PN-ACE-768
101072

3114-36 3a-04

Jordan Water Quality Improvement and Conservation Project

ZARQA RIVER CONVEYANCE STUDY

PHASE B - FEASIBILITY AND ENVIRONMENTAL ASSESSMENT OF THE ZARQA RIVER CONVEYANCE SYSTEM BETWEEN HWARET AND ABU ZEIGHAN WEIRS

Prepared for the

Government of Jordan

by

HARZA
Engineering Company

in association with

Consolidated Consultants, Inc

April 1996

Jordan Water quality Improvement and Conservation Project

ZARQA RIVER CONVEYANCE STUDY

PHASE B - FEASIBILITY AND ENVIRONMENTAL ASSESSMENT OF ZARQA RIVER CONVEYANCE SYSTEM BETWEEN HWARET AND ABU ZEIGHAN WEIRS

EXECUTIVE SUMMARY

This report presents the results of an environmental assessment, an economic and financial analysis, and a preliminary design of the Zarqa River Conveyance Study, a component of the Jordan Water Quality Improvement and Conservation Project The Conveyance Study was initiated to evaluate the potential for improving the conveyance efficiency of the Zarqa River channel and the quality of water diverted from the Zarqa River at the Abu Zeighan Weir The study has been performed by Harza Engineering Company (Harza) in association with Consolidated Consultants (CC) under a subcontract with Development Alternatives, Inc

Previous reports associated with this study have included an Inception Report, a Data Evaluation Report, and a Conceptual Studies Report which covered the identification and evaluation of alternatives resulting in the selection of a preferred alternative

Based on these earlier studies, it was concluded that no losses occur in the Zarqa River channel upstream of the Hwaret Weir and possibly some losses occur between the Hwaret Weir and the Abu Zeighan Weir It was further concluded that the saline springs and seeps located in the reach between the Hwaret Weir and the Abu Zeighan Weir degrade the diversion from the Zarqa River to the King Abdullah Canal to the extent that yields are significantly reduced in the irrigated area The preferred alternative to improve the quality of the diversion is to divert the releases from the KTD at the Hwaret Weir around the area of seeps and springs

The Jordan Valley Authority reviewed a draft of the Conceptual Report and decided that the preferred alternative consisted of a pipeline form the Hwaret Weir to the Abu Zeighan Canal The studies associated with this report were oriented toward the confirmation of the technical, economic, and environmental feasibility of this alternative and the development of a preliminary design

Topographic surveys were performed for the components of the preferred alternative The survey data were drawn for a one meter contour interval and digitized The digitized maps were redrawn to a scale appropriate for the preliminary design of the structures of the recommended alternative

Geotechnical studies, consisting of field and laboratory investigations, were performed and as a result, it was concluded that the proposed structures can be supported by the foundation materials at the site provided that certain reasonable design criteria are met These criteria were used in the preliminary design

Preferred Project Components

The project will consist of the replacement of the Hwaret Weir, an integral intake structure, a desanding basin, a pipeline conveyance system with two river crossings, and an outlet structure Preliminary designs were developed for the following components

The geotechnical investigation indicated a preference for the replacement of the old weir rather than rehabilitation Therefore, the existing weir, intake, and the canal in the Hwaret Weir area will be demolished and the area will be excavated, cleared, and prepared for the construction of

new structures The new weir will have an hydraulic height of about five meters and be about 41 5 meters wide with a crest level at El -184 m A series of concrete blocks will be installed for energy dissipation

The intake structure will be located on the left bank with its crest is at El -184 m Flow to the intake will be regulated by sluice gates and a trashrack will be used to prevent trash from entering the pipe

A desanding basin will be located on the left bank, about 20 meters downstream from the downstream end of the intake Provision for the desanding basin was considered necessary based on the experience at Thahab Weir The desanding basin will cause settlement of all sediment greater than 0 1 mm and much of the sediment between 0 06 and 0 1 mm

The pipeline will be about 3 7 km long and have an inner diameter of 1 4 meters Two viaducts are required for river crossings The pipeline has been aligned to avoid dwellings, to stay close to the road and to provide minimum number of bends Average excavation along the route is about two meters

The outlet structures include an energy dissipation valve and house, and an outlet basin The outlet will dissipate the flow energy with two Bailey polyjet valves After exiting the valves, the flow will enter an outlet basin from which it will be delivered in the Abu Zeighan Canal

Cost of Project

The Project cost was developed using unit prices collected through inquiries with local manufacturers and contractors and materials quantities estimated from the preliminary design drawings The original concept of basing the unit prices on three similar ongoing projects, as per the scope of work, was not possible as no ongoing or recently completed projects could be identified The pipe costs was based on costs collected through the survey and quotations from a US manufacturer

The construction cost is estimated to be JD 5 3 million This cost includes field costs, a contingency allowance of 15 percent, an estimate for final design, and an allowance of 10 percent for engineering services during construction and owner's administrative costs

Operation and maintenance costs are estimated to be JD 55,000 per year based on providing the services from the JVA'a existing O&M group

Economic Analysis

The project benefits accrue from the supply of better quality water to the KAC The benefits will be measured in terms of improved yields and a reduction in damage to the crops The 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, economic data obtained from results of two surveys of randomly selected farms in the central and southern Jordan Valley, and data on cropping patterns for the southern Jordan Valley obtained from published statistics and from unpublished data provided by JVA

The assessment approach involved estimating the effect of EC on the yield of individual crops grown in the southern Jordan Valley during the 1990-91 through 1994-95 growing seasons The economic data used in the study came from two sources covering different periods and areas in the Jordan Valley For the 1991-1992 season in the southern Jordan Valley, economic data were collected from Salman, 1994 and for the 1993-1994 season in the central Jordan Valley from the Water & Environment Research & Study Center, 1995 Data were available for most of the more widely planted crops and for several technologies

Under current operating conditions much of the water in the KAC in the summer months is diverted to Amman for municipal and industrial use This is likely to continue as long as supplies in Jordan are scarce Under these conditions, it is estimated that the annual benefit to the Project amounts to JD 1 7 million If the diversion to Amman varies depending on other supplies, it is estimated that the annual net benefit would amount to about JD 860,000 The economic analysis was performed for both values Any indirect benefits were not considered

The economic justification of the project was evaluated using net present value and benefit-cost ratio criteria These criteria were computed using a 10 percent discount rate and a 50-year period of analysis Based on a construction cost of JD 5 3 million and benefits amounting to JD 1 7 million per year, the Project is economically justified with a benefit cost ratio of 2 9 and a net present value of about JD 10 million For a benefit of JD 860,000, the B/C would be about 1 5 and the NPV would be JD 2 4 million

Financial Analysis

The financial analysis was performed to estimate the annual "equalization revenue" required to result in a cumulative present value of the cash flow equal to zero This approach was taken because it is difficult to estimate the revenue to the nation as a result of the implementation of this project and, therefore, the derivation of a financial rate of return is not relevant The ratio of this annual equalization revenue to the total net benefit provides an indication of the "coverage" that the Project improvements provide Allowing for 100 percent debt financing, a 6 0 percent cost of debt (based on the assumption of a soft loan), and a debt repayment period of 20 years, the equalization revenue would be about JD 430,000 per year which is about 25 percent of the annual benefit Therefore, taxes in the amount of 25 percent of the additional income would repay the Project loan and operating costs in 20 years

Project Implementation

It is expected that the Project can be in operation by April 1997 if design is started in May 1996

Environmental Impact

Three alternatives and a "no-action" alternative were evaluated for potential environmental impacts The alternatives included

1 A pipeline from Hwaret Weir to Abu Zeighan Weir (preferred project),

2 A combination of canal-pipeline from Hwaret Weir to the Abu Zeighan Weir, and

3 A pipeline from Thahab Weir to the Abu Zeighan Weir

For each alternative, the environmental impacts were analyzed for surface water, ground water, water quality, vegetation wildlife, aquatic resources, and human environment The preferred project indicated least impacts Most of these impacts can be avoided with appropriate mitigation measures as follows

Construction impacts are expected to be minimal as construction will likely occur during the summer months as recommended

Compensation for the destruction of any crops during construction is recommended

Fuel storage and fueling areas will be located away from cultivated areas, areas that drain into cultivated areas or the stream channel

Spill cleanup materials will be provided and stored on-site for quick access

Although not provided for in the preliminary design, a minimum release facility can be added to the weir through the diversion conduit

The environmental study report has been published as a stand-alone report In addition to an expansion of the above, it includes a discussion of the environmental impacts of two other potentially feasible alternatives, compatible with the selected alternative, leading to the final selection of the preferred alternative

Recommendation

Because the project is technically Environmentally and economically fea sible, it should be implemeted as quickly as possible

ZARQA RIVER CONVEYANCE STUDY

PHASE B - FEASIBILITY AND ENVIRONMENTAL ASSESSMENT OF ZARQA RIVER CONVEYANCE SYSTEM BETWEEN HWARET AND ABU ZEIGHAN WEIRS

TABLE OF CONTENTS

Chapter		Page
1	INTRODUCTION	1-1
	1 1 General	1-1
	1 2 Authorization	1-1
	1 3 Scope	1-1
	1 4 Mobilized Staff	1-2
	1 5 Background	1-2
	1 6 Description of Project Area	1-3
	1 6 1 Zarqa River Basin	1-3
	1 6 2 General Climate	1-4
	1 6 3 Water Resources	1-4
	1 6 4 Watershed Characteristics	1-5
	1 6 5 Geology	1-6
	1 6 6 Groundwater Regime	1-7
	1 6 7 Water Quality	1-8
	1 7 Existing Developments	1-8
	1 8 Summary of the Phase A Reports	1-9
	1 8 1 Phase A, part 1, "Inception Report"	1-9
	1 8 2 Phase A, Part 2, "Data Evaluation"	1-9
	1 8 3 Phase A, Part 3, "Selection of a Preferred Alternative"	1-10
2	ZARQA RIVER CHANNEL CONVEYANCE EFFICIENCY AND WATER QUALITY	2-1
	2 1 Conveyance Efficiency	2-1
	2 2 Water Quality	2-4
	2 3 Summary	2-5
3	GENERAL APPROACH TO THE PHASE B STUDIES	3-1
	3 1 Adopted Concept	3-1

