	297	1.22	100%	309	12.355	11,548	792
Tomato (tun)	1.87	97%	1,383	1.21	100%	1,419	35.645	4,159	285
Squash	1.73	100%	194	1.24	100%	194	-	-	-
Cucumber	1.87	97%	967	1.21	100%	1,000	33.007	-	256
Okra	2.29	55%	28	1.41	80%	41	13.050	-	694
Cauliflower	1.97	99%	270	1.22	100%	273	2.578	-	37
String Bean	2.30	54%	252	1.36	81%	377	125.509	2,037	213
String Bean	2.30	54%	193	1.36	81%	269	96.065	1,559	163
Molokhia	2.29	89%	151	1.41	99%	169	17.389	113	92
Molokhia (PH)	2.29	89%	390	1.41	99%	435	44.786	625	509
Sweet melon	2.26	96%	89	1.43	100%	93	3.631	11,816	881
Eggplant	1.87	86%	271	1.21	98%	308	36.992	25,293	8,812
Eggplant	1.87	86%	85	1.21	98%	97	11.598	7,930	2,763
Others	2.30	91%	171	1.41	100%	188	16.816	16,446	2,787
Others	2.30	91%	136	1.41	100%	149	13.330	13,037	2,209
						Sub-total 1991 data		68,600	15,123
						Sub-total 1993 data		50,787	8,681

Items in italics are used to develop estimates referred to as 1993 data

			1990-1994 AVERAGES Cropping Pattern 1990	1994
benefit (JD) using 1991 data	1,408,675	865,302	797,644	481,822
benefit (JD) using 1993 data	1,880,493	1,091,100	1,100,454	616,007
unit benefit (JD/du) using 1991 data	35.423	40.134	20.058	22.348
unit benefit (JD/du) using 1993 data	47.287	50.607	27.672	28.571
change in crop production -1993 data	7.1%	9.2%	4.3%	5.2%
change in crop production -1991 data	7.1%	9.3%	4.4%	5.3%
percentage increase in returns - 1991 data	8.8%	12.0%	4.9%	8.6%
percentage increase in returns - 1993 data	8.2%	12.7%	4.7%	7.1%

ATTACHMENT 1

بسم الله الرحمن الرحيم

THE HASHEMITE KINGDOM OF JORDAN

MINISTRY OF TOURISM & ANTIQUITIES

Department of Antiquities

Amman

المملكة الأردنية الهاشمية

وزارة السياحة والآثار

دائرة الآثار العامة

عمان

Ref. 1/1/8 الرقم

Date 1996/3/12 التاريخ

1416/10/ الموافق

عطوفة امين عام سلطة وادي الاردن

ارجو التلطف بالعلم بأنه تم اجراء الكشف اللازم على المسار المقترح لخط المياه الناقل المسمى خط الزرقاء من قبل السيد عبد السميع ابو دية مدير مشروع المصادر التراثية في دائرة الاثار العامة يرافقه مندوب شركة اتحاد المستشارين المهندس خالد مراد بتاريخ ١٩٩٦/٣/١١ وقد تبين انه لا يوجد اية اثار ظاهرة على السطح في مسار الخط المذكور من منطقة السير التحويلي في الجوارات شرقا الى قناة الملك عبد الله منطقة ابو الزيمان غربا .

وعلية فانه لا يوجد لدى هذه الدائرة ما يمنع من تنفيذ المشروع على ان يقوم المتعهد بابلاغنا عن اية اثار قد تظهر اثناء عملية الحفر .

وتفضلوا بقبول فائق الاحترام

مدير عام دائرة الآثار

د. غازي بيشه

نسخة/الى السيد عبد السميع ابو دية / اشارة الى كتابه رقم ٩/١/١٩ تاريخ ١٩٩٦/٣/١٢ .

نسخة/الى السادة شركة اتحاد المستشارين .

نسخة/الى مفتش اثار محافظة البلقاء .

نسخة/الى مفتش اثار الاغوار الوسطى .

ع أ / ن س .

BEST AVAILABLE COPY

ATTACHMENT 1

Translation of Letter

Ministry of Tourism and Antiquities
Dept. of Antiquities

Ref. : 8/1/1/722
Date : 14/3/1996

H. E. The Secretary General
Jordan Valley Authority

Kindly be informed that a site visit was conducted on 11/3/1996, to check the proposed alignment for the Zarqa River Conveyance, by Mr. A. Abu Dayyeh, Project Manager, Heritage Resources Project, Dept. of Antiquities accompanied by Eng. Khaled Murad, Consultant's Representative.

No antiquities were found along the proposed route between Hwaret Weir and Abu Zeighan Weir, therefore this department has no objection towards the construction of this project, provided that the Contractor keep this department informed on any antiquities that may be found during construction.

Regards,

Dr. Ghazi Bisheh
General Manager