3 2 General Approach 3-1
3 2 1 Environmental Assessment 3-1
3 2 2 Field Studies 3-2
3 2 3 Economic and Financial Analysis 3-2
3 2 4 Preliminary Design 3-2

4 FIELD INVESTIGATIONS 4-1

4 1 Geotechnical Investigations 4-1
4 2 Topographic Survey 4-2

5 PRELIMINARY DESIGN 5-1

5 1 Project Elements 5-1
5 2 Design Criteria 5-1
5 2 1 Materials and Mixes 5-1
5 2 2 Internal and External Protection 5-2
5 2 3 Velocities 5-2
5 2 4 Maximum Pressure in Closed Conduits 5-2
5 2 5 Strength and Loading 5-2
5 2 6 Washouts and Air Valves 5-2
5 2 7 Excavation 5-2
5 2 8 Protection Works 5-2
5 2 9 Construction Materials 5-2
5 2 10 Diversion of Flows During Construction 5-3
5 2 11 Operation and maintenance 5-3
5 2 12 Environmental Impact 5-3
5 2 13 Training Requirements for Operation and Maintenance Personnel 5-4
5 3 Project Features 5-4
5 3 1 Replacement of the Hwaret Weir and Intake 5-4
5 3 2 Desanding Basin 5-5
5 3 3 Pipeline 5-6
5 3 4 Rover Crossings 5-6
5 3 5 Outlet Structures 5-6

6 PROJECT COST 6-1

6 1 Unit Cost on Similar Project 6-1
6 2 Capital Cost 6-1
6 3 Operation and Maintenance Cost 6-2

7 ECONOMIC AND FINANCIAL ANALYSIS 7-1

7 1 Economic Analysis 7-1
7 1 1 Project Costs 7-1
7 1 2 Project Benefits 7-1
7 1 2 1 Average Water Quality Conditions 7-2

7 1 2 2 Approach to the Derivation of Economic Benefits 7-3

7 1 2 3 Economic Benefit 7-7
7 1 3 Benefit Build-up Period 7-7
7 1 4 Economic Justification 7-7
7 1 5 Sensitivity Analysis 7-7
7 2 Financial Analysis 7-8
7 2 1 Investment Cost 7-8
7 2 2 Repayment 7-9

8 PROJECT IMPLEMENTATION AND CONSTRUCTION 8-1

8 1 Project Organization 8-1
8 2 Preconstruction Activities 8-1
8 3 Construction Activities 8-1

9 ENVIRONMENTAL ASSESSMENT 9-1

9 1 Alternatives Included for Environmental Assessment 9-1
9 2 Affected Environment 9-1
9 3 Comparison of Environmental Effects 9-2
9 3 1 Construction and Operation Effects on Land Use (Exhibit 9 1) 9-2
9 3 2 Operation Effects on Streamflow (Exhibit 9 2) 9-2
9 3 3 Operation Effects on Water Quality (Exhibit 9 3) 9-3
9 3 4 Operation Effects on Aquatic Life, Vegetation and Migratory and Resident Bird Habitat (Exhibit 9 4) 9-3
9 3 5 Operation Effects on Human Uses of Water in the Zarqa Riverand Irrigated Areas (Exhibit 9 5) 9-4
9 3 6 Selected Alternatives 9-5
9 4 Environmental Consequences 9-5
9 4 1 Construction Effects 9-6
9 4 2 Effects on Streamflow and Water Quality 9-9
9 4 3 Groundwater 9-13
9 4 4 Wildlife and Aquatic Resources 9-13
9 4 5 Suitability of Water for Agriculture and Other Uses 9-14
9 4 6 Maintaining Productivity of Affected lands 9-15
9 4 7 Antiquities 9-16
9 4 8 Human Population 9-16
9 5 Recommended Mitigation Measures 9-17
9 5 1 Construction Impacts 9-17
9 5 2 Diversion of KTD Water from the River Channel 9-18
9 6 Monitoring 9-18

10 CONCLUSIONS AND RECOMMENDATIONS 10-1

REFERENCES

EXHIBITS

APPENDIX

Tables

No.		Page
7 1	Crop Tolerance and yield Potential as Influenced by Irrigation Water Salinity (EC, MMOHS/CM)	7-2
7 2	Average EC Values for 1989-1994	7-3
7 3	Summary of Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation	7-6
7 4	Sensitivity Analysis	7-8

Exhibits

1 1 General Location Map
1 2 Area Downstream from KTD
1 3 Historical Monthly Streamflow (cms), Zarqa River at KTD
1 4 Historical Monthly Intervening Flow (cms), KTD to Abu Zeighan Weir
1 5 Historical Monthly Intervening Flow (cms), KTD to Thahab Weir
1 6 Historical Monthly Intervening Flow (cms), KTD to Hwaret Weir
1 7 Groundwater Equipotential Lines of the Zarqa Group Aquifer Systems
1 8 Hydrogeological Cross Section
1 9 Hydrogeological Cross Section
1 10 Location of Pipeline Route
2 1 Monthly EC Values
5 1 Project General Plan View
5 2 Hwaret Overflow Weir, Intake and Desanding Basin - Location Plan
5 3 Hwaret Overflow Weir Plam and Section
5 4 Intake Structure Plan and Section
5 5 Desanding Basin Paln and Section
5 6 Pipeline Plan
5 7 Vertical Profile of Pipeline and Ground Elevation
5 8 Data from Vertical profile of Pipeline
5 9 Typical Pipeline Alignment Details
5 10 Viaduct 1 Plan and Profile
5 11 Viaduct 2 Plan and Profile
5 12 Valve House and Pipe Outlet Location Plan
5 13 Valve House Plan and Section
5 14 Pipe Outlet at Abu Zeighan canal Plan and Section
6 1 Unit Costs on Similar projects
6 2 Daily Wages schedule
6 3 Cost Estimate
7 1 Electroconductivity (EC) Measurements, Mixing Ratios, and Estimated Average EC's With and Without Project
7 2 Estimated Cost and Irrigated Area for Various Crops
7 3 Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation (1990-1991 Season)
7 4 Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation (1991-1992 Season)
7 5 Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation (1992-1993 Season)
7 6 Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation (1993-1994 Season)
7 7 Analysis of Estimated Farm-Level Economic Returns (JD) Resulting from Project Implementation (1994-1995 Season)
7 8 Financial Analysis
8 1 Implementation Schedule
9 1 Effects of Construction of Alternatives on Land Use and Dwellings
9 2 Effects of Alternatives on Zarqa river Flow below Thahab Weir

12

9 3 effects of Alternatives on Water Quality of Zarqa River at Sites Downstream of the Thahab Weir and in the KAC-s
9 4 Effects of alternatives on Fish, Wildlife and Habitat in Zarqa River
9 5 Effects on Human Uses of the Zarqa River and in the Areas Irrigated from the KAC-s
9 6 Average EC's (ds/m) in the KAC-s for Various Growing Periods
9 7 Predicted Salinity in Abu Zeighan Canal relative to flow at Thahab Weir

9 3 effects of Alternatives on Water Quality of Zarqa River at Sites Downstream of the Thahab Weir and in the KAC-s
9 4 Effects of alternatives on Fish, Wildlife and Habitat in Zarqa River
9 5 Effects on Human Uses of the Zarqa River and in the Areas Irrigated from the KAC-s
9 6 Average EC's (ds/m) in the KAC-s for Various Growing Periods
9 7 Predicted Salinity in Abu Zeighan Canal relative to flow at Thahab Weir

Chapter 1

INTRODUCTION

1.1 General

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 (DAI) and USAID

The Zarqa River Conveyance Study was included as a part of the WQIC program to evalute 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 objective of this study is to assess the technical, environmental, economic, and financial feasibility of conveying water efficiently and improving quality in the 23-kilometer reach of the Zarqa River between KTD and Abu Zeighan Weir

The study was performed in two phases Phase A has been completed and consisted of a conceptual study to identify feasible alternatives and priorities Phase A was divided into three parts 1) data collection and evaluation, 2) analysis of data, and 3) identification and evaluation of alternatives to mitigate channel efficiency or quality impacts leading to the selection of a preferred alternative Phase B, which is the subject of this report, includes an environmental assessment of the alternatives selected in Phase A, and an economic and financial analysis and a preliminary design for the elements of the preferred alternative

Pertinent data and information relevant to the study were collected in Phase A, Part 1 and presented in an inception report in April 1995 The Phase A, Part 2 report entitled, "Data Evaluation," was submitted in May 1995 The Phase A, Part 3 report, which included a conceptual study of various alternatives and a selection of a preferred alternative, was finalized and submitted in February 1996

1.2 Authorization

This study is being performed as a part of the Jordan Water Quality Improvement and Conservation Project by Harza Engineering Company (Harza) in association with Consolidated Consultants (CC) under a subcontract with DAI

1.3 Scope

The scope of work for Phase B consisted of the following tasks

An assessment of the natural, social, and economic environment to include a scoping statement and an assessment prepared in accordance with USAID environmental

15

regulations

Field studies to include topographic surveys and a geotechnical assessment

The development of capital and O&M costs using similar on-going projects

An economic and financial analysis of the preferred alternative

A preliminary design and the preparation of drawings for the selected alternative

1.4 Mobilized Staff

Phase B was performed as a cooperative effort by Harza and CC staff The personnel mobilized to perform this effort included the following individuals.

Individual	Company	Position
Michael Saunders	Harza	Project Manager
Khalid Jawed	Harza	Lead Engineer
Alex Vircol	Harza	Senior Planning Engineer
Monica Cheng	Harza	Senior Hydrologist
Tony Wolff	Harza	Planning Engineer
Joe Moawad	Harza	Planning Engineer
Kirk Peterson	Harza	Planning Engineer
Khaled Murad	CC	Deputy Manager
O Rimawi	CC	Hyrogeologist
I Abu Taha	CC	Geologist
L Kandah	CC	Water Engineer
S Smadi	CC	Senior Hydraulic Engineer
S Dweiri	CC	Hydrologist
N Nafash	CC	Senior Civil Engineer
M Habash	CC	Senior Civil Engineer

1 5 Background

In the later part of the 1970's, the Jordan Valley Authority (JVA) began to suspect that all of the water released from the King Talal Reservoir (KTR) was not reaching the King Abdullah Canal (KAC) In 1980, the JVA performed a two-day study that appeared to confirm this suspicion Over the next ten years, a total of six studies were performed in an attempt to confirm that losses do occur, to quantify the losses, and to identify the river reaches within which the losses were occurring In 1994, two additional studies were performed, one by the University of Jordan which consisted of a water balance study of the river using estimated data and the actual data provided by the JVA, and one by ISPAN which consisted of a review of the other studies The ISPAN review was done to support funding by USAID of additional study of the Zarqa River channel efficiency

In addition to the issue of conveyance efficiency, the poor quality of the Zarqa River is an issue of increasing concern Greater diversions from the KAC to Amman for municipal and industrial

(M&I) use has resulted in a greater use of the poorer quality Zarqa River water for irrigation on lands in the Jordan Valley south of the Zarqa River During the summer months of 1994, all of the water diverted into the KAC from the Yarmouk River was used in Amman or on the lands north of the Zarqa River The application of Zarqa River water to the lands south of the river has evidently resulted in decreased yields and damage to the citrus trees The deterioration of the quality of the Zarqa River water is caused primarily by a series of salt springs and seeps located in the lower reach of the river

The overall objectives of this conveyance study, therefore, are to

1 Develop a defendable argument with respect to channel losses,
2 If warranted, recommend a plan to improve channel efficiency, and
3 Identify the means to improve the Zarqa River water quality

In addition, potential for developing hydroelectric power is including in the study plan

1.6 Description of Project Area

1.6.1 Zarqa River Basin

The Zarqa River is a major tributary of the Jordan River and originates in the central part of Jordan at an elevation of about 1,600 meters above mean sea level (El 1600) near Salkhad and joins the Jordan River at an elevation of -300 meters below mean sea level (El -300) The river drains the eastern escarpment which begins at the edge of the Jordan River Valley (the Valley) and merges gradually with the elevated plains and deserts of the Arabian and Syrian plateaus. The elevation of the escarpment varies around 700 meters, while the Valley ranges from -200 to -400 meters

The Zarqa River basin of interest for this study is the basin below KTD located about 40 kilometers (km) upstream from the confluence of the Zarqa River with the Jordan River and about 23 km upstream from the KAC The drainage areas of the river at selected locations are shown below

Location	Drainage Area (Sq Km)
KTD	3,300
Thahab Weir	3,396
Hwaret Weir	3,431
Abu Zeighan Weir	3,440
@ confluence with the Jordan River	3,540

Exhibits 1 1 and 1 2 show the general location of the project and the Zarqa River basin downstream from KTD, respectively

KTD was constructed in the 1960's and raised in the 1980's The dam is about 110 meters (m) high and impounds a reservoir of about 86 million cubic meters (MCM) at the normal pool level

17

(El 179)

Over the 23-km river reach between KTD and the KAC, the Zarqa River flows through a winding, steep-sided valley In this reach, there are three weirs, Thahab, Hwaret, and Abu Zeighan

Thahab Weir is located approximately 11 5 km downstream from KTD This is a concrete diversion weir used for diverting water from the weir into Carrier Pipes I and II for irrigation The capacities of these pipes are about 1,000 and 1,770 litres per second (l/s), respectively

Hwaret Weir is located about 5 km downstream from the Thahab Weir The weir served a canal with a capacity of 800 l/s for irrigation in the Valley The weir and canal are in poor condition and have been abandoned by the JVA

Abu Zeighan Weir is located at the eastern edge of the Valley and diverts Zarqa River water into the KAC through the Abu Zeighan Canal The capacity of this canal is about 7,500 l/s

1.6.2 General Climate

The general climate of the Zarqa River basin is a transition between Mediterranean and arid climate Altitude and latitude control prevailing 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 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 are frequent on the plateau during winter nights During spring, Kamsinic frontal depressions travelling from the north African coast occasionally cause abnormally increased surface winds and temperatures Associated unstable air at higher altitude often develops into thunderstorms with occasional hail A seasonal low pressure trough which occurs in summer over the Arabian Gulf, Iraq, Syria, and Cyprus causes westerly winds to enter Jordan from Mediterranean Fall is associated with a change in the pressure system as the seasonal trough extending over Cyprus to Iraq begins to migrate southeast Mediterranean depressions start developing with continental air from the Asiatic Steppes and warmer moist air from Mediterranean Sea, causing a decrease in temperature and the onset of seasonal frontal rains

Annual precipitation is highest 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 Over the basin, downstream from KTD, the annual precipitation decreses significantly

Mean monthly precipitation at Amman, located in the Highlands, varies from zero (in the months of June through September) to about 65 mm in January High precipitation occurs during the months of December through March Mean monthly temperature of Amman varies from about 8 C (January) to about 26 C (July-August)

1.6.3 Water Resources

The inflow to KTR includes three components, 1) natural streamflow, 2) diversion from the Qa'Khanna Basin, and 3) municipal and industrial return waste water from Amman, Zarqa, and vicinity Monthly flow data for these components were collected by Harza from various agencies in Jordan including the JVA and the Water Department during the hydrological investigations for raising KTD and storage on side wadis The pertinent reports are listed below

1 Harza Overseas Engineering Company, "The Raising of King Talal Dam, Feasibility Study," prepared for the Jordan Valley Authority, April 1982 (Harza, 1982)

2 Harza Engineering Company International, "The Raising of King Talal Dam, Final Design Report," prepared for the Jordan Valley Authority, August 1983 (Harza, 1983)

3 Harza Engineering Company in association with Arabtech Consulting Engineers, "Storage Facilities in Jordan Valley, Final Report on Technical, Economic and Financial Feasibility and Preliminary Design," Three Volumes, prepared for the JVA, April 1989 (Harza, 1989)

The inflow data from October 1953 through September 1985 were obtained from the previous reports Additional data up to September 1994 were collected as part of this study

Based on the above data, mean annual flow in KTR is about 2.30 cms The mean annual intervening flow between KTD and Abu Zeighan Weir is about 0.13 cms Exhibits 1 3 to 1 6 show the monthly flow data for Zarqa River at KTD, intervening flows from the area between KTD and Zeighan Weir, intervening flows from the area between KTD and Thahab Weir, and intervening flows from the area between KTD and Hwaret Weir, respectively

1.6.4 Watershed Characteristics

The river reach between KTD and the Thahab Weir is about 11 5 km long, with an intervening drainage area of about 96 sq km The river valley is narrow with steep, high hills on both banks A number of small tributaries draining the steep hilly slopes, and relatively flat slopes near the top of the hills join the Zarqa River Significant tributaries are Wadi en Naim, Wadi el Azab, Wadi el Huna, Wadi Abu er Ruweis, and Wadi el Bam Small villages and a few scattered homes are located on the flat slopes

The steep-sided valley in this reach has many indications of instability, and there is a potential of land-sliding The channel has been downcut through sandstone and limestone formation The channel bed consists of large cobbles, gravel, shingle, and coarse sand with underlying stratra of fine sand and gravel Soils are dominantly clayey silt and fine sand with relatively low permeability Agriculture is practised on both banks There is a well-developed farm on the left bank near the concrete factory mining area Two lift irrigation pumps were seen during the field visit on April 18, 1995

The reach between Thahab Weir and Hwaret Weir is about 4 8 km long with an intervening drainage area of about 35 sq km The river valley is somewhat wider compared to the upper

reach The river bed consists of cobbles, gravel, and sand The underlying strata is fine to coarse alluvium

Three main wadis enter the river in this reach in addition to small watercourses These include Wadi Sadd en Nim, Wadi Hajjaj, and Wadi el Tahima Agriculture is practised on both banks where feasible Soils are dominantly clayey silt and fine sand with relatively low permeability

The river reach between Hwaret and Abu Zeighan Weirs is about 4 7 km long with an intervening drainage area of about 9 sq km Downstream from Hwaret Weir, the valley widens and permits cultivation especially on the right bank The irrigated area is served by one of the pipelines originating at the Thahab Weir Significant irrigation return flow or overflow from the watercourses can enter the Zarqa River in this reach.

A few small wadis enter the river The two named wadis are Raud El Mokhamah and Hanifa. A number of springs exist in this reach

1.6.5 Geology

The study area consists of four distinctive geomorphic-topographic zones The geomorphic-topographic zones, in accordance with Ministry of Agriculture and Natural Resources Authority (NRA) classifications, are as follows

- Highlands where the elevation exceeds 800 m above mean sea level
- Escarpment with an elevation range between 800 m and sea level
- Foothills with elevations in range of sea level and 200 m below sea level and
- Rift Zone which is between 200 m below sea level and Dead Sea level

The highlands are located away from the Zarqa River to the north, south, and west The area between the KTD and about 5 km downstream from the dam is classified as "escarpment " The area located between 5 km downstream from KTD and the Hwaret Weir falls under the foothill classification, while the area below the Hwaret Weir and up to the Abu Zeighan Weir belongs to the Rift Valley Zone

These geomorphic-topographic zones are characterized by the presence of various exposures of geological formations The highlands are characterized by upper cretaceous sediments of the lower part of the Ajlun Group Because of this formation, occasional high slope cuts dominate in the areas of highlands From Subeihi area to Zarqa River and from Khashaba village to Zarqa River, lower cretaceous rocks (Kurnub Sandstones) are exposed with occasional appearance of Jurassic rocks

Because of lithological nature of the Kurnub formation which mainly consists of friable sandstone with some intercalations of calcareous sandstone, the slopes of the Zarqa River flanks are steep varing between 15 and 8 percent Because of the lithological nature of Jurassic rocks, which are limestone and dolomitic limestone, wadi flank slopes are relatively less steep in the range of 5 to 8 percent In the foothill area, the lithological nature of the exposed Triassic rocks, which consist of limestone, shales marls, and marly limestones, has resulted in gentle slopes in the range of 3 to 6 percent Downstream from the foothills towards the Ghor area, where Rift Valley Zone predominates and quaternary rocks of the Lisan formation, alluvium, colluvium, and soil(s) are present, the Zarqa River

channel slope is relatively flat The rocks exposed in this zone are Kurnub, Triassic, Jurassic, and Quaternary Due to the different types of rocks exposed in this zone, the slopes of the adjacent flanks are variable and range between 3 and 15 percent

The rock units exposed in the area between KTD and the Abu Zeighan Weir range in age from Triassic to recent The spatial distribution of these rock units in the order of their existence is discussed below

Kurnub sandstone of early Cretaceous age is exposed at KTD and extends downstream until Jurassic rocks appear These Jurassic rocks are older in age and extend downstream until rocks of the Triassic age (the oldest rocks) become exposed at the surface of the wadi course and in the adjacent area as a core of a geological window Further dowmstream from the Triassic rocks, the Jurassic reappear again. Lastly, Quaternary deposits (lisan, alluvial, and colluvial deposits) unconformably overlie the Jurassic rocks

The Triassic-Jurassic rocks exposed in the area and encountered in deep wells drilled in the Jordan Valley and other parts of Jordan are knows as the Zarqa Group, which is further subdivided into two formations the Main Formation (Z1) of Triassic age and Azab Formation (Z2)

The rocks of the Main Formation (Z1) are exposed over a reach of about 3 5 km starting at a distance of about 5 km downstream from the KTD along the Zarqa River This formation consist of shales clays, marly limestone, marls, calcareous sandstones, limestones, and massive gypsum beds, where the gypsum bands are mined for the use in the manufacture of cement. The thickness of this formation reaches about 100 m as exposed in Wadi Huna

The Azab Formation (Z2) consists of limestone, hard, massive, yellowish-gray in color, dolomite, sandstone, and shale This formation is exposed in two regions along the course of Zarqa River The first exposure appears at the KTD along a stretch of 5 km where it overlies the Main Formation The second exposure starts to appear once again as an overlying material of Main Formation 8 5 km downstream of KTD

The Early Cretaceous rocks which are known locally as the Kurnub Group (K), overlie conformably the Azab Formation of the Zarqa Group The Kurnub Group is not exposed along the river course between KTD and the Abu Zeighan Weir, but it is exposed on both flanks of the river course It consists of arenaceous deposits at its base, generally composed of white sandstone with thin beds of dolomite, and shales, while in its upper part, it consists of varicolored sandstones with intercalations of shale, limestone, dolomite, and marl

The Quaternary deposits consist of the Lisan Formation and recent superficial deposits The Lisan Formation consists of marl, clay, gypsum, and occasional gravels of brackish-lacustrine deposits It is exposed on both flanks of the Zarqa River downstream of the Abu Zeighan bridge Its exposure on the left flank is directly near the river while, on the right flank, it is more than 100 m away from the river Recent superficial deposits occasionally cover the Lisan deposits Generally, these deposits consist of alluvial fluorite, collovium, fan deposits, talus deposits, and soils These deposits consist of unsorted coarse to fine clastics The Alluvial deposits along the Zarqa River course have a variable thickness ranging from few centimeters to more than 40 m as indicated in the recently drilled well downstream of the Hwaret Weir (Abu Zeighan well No 1)

1.6.6 Groundwater Regime

There are two main aquifer systems in the area, the Lower Aquifer System and the Upper Aquifer System The Lower System consists primarily of the Kurnub Group of Early Cretaceous Age and the Zarqa Group of Triassic-Jurassic Age These two groups are hydraulically connected on a regional scale forming one aquifer system The Upper Aquifer System consists of alternating aquicludes and aquifers of Late Cretaceous-Early Tertiary Age of the Ajlun and Balqa Group (A1-7 and B1-4) and covers most parts of North and Central Jordan Exhibits 1 7 to 1 9 provide an idea of the groundwater system in the study area

Two separate water levels and different water qualities are observed in the Kurnub Group and the Zarqa Group in some places in the highlands like Subeihi and the Baqqa' area. However, these form one static water level in the Rift Valley

Recharge occurs over the highlands through the Upper Aquifer System Because of the topography, there is a groundwater divide in the recharge area Some of the groundwater in the Upper Aquifer system moves towards the Jordan Valley in the west and appears on the escarpment as base flow, seepage, and spring flow (good water quality) while most of the water moves towards the east away from the divide As water flows eastward in the Upper Aquifer System, it infiltrates downwards through the different aquifers, aquitards, and aquicludes through fractures and major and minor faults until it finally recharges the Lower Aquifer System In the Lower System, the water changes its direction toward the west and finally emerges as springs or is encountered in wells (flowing and nonflowing) with thermal brackish water in the Jordan Valley

Seepage and springs of a brackish and thermal nature are present over almost all of the reach between the Hwaret Weir and the Abu Zeighan Weir, and continuosly recharge the surface water flow in the Zarqa River Because of seepage and springs, the water quality of the Zarqa River is severely impacted in this reach

1 6.7 Water Quality

The JVA has a comprehensive and extensive water quality monitoring program which includes the Zarqa River and the KAC The data collected at various locations were evaluated EC is in the range of 1 10 to 1 25 mmhos/m near the Hwaret Weir and increases to between 2 0 and 3 5 mmhos/m near the Abu Zeighan Weir

1 7 Existing Developments

Existing developments on the Zarqa River in the study area consist of the KTD, three diversion weirs - Thahab, Hwaret, and Abu Zeighan, and two carrier pipelines designated as Zarqa Carrier I (ZCI) and Zarqa Carrier II (ZCII)

KTD was constructed in the 1960's and raised in the mid 1980's The dam is about 110 m high and impounds a reservoir with a gross storage of 86 MCM at El 179, the normal pool level The reservoir stores spring flood runoff, diversions from the Qa'khanna Basin, and return flow from the M&I supply to Amman for the eventual irrigation releases to the Jordan Valley The project includes a gated spillway with a capacity of 4,500 cms and a two-unit powerhouse with a rated

capacity of 4 0 MW The outlet capacity of the reservoir ranges from 1 2 cms to 6 5 cms through the powerhouse and 21 0 cms to 31 5 cms through the emergency outlet Reservoir characteristics for the reservoir are listed below

Elevation of top of dam	185 0 m
Normal pool level (NPL)	179 0 m
Storage at NPL	86 0 MCM
Minimum reservoir level (MRL)	123 0 m
Storage at MRL	8 2 MCM

Thahab Weir, the most upstream weir, is located about 13 km downstream from the KTD (along the river thalweg) It diverts water into two carrier pipes, ZCI and ZCII The ZCI supplies water to the Zarqa Triangle, while the ZCII serves the Middle Ghor

Hwaret is the next downstream weir, located about 18 km downstream from KTD The weir is in a poor condition and has been abandoned A canal originating at the weir has also been abandoned

The third weir downstream is the Abu Zeighan Weir which is located about 20 km downstream from KTD and about 2 km upstream from the KAC.

1.8 Summary of the Phase A Reports

During Phase A, the preferred alternative was selected after basic data were collected and evaluated and a series of alternatives were considered A summary is presented here, and more detail is presented in the subsequent chapters of this report

1.8.1 Phase A, Part 1, "Inception Report"

The activities associated with Part 1 Phase A included data collection, a preliminary analysis of the data, and a reconnaissance of the study area. The data collection activity consisted of meetings with the JVA and the Water Authority of Jordan, and the collection of operation data for KTD and the KAC, water quality data for the Zarqa River and the KAC, and basic data related to the earlier channel conveyance efficiency studies Meetings were held with members of the staff of the Operations, Water Quality, and Planning units, and staff of the Water Authority's Irrigation Department

Based on preliminary analysis of the data, field visits and discussions with the JVA's staff, the following conclusions were drawn

Channel losses occur primarily in the reach below the Thahab Weir

Improvement of the quality of the Zarqa River water diverted into the KAC is essential to maintenance of the integrity of the irrigation activities in the Jordan River Valley south of the Zarqa River

The favoured alternative to improve water quality and the conveyance efficiency of the

23

Zarqa River is to divert the releases and the unregulated water of the Zarqa River at Hwaret around the reach of saline inflows

1.8.2 Phase A, Part 2, "Data Evaluation"

A comprehensive report was prepared on data evaluation The evaluation studies were directed at channel efficiency and water quality

The channel efficiency study indicated that little or no loss occurs in the reach of the Zarqa River between KTD and the Thahab Weir Between the Thahab Weir and the Abu Zeighan Weir, losses may occur when the flows in the river are greater than about 1,000 l/s The losses may vary between 10 and 15 percent

Evaluation of water quality data was made at a number of observation locations This evaluation indicated that

> Water in the KAC, north of the Zarqa River, which primarily originates in theYarmouk River, has been and continues to be of good quality and suitable for irrigation without restriction
>
> The quality of the water released from KTD is marginal and may be deteriorating
>
> Water from the saline springs and seeps would be toxic to crops, if undiluted
>
> Mixing of the water from KTD and the seeps and springs results in an irrigation supply that must either be diluted or will cause significant reductions in the yields of vegetable and citrus crops
>
> Deterioration of the KTD releases occurs in the river reach between the Hwaret Weir and the Abu Zeighan Weir

Based on the above observations, it was concluded that to improve the quality of water being delivered for irrigation, either the seeps and springs should be diverted away from the river or the KTD releases should by-pass the river reach between the Hwaret and Abu Zeighan weirs

1.8.3 Phase A, Part 3, "Selection of a Preferred Alternative"

Several alternative concepts listed in the Scope of Work, plus configurations that were identified after site visits and discussions with the JVA, were consolidated into five alternatives for evaluation four irrigation supply schemes (IRR1, IRR2, IRR3a, and IRR3b) and one irrigation and power development scheme (POW) In defining the alternatives, the opinions of the personnel from the Irrigation Department and JVA who are most familiar with the river, existing structures, operation of the system and the users, were given due consideration

The schemes considered intake locations at two of the existing weirs (Thahab and Hwaret) and various types of conveyance including ductile iron pipe, canal, and steel pipe Depending on the configuration, integrated pumping stations, powerhouses, and reregulating ponds were included

in some alternatives

The five selected alternatives were configured, assessed and compared at a conceptual level The alternatives were compared on the basis of overall cost, the operation and maintenance cost, the implementation period, the annual volume of water saved, the quality of water dilivered to the KAC, and an environmental ranking The irrigation/power alternative was evaluated based on cost components that would separately affect irrigation and power Following the comparison and evaluation process, alternate IRR3a consisting of an intake at rehabilitated Hwaret Weir and a closed conveyance pipe (ductile iron) from the Hwaret Weir to the Abu Zeighan Weir was selected as the preferred alternative Exhibit 1 10 shows the pipeline route

Chapter 2

ZARQA RIVER CHANNEL CONVEYANCE EFFICIENCY AND WATER QUALITY

The original emphasis of this Zarqa Conveyance Study was on the improvement of the channel efficiency of the Zarqa River As an indication of this emphasis, essentially all of the alternatives identified in the scope of work related to eliminating channel losses As a result of our investigations, it became apparent that the emphasis should be on improving water quality and that channel losses were only a minor problem Therefore, for background, this chapter on conveyance efficiency and water quality describes the situation for the evaluation of alternatives and the resultant economic analysis

2.1 Conveyance Efficiency

Water losses in the Zarqa River channel between KTD and the Abu Zeighan Weir were suspected by the JVA operation staff as early as 1980 when a first attempt was made to quantify those losses Since that time, a number of studies have been performed to define the magnitude of the losses and to identify the subreaches where these losses occur. The studies are listed below with their conclusions Details of the studies were provided in the report entitled "Comprehensive Report for the Zarqa River Conveyance Study," submitted in May 1995 as a part of this project.

- Joudeh, Omar Water Balance Study of Zarqa River Downstream of King Talal Dam, JVA, Hydrology and Groundwater Division, 1980

  This was a one time flow measurement program with one release from KTD, which indicated

  1 Minor losses between KTD and Thahab Weir
  2 Significant losses between Thahab Weir and Hwaret Weir
  3 Significant losses between Hwaret Weir and Abu Zeighan Weir

- Joudeh, Omar and Ismail Hashem Gain-Loss Measurements on Zarqa River near Deir Alla (Preliminary Report), JVA, Hydrology and Groundwater Division, 1981

  This study was conducted for four days with slight variation in flow On the average about 13 8 percent losses were reported between the Thahab Weir and the Hwaret Weir and about 10 1 percent between the Hwaret Weir and the Abu Zeighan Weir

- Hijazi, Daoud Untitled, Measurements taken on 1 March 1984, JVA, 1984

  This study covered the reach between the Thahab Weir and the Abu Zeighan Weir Because of some technical errors, the data were not considered reliable

- Hashem, Ismail and Daoud Hijazi A Report on Water Losses Between King Talal

and Irrigation Line, JVA, Groundwater Directorate, 1984

This study did not provide sufficient information to draw any conclusions on losses The authors recognized the limitations of the study However, most of the losses were attributed to the river reach downstream from the Thahab Weir

• Hijazi, Daoud Untitled, Measurements made on 2 to 4 and 6 to 9 October 1984, JVA, 1984

Sets of flow measurements were made from October 2 to October 9, 1984 The study concluded that a small gain was realized between KTD and the Thahab Weir, minor losses occurred between the Thahab Weir and the Hwaret Weir and between the Hwaret Weir and the Swalha Bridge, and significant losses occurred between the Swalha Bridge and the Abu Zeighan Weir

• Harza Engineering Company in association with Arabtech Consulting Engineers, Storage Facilities in the Jordan Valley, Final Report on Technical, Economic and Financial Feasibility and Preliminary Design, Vol II, Part II-Main Report, April 1989

Harza-Arabtech made flow measurements over a period from October 1987 through June 1988 at six locations - downstream of the KTD, upstream and downstream of the Thahab Weir, upstream and downstream of the Hwaret Weir, and upstream of the Abu Zeighan Weir Field flow measuring conditions, limitations of instruments with respect to flow magnitude, and hydraulic characteristics of the river cross sections selected for flow measurements were carefully evaluated The computations of gain/loss did not consider contribution from springs, losses due to evaporation or pumping for irrigation upstream from the Thahab Weir The conclusions reached were

1 Hydraulic conditions of the channel do not permit accurate measurements of flow An error ranging between 3 to 5 percent can be expected Because of this error, the differences between the measurements made at the upstream and downstream ends of a reach were inconsistent

2 Any indicated loss or gain within the above range was judged to be due to measuring errors and not the actual gain or loss

3 Based on the difference above that range, the reach between KTD and the Thahab Weir did not show any gain or loss, whereas the reaches between the Thahab and Hwaret Weirs and between the Hwaret and Abu Zeighan Weirs indicated gains

• University of Jordan Baseline Report on Water Conveyance Efficiency in the Zarqa River below King Talal Dam, 1984

This study established a water balance between total flows from KTD and spring flows designated as "inflow" to the reach between KTD and the Abu Zeighan Weir, and total

outflow as water diverted to ZCI and II, the Swalha Canal and to the KAC at the Abu Zeighan Weir Monthly conveyance efficiencies were defined as the ratio of outflow to inflow The monthly efficiencies ranged between 79 to 86 percent The study did not define where the losses occur

• An Appraisal of Conveyance Losses in the Zarqa River below King Talal Dam, based on previous studies made by ISPAN, 1984

ISPAN's review summarized the reports and concluded that

1 The highest losses occur in reach downstream from the Thahab Weir.

2 Flow data are insufficient to accurately determine the magnitude of channel losses Some studies indicate highest losses downstream from the Swalha Bridge (downstream from the Hwaret Weir) to the Abu Zeighan Weir

3. Further studies are needed, considering the filling and draining of the sub-reaches, evaporation losses and pumping from the river

• Harza Engineering Company in association with Consolidated Consultants, Flow Measurements made on September 12 to 14, 1995

In the performance of this study, Harza-CC made a field reconnaissance of the entire reach between KTD and the Abu Zeighan Weir, identifying any irrigated area along the river upstream from the Thahab Weir, river bed conditions, and locations of springs A hydrogeological assessment of the river reach was also made One set of flow measurements was made under carefully controlled measuring parameters The measurements indicated a gain in all measuring sub-reaches - about 4 0 percent between KTD and the Thahab Weir, about 0 5 percent between the Thahab and Hwaret Weirs, about 0 7 percent between the Hwaret Weir and the Swalha Bridge, about 8 8 percent between the Hwaret Weir and immediately downstream of Women Spring, and about 1 4 percent between Women Spring and the Abu Zeighan Weir

Based on Harza-CC reviews of previous studies and on Harza's own investigations, the following conclusions are presented

1 The groundwater regime study/analysis indicated that there should be a gain in the water flowing in the Zarqa River between the Hwaret Weir and the Abu Zeighan Weir, where many saline springs and seeps enter the river Also, most probably, there may be slight gain in water between KTD and the Hwaret Weir However, the flow measurements show that this situation is possible in some seasons, while at other times there could be losses between the Hwaret and Abu Zeighan Weirs

2 The accuracy of the flow measurements in the Zarqa River is limited by the hydraulic conditions, especially irregular cross sections and non-uniform flow distribution across cross-sections in most of the subreaches In all studies

28

performed, the differences between flow measurements were mostly within the accuracy of the measurements and cannot be taken as an accurate indicator of loss or gain

3 The river reach between KTD and the Thahab Weir is most likely a minor fresh water gaining reach

4 The reach between the Thahab Weir and the Hwaret Weir is a minor gaining reach

5 The reach between the Hwaret Weir and the Abu Zeighan Weir receives flow from saline springs and could be a gaining reach but at times may show losses The construction of a pipeline from the Hwaret Weir to the Abu Zeighan Weir will serve two purposes first, the deterioration in water quality will be avoided; and second, the losses observed in this reach will be avoided This will be an additional benefit of the project Because of uncertainty in the magnitude of losses under various flow conditions, the benefits cannot be exactly quantified

2.2 Water Quality

At present, the quality of the releases from KTD are marginally acceptable for irrigation As the releases are conveyed through the lower reaches of the river, the quality is degraded by saline seeps and springs emanating from the Zarqa Formation that, at some times, render the water unacceptable for irrigation This mixing of saline water has deteriorated the quality of irrigation water supplied through the Abu Zeighan Canal and is reportedly causing damage to crops and reductions in yield

The Laboratory of Soil and Environment Directorate of the JVA is operating and maintaining about 60 to 70 water quality monitoring stations on the KAC, the side wadis, the Zarqa River, at various dam sites and on canals carrying diversions from weirs or outflows from treatment plants Some special groups in the JVA have also conducted intensive one-time quality monitoring studies For general monitoring, only EC (electric conductivity) and pH (acidity) are measured Special studies have included other parameters such as boron (B), calcium (Ca), Chloride (Cl), potassium (K), magnesium (Mg), sodium (Na), carbonates (CO_3), bicarbonates (HCO_3), nitrates (NO_3), sulphate (SO_4), and sodium absorption ratio (SAR)

The irrigation water quality parameter most significant for crop yield is salinity (defined in terms of EC values) Another significant parameter is the pH value The data for these two parameters collected by different groups at various locations on the Zarqa River and the KAC were reviewed, evaluated, compared, and plotted as time series

To clearly understand the water quality deterioration by the saline water from the Zarqa Formation, four sites were judged to be of significance for evaluation - the Zarqa River downstream from KTD, the Zarqa River at the Abu Zeighan Weir, the KAC-Swalha (before mixing with the Abu Zeighan Canal water), and the KAC-Maadi (after mixing with the Abu Zeighan Canal water) Exhibit 2 1 shows a plot of monthly values for these sites for the

period from 1986 through 1994 This exhibit clearly shows how the EC values of the releases from the KTD are degraded by the saline water emanating from the springs and seeps in the Lower Zarqa River (comparing KTD EC with Abu Zeighan EC) and how the flow of the Abu Zeighan Canal degrades the quality of the KAC water (by comparing EC values of KAC-Swalha and KAC-Maadi)

Field measurement data evaluated by Harza-CC in September 1995 and previous studies by special groups of JVA indicated that

1 The river reach between KTD and the Thahab Weir does not receive saline water Springs in this reach are supported by the Kurnub Formation that is of good water quality

2 The river reach between the Thahab and Hwaret Weirs is also recharged from the Kurnub Formation. However, no spring has been identified in this reach

3 The river reach between the Hwaret and Abu Zeighan Weirs has a number of springs emanating along both banks of the river The springs are supported by Zarqa Group water which is under artesian conditions and has a high EC value (highly brackish/saline) Therefore, severe water quality deterioration occurs in this reach

2.3 Summary

It appears that, if any losses occur in the Zarqa River channel, these losses are probably minor and occur only in the reach below the Hwaret Weir When the measurements indicated a gain in this reach, it could have beeen only a net gain and losses could have been ocurring

It is also apparent that there is a serious water quality problem resulting from the contamination of an already marginal water supply from the KTD by the saline seeps and springs also located in the reach below the Hwaret Weir

The provision of a facility to bypass the releases from the KTD around the area of the springs and seeps will then serve to meet both objectives of the study

1 The channel efficiency will be improved to some degree, and

2 The quality of the diversions into the KAC will be improved

Chapter 3

GENERAL APPROACH TO THE PHASE B STUDIES

The Phase B studies include an environmental assessment of the alternatives retained after the completion of the Conceptual Study, Phase A, Part 3, an economic and financial analysis of the preferred alternative, and a preliminary design of the elements of the preferred alternative

3.1 Adopted Concept

The adopted concept for meeting the overall objectives of this Conveyance Study, which are to improve the quality of Zarqa River diversions into the KAC and to improve the channel efficiency in reaches that exhibit the potential for losses, is to divert KTR releases around the lower reach of the Zarqa River Application of this concept resulted in the selection of alternatives that diverted water into a pipeline or canal originating at either the Hwaret Weir (the preferred alternative) or the Thahab Weir and terminating at the Abu Zeighan Canal.

The JVA, as a result of their review of the draft report on the selection of alternatives, identified the pipeline alternative from the Hwaret Weir to the Abu Zeighan Canal as their preferred alternative Therefore, in the performance of the Phase B studies, the initial emphasis was placed on the confirmation of this alternative

3.2 General Approach

The general approach to the Phase B studies consisted of performing a two-stage environmental assessment, field studies to confirm the assumptions made during the Phase A, Part 3 alternatives evaluation, a preliminary design of the selected alternative, and finally, an economic and financial analysis of the recommended project

3 2.1 Environmental Assessment

The environmental assessment was started during the final stages of the conceptual studies so that environmental input could be used as a evaluation parameter for the selection of a preferred alternative The first stage consisted of an initial screening of all of the alternatives under consideration The second stage consisted of the performance of an environmental assessment carried out under applicable regulations for USAID funded projects The alternatives for which the environmental assessment was performed included

1. No-action (required under USAID regulations)
2. A pipeline from the Hwaret Weir to the Abu Zeighan Canal to convey releases from the KTD around the area (the preferred alternative)
3. A canal/pipeline combination from the Hwaret Weir to the Abu Zeighan Canal (a lower capital cost option that would require a higher operating cost and a more intense maintenance effort)
4. A pipeline from the Thahab Weir to the Abu Zeighan Canal (a significantly higher cost option retained in case there were difficulties in the rehabilitation/replacement

of the Hwaret Weir)

The environmental assessment of the alternatives has been submitted previously as a separate report and has been summarized in this report

3 2.2 Field Studies

The field studies consisted of a series of geotechnical investigations and topographic surveys performed to confirm the assumptions made in the conceptual studies and to improve the estimates of cost

The geotechnical investigations were oriented toward the confirmation of the assumption that the rehabilitation or replacement of the Hwaret Weir is technically feasible and to provide necessary data/ information for designing foundation conditions for the structures The program consisted of drilling eight holes at four locations - the Hwaret Weir, the two river crossings, and the outlet structure

A topographic survey was carried out for a land strip to precisely define the pipeline route The land strip extended from the Hwaret Weir to the Abu Zeighan Weir The survey data were used for the weir studies, finalizing the pipeline layout, estimating the length of pipe, establishing the locations of the pipe-river crossings and a site for the outlet, and estimating the volume of excavation and fill required for the pipeline

3 2 3 Economic and Financial Analysis

The economic analysis was based on the primary benefits resulting from the improvement in yields that result from the improvement in the quality of the irrigation water The anticipated improvement in water quality was estimated in terms of electroconductivity The anticipated improvement in yield was measured on an incremental basis using economic data from the 1991-92 and 1993-94 seasons in the Jordan Valley and crop tolerance and yield potential relationships with water salinity as developed by the FAO The estimates of costs are based on material quantity estimates prepared from layout studies and unit prices derived on the basis of current information in Jordan collected from manufacturers and contractors The original approach of deriving these prices from information collected on at least three similar ongoing projects was not possible because there are currently no pipeline projects under construction nor any recently completed projects for which this information is available

The financial analysis results in the definition of a cash flow and a financial rate of return for the investment

3 2.4 Preliminary Design

The preliminary design is a continuation of the layout studies performed for the economic analysis It consist of the further development of basic design criteria and concepts taking into consideration the specific design condition and constraints and the preparation of preliminary design drawings for all components of the recommended alternative As a result, the preparation

of the final designs and contract documents will be greatly facilitated, and an early start on construction can be accomplished

Chapter 4

FIELD INVESTIGATIONS

4.1 Geotechnical Investigations

The scope of the geotechnical investigations was developed after the initial environmental screening indicated that the pipeline alternative from the Hwaret Weir to the Abu Zeighan Canal was environmentally acceptable, the conceptual studies indicated that the alternative was cost competitive, and the JVA had indicated a preference for the alternative The scope was, therefore, oriented toward establishing the technical feasibility of rehabilitating or replacing the Hwaret Weir as well as the technical criteria for the other structures If any questions arose as to the construction of the Hwaret to Abu Zeighan alternative, the geotechnical investigations would have been redirected to the Thahab Weir to Abu Zeighan Canal alternative

The objective of the investigations was to determine the surface and subsurface conditions and the physical and mechanical properties of the foundation materials at the proposed weir site, along the pipeline alignment, at the river crossings, and at the outlet of the pipeline The scope of the investigations included the following tasks

1. Collect information and maps of the area showing land use, geology, surface topography, and drainage pattern

2. Perform a preliminary site visit to review conditions and select drilling sites

3. Drill eight boreholes, two each at the Hwaret Weir, the two pipeline crossings over the river, and the pipeline outlet

4. Perform necessary laboratory tests

5. Analyze field and laboratory data

6. Develop conclusions and recommendations

The investigations were performed under a subcontract with the Arab Center for Engineering Studies, a local Jordanian consultant

It was concluded, as a result of the field and laboratory investigations, subsurface conditions, engineering analysis, and practical experience of the subcontractor that the proposed structures can be supported by the foundation materials at the site provided, among other recommendations, that

1. Any foundation should be a minimum 1 5 m below the finished level of the ground surrounding the structure

2. An allowable bearing pressure value of 2 3 kg/cm^2 is recommended for the entire

site area based on previous experience with similar materials

3 Because of granular nature of the subsurface material, settlement is expected to be small, uniform, and within tolerable limits

4 Temporary excavation slopes should be steeper than 1H 2V

5 Wadi materials are generally considered suitable backfill

As a result of these geotechnical investigations and further visits to the site by design-oriented personnel, it is concluded that replacement of the Hwaret Weir is technically feasible, and the alternative originating at the Thahb Weir was dropped from further consideration.

Other criteria and an expansion of the discussions relating to the reported criteria are contained in the Geotechnical Studies Report which is attached to this report as Appendix A.

4 2 Topographic Survey

Topographic surveys were performed for the three major components of the project as follows

In the vicinity of the existing, abandoned Hwaret Weir, to locate a new weir, intake, and desanding basin.

Along the proposed alignment of the pipeline from the Hwaret Weir to the Abu Zeighan Weir

In the vicinity of the Abu Zeighan Weir

The survey data were drawn for a one-meter contour interval and digitized The digitized maps were redrawn to a scale appropriate for the preliminary design of the structures of the recommended alternative The Phase B studies were delayed by about one month during the survey process because access to a portion of the alignment was denied by a local farmer

35

Chapter 5

PRELIMINARY DESIGN

A preliminary design was performed for the replacement of Hwaret Weir, the installation of a pipeline from the new weir to the Abu Zeighan Canal, and an outlet facility to dissipate the energy of the water discharging into the canal

5 1 Project Elements

The project implementation includes the following activities

Removal of the existing abandoned Hwaret Weir, old intake, and parts of the canal,

Construction of a new weir and integral intake facility with appropriate controls,

Construction of a sediment settling basin,

Construction of a 3 6-km pipeline

Construction of two viaducts to provide for river crossings for the pipeline

Construction of an outlet to permit discharge directly into the Abu Zeighan Canal.

A large scale plan of the project is shown on Exhibit 5 1

5 2 Design Criteria

Design criteria have been established in accordance with accepted codes and standards and specific site conditions General criteria in accordance with the scope of work are identified herein. Additional feature-specific criteria that are better addressed under the description of the feature are presented in subsequent sections

5.2.1 Materials and Mixes

Concrete Aggregate - Washed river gravels will probably be used, however, if this material is not suitable, aggregate can be obtained from local sources

Cement - Portland (Hydraulic) Type II A cement

Concrete - 28-day compressive strength - 211 kgf/cm2
W/C ratio - 0 58 by weight

Pipeline - Ductile iron pipe classified as ANSI/AWWA C150 or similar

Backfill - Wadi materials

5 2 2 Internal and External Protection

Internal protection will be provided by centrifugally-applied cement, and external protection will be provided from a 1-mil-thick layer of asphalt coating as per AWWA C151

5 2 3 Velocities

Pipeline - maximum velocity will be limited to 3 0 m/s and the minimum velocity will be 0 3 m/s

Desander - maximum velocity will be 0 3 m/s A minimum velocity designation is not appropriate

Intake - maximum velocity will be limited to 1 0 meters per second A minimum velocity designation is not appropriate

5 2.4 Maximum Pressure in Closed Conduits

The maximum allowable pressure in the identified iron ductile pipe is 10 6 kgf/cm^2

5 2 5 Strength and Loading

Pipeline - Strength criterion is 1,150 kgf/cm^2 and loading limit is 550 kgf/cm^2

Concrete - Strength criterion is 211 kgf/cm^2 and loading limit is 84 kgf/cm^2 to 96 kgf/cm^2 depending on the loading The modulus of rupture is 28 8 kgf/cm^2

5 2 6 Washouts and Air Valves

Air valves will be installed at every summit point or abrupt change downward to permit the release of any air that may accumulate there during the filling of the pipe and to allow entrance of air during draining of water

Washouts (blowoffs) will be installed at each low point along the pipe so that all of the water may be drained from the pipe The diameter of the blowoff will be about 25 cm

5 2 7 Excavation

Temporary slopes	1H 2V
Permanent slopes	1 5H 1V

5 2 8 Protection Works

The protection works will consist of burying the pipeline a minimum of two meters below the final ground surface

5.2 8 Construction Materials

See 4 2 1, materials and mixes

5 2 9 Diversion of Flows During Construction

It is expected that the weir reconstruction will be completed within the dry season As such, the only flows expected in the river will be releases from the KTR. To accommodate these releases, which cannot be interrupted, a water control plan will have to be implemented The recommended steps for this plan are

1. Demolish the right side of the existing structure behind upstream and downstream cofferdams and build the new structure with a 2 0-m wide by 1 0-m high box culvert incorporated

2. Partially dismantle the cofferdams and close the remaining central portion of the cofferdam into the left bank on the up and downstream sides Water released from the KTD will be channeled into the box culvert

3. Construct the intake and the left side of the weir behind the new cofferdam (the new cofferdam can be much lower because, unlike step 1, the releases now flow at the invert level of the box culvert and do not have to pass over the existing weir)

4. Dismantle the cofferdam and simultaneously construct an earth approach wall to guide the releases through the intake Connect the two sections of the weir and install controls in the box culvert

The desander can be under construction at any time during this process, initially as the river is diverted to the other side and later under the protection of the gated intake

5.2 10 Operation and Maintenance

Operation of the system will be relatively simple and can be accomplished with existing personnel The intake will remain open under all except flood conditions Flow regulation, if desired, will be accomplished with the gates located at the intake Operation for a minimum flow release is discussed in the following subsection

Maintenance activities will not constitute a major undertaking, however, systematic monitoring is very important The air valves must be kept in good working order as any malfunction could result in pressures that might cause damage to the pipeline The pipeline alignment should be periodically inspected to detect any leakage or any other damage The skills and equipment to perform cleaning must be obtained It is expected that these skills are available in the MWI as there are other major pipelines in their system The desanding basin and the flushing canal back to the river will require periodic maintenance to permit proper operation A knowledge of its

functioning will be required in order to make any on-site adjustments that may be required It is expected that the proposed pipe linings will prevent corrosion to the pipe If additional protection is required, for example cathodic protection, additional maintenance activities will be required

5.2.11 Environmental Impact

Construction impacts are expected to be minimal as construction will likely occur during the summer months as recommended

Compensation for the destruction of any crops during construction is recommended

Fuel storage and fueling areas will be located away from cultivated areas, areas that drain into cultivated areas and the stream channel

Spill cleanup materials will be provided and stored on-site for quick access

Although not provided for in the preliminary design, a minimum release facility can be added to the weir through the diversion conduit

5.2 12 Training Requirements for Operation and Maintenance Personnel

As this is a small, easily operated, low maintenance project, no additional training requirements for operation and maintenance personnel are anticipated

5 3 PROJECT FEATURES

5.3.1 Replacement of the Hwaret Weir and Intake

As a result of further inspection and the geotechnical investigations, it was concluded that the better technical solution for the re-use of the Hwaret Weir was to completely replace the structure Therefore, the existing weir, intake, and canal intake at the Hwaret weir area will be demolished, and the area will be excavated, cleared, and prepared for the construction of the new structure

The new weir will be similar to the old weir, however it will have a more elaborate stilling-basin configuration. It will consist of an overflow structure with an integral intake A plan view of the weir and intake are shown on Exhibit 5 2 The weir will span 41 5 m across the Zarqa River and will be a concrete gravity structure with its crest at El -184, designated as the minimum water level The river bed elevation at the weir structure is at about El -189, resulting in a hydraulic height of five meters The maximum height of the overflow section over the deepest foundation level is about eight meters The downstream face of the weir slopes four meters over a horizontal distance of six meters Following a 9 5-m horizontal apron section at El -188 is a series of concrete blocks 1 25 m high, 1 m wide, and 2 m long to serve as energy dissipators The blocks are arranged in two rows and spaced one meter apart Beyond the dissipators is a gabion mattress 6 m long by 41 5 m wide with a thickness of 0 5 m The gabion mattress consists of 6 x 2 0 x 0 5 m gabion boxes, covering a rockfill section The gabion mattress protection

along with the rockfill adds overall stability to the weir structure The side walls of the weir are at El -181, 1 m above the maximum water elevation A plan and section of the weir are shown on Exhibit 5 3

The crest elevation of the weir is selected to provide a submergence of 1 8 m over the pipe in the intake to effectively pass the minimum release from KTR The maximum water surface level for the design of bank protection corresponds to a 100-year flood A cutoff under the weir, the downstream apron, and the gabion mattress are provided to resist uplift pressure

The intake structure is connected to the weir structure by a shared wall on the left bank The invert of the pipe at the intake is at El. -187 2 The intake is 9 0 m long and 3 0 m wide It consists of a two-bay entrance which provides control to the system by 1 5 x 1.5 meter sluice gates The intake is oriented on a 10-degree angle off the weir centerline to provide for the entry of water at all levels because of a slight bend in the river at the location of the intake To prevent trash and debris from entering the pipeline, the intake structure is equipped with trashracks The crown of the pipe is set 1 8 m below the minimum water level and about 0 3 m below the invert of the intake to provide proper submergence at the pipe intake. The pipe invert elevation at the intake is governed by the desanding basin outlet and is at El -187 2 A retaining wall ties the intake back to the existing topography. Backfill is provided behind the wall A plan an section of the intake structure are shown on Exhibit 5 4

4 3 2 Desanding Basin

The desanding structure is 49 5 m long and 7.5 m wide and includes two chambers and a flushing canal The desanding chambers will be 40 m long, 3 m wide, and have walls ranging from 4 0 to 5 0 m high. The dimensions of the desanding basin are designed to provide a flow velocity of less than about 0 3 m/s (1 foot per second) at the design discharge This would cause settlement of all sediment sizes of 0 1 mm and above and a significant amount sizes between 0 062 mm and 0 1 mm. A relatively steep bottom slope is provided to facilitate the transport of settling material to the flushing chamber The location of the desander relative to the weir and intake is shown on Exhibit 5 2, and a plan and section of the basin are shown on Exhibit 5 5

Water will flow from the intake structure to the desander, located approximately 20 m downstream, at a slope of 0 5 percent The pipe invert elevation at the inlet to the desander is El -187 3 Water enters a basin area and then is distributed into two desanding chambers The entrance to each desanding chamber is controlled by a 1 5 m by 1 5 mr sluice gate Sediment will settle in the bottom portion of the chamber and slowly flow along the length of each 40 m long chamber A 1-m drop along this span (corresponding to a 2 5 percent slope) will facilitate the collection of sediment The collected sediment will flush out to the river through a 1 5-mete- wide flushing canal controlled by a 1 5 m by 2 0 m sluice gate Sediment-free water will flow into another basin and then back into the pipeline The pipe invert elevation at the outlet from the basin is located at El -187 0 Water entering the downstream basin from the 2 desanding chambers will be controlled by two 1 5 m x 1 5 m sluice gates A 1 5m-wide concrete platform at El -184 0 will be constructed at the upstream side of the sluice gates

4.3.3 Pipeline

The ductile iron pipeline will be about 3,655 m long and include two viaduct crossings over the Zarqa River at a distance of about 488 m and 2,642 m from the intake The pipeline will be buried over all of its length except for about 157 m where it crosses the river The horizontal alignment of the pipeline is designed to avoid environmentally sensitive areas, to stay away from dwellings, to stay close to the road and old canal path, and to utilize the allowable pipe joint deflection The vertical profile is designed to keep the pipeline sufficiently below the hydraulic gradient to avoid negative pressure and to provide an earth overburden of about 2 m on the average A plan of the pipeline is shown on Exhibit 5 6 The vertical profile is shown on Exhibit 5 7 and data from the vertical profile are shown on Exhibit 5 8

The pipe is designed for a diameter of 1,400 mm to reflect a design discharge of 4 5 cms This discharge allows for a 40 percent growth in use along the KAC with a surcharge representing a maximum daily requirement If additional capacity is necessary, the pipe can transport up to 5.5 cms (velocity about 3 5 m/s) The intake can also handle this flow Typical pipeline alignment details are shown on Exhibit 5.9.

The gross head between the Hwaret Weir and the outlet is about 49 m Hydraulic conditions, including an allowance for transient pressures, permit the use of a pipe with the minimum handling thickness which is about 13 mm The average maximum velocity in the pipe will be about 3 0 m/s, and the anticipated head loss over the length of the pipeline will be about 25 m

5.3.4 River Crossings

The alignment of the pipeline requires that the Zarqa River be crossed two times The first span will be located in the vicinity of an existing pipeline crossing about 500 m downstream from the intake The span will be about 75 m long over which the pipe will be supported on a series of 10 piers The maximum height above ground over this span will be five meters The second crossing will occur about 2,260 m downstream from the intake The pipeline span will occur over a length of about 80 m. The pipe will be supported on 10 piers and will be a maximum of 2 m above the bed of the river The invert level of the viaducts will be above the 100-year flood level A plan and profile for the viaducts are shown on Exhibits 5 10 and 5 11

5.3 5 Outlet Structure

The outlet structure includes a valve house to contain the dissipation valve and an outlet basin into the Abu Zeighan Canal The structures are located at the Abu Zeighan Weir, near the town of Abu Zeighan A location plan is shown on Exhibit 5-12

The valve house consists of a 12 m by 7 5 m reinforced concrete structure, with two parallel pipes and valve arrangements, a bridge crane, and a laydown area for replacement of valves A plan and section of the valve house is shown on Exhibit 5 13

After bifurcation of the main pipe, the flow enters the valve house in two, parallel 0 6-m-diameter pipes The flow energy is dissipated after entering the valve house by two Bailey

41

polyjet valves Because of potential for downward adjustment of the dissipation equipment if the flow volume increases, Bailey valves have been selected to dissipate net head at the end of the pipe Four ball valves, one on each side of the Bailey valves, enable the Bailey valves to be isolated for repair and/or replacement After the flow energy is dissipated, the flow exits the valve house in two 0 6-m-diameter pipes The centerline elevation of the valves arrangements is at El -232 The pipe and valve arrangements are seated on a concrete foundation platform.

A 4 0 m by 7 5 m laydown area has been provided for the removal, repair, and replacement of the valves This area is located on the south side of the valve house A large sliding door has been provided to allow trucks to back into the valve house, for loading and unloading of equipment

The outlet basin will be a reinforced concrete box-style design with an end sill for flow regulation The flow exits the valve house toward the canal in the two 0 6-m-diameter pipes Approximately 50 m from the valve house, the two pipes turn northward toward the canal From the valve house to the outlet basin, the centerline elevation of the pipe is constant at El -232 The outlet basin is about six meters wide by seven meter long box-shaped structure with no cover The 0 6-m pipes will end in the outlet basin with a 90-degree elbow and 1-m section of pipe to direct the flow into the basin The wall of the existing canal will be removed to a height of 2 4 m above the bottom of the canal The remaining wall will serve as an end sill to the outlet basin to equalize the flow entering the canal A plan and section of the outlet basin are shown on Exhibit 5 14

Chapter 6

PROJECT COST

Cost estimates have been prepared for the features described in the preliminary design The costs used in this estimate represent the prevailing rates during early 1966 The estimates are based on the assumption that most of the materials and supplies will be purchased in Jordan or through Jordanian agents All costs are expressed in Jordanian Dinars (JD) At the time of the estimate, the exchange rate for U S dollars was about 0 7 JD

6.1 Unit Cost on Similar Projects

The scope of services required that unit costs be collected from at least three similar ongoing projects and that they be broken down into material, labor, equipment, transportation, overhead, and profits An attempt was made to collect this unit cost data for pipeline projects in Jordan, however, no on-going or recently completed pipeline projects could be identified

As a result, the unit cost data for similar works were collected through inquiries to local manufacturers and contractors. The information collected as a result of these inquiries is presented on Exhibit 6 1 The rates shown are composite rates that include material, labor, equipment, transport, overhead and profit. The manufacturers and contractors contacted were not willing to break down their rate information into the various components However, to provide a general idea of current labor, material and equipment rates, the JVA staff provided information based on their experience on recent projects This is given on Exhibit 6 2 The overhead cost and profit rate varies with contractors As a best guess, the overhead and profit may be about 15 and 10 percent, respectively

The composite rates include equipment operating expenses (EOE), equipment ownership/depreciation cost (EO/D), supplies, material and subcontract (SMS) if any, and indirect cost by the contractor The EOE includes fuel, lubricants, and repair parts, but not operators and repair labor, who are generally part of direct labor The EO/D includes the allocated cost of a piece of equipment to the work on which it is used The depreciation rates are derived by allocating the price of the new equipment over its assumed economic life The SMS include material in permanent works, consumable supplies (except those under EOE), speciality items and payment for services, generally obtained by inquiring suppliers, venders and manufacturers or subcontractor Indirect expenses are the costs required by a contractor for project management, supervision, engineering, and administration to proceed with the work These include overhead labor, supplies, general operation expenses, outside services expenses, taxes, insurance, and performance bond

6 2 Capital Cost

The capital cost includes civil works, mechanical equipment, access, contingencies, escalation during construction, engineering, and administration Acquisitions are not included because most of the land will continue to be used for farming as the pipe will be buried and the remainder of the land already is a part of a JVA system or is along the Zarqa channel No relocations will be necessary It is expected that the project will be implemented immediately,

and, therefore, inflation to the beginning of construction will be minimal

Estimates of the construction quantities were based on the preliminary designs and drawings The major items of permanent equipment include the pipe, valves, and gates The prices for civil equipment were based on the survey of Jordanian manufacturers and contractors The price used for the pipe was based on the survey and an estimate from a US manufacturer The prices for the other permanent equipment were based on contacts with international manufacturers or Harza experience

A contingency allowance of 15 percent was included in this cost estimate for unforseen site conditions, possible omissions, approximations, and the chance of future design changes Indirect costs for engineering services prior to and during construction and for the administration costs of the owner chargeable to the project were based on an existing estimate for design, and an experience estimate of 10 percent of the direct costs for construction services and owner's administration.

The project is estimated to cost JD 5, 311,000 A summary of the cost is presented below, and a detailed estimate of capital cost is presented on Exhibit 6 3

Feature	Estimated Cost (JD)
Hwaret Weir	521,000
Intake	100,000
Desanding Basin	250,000
Outlet Facilities	881,000
Pipeline and Viaducts	3,559,000
Total	5,311,000

6 3 Operation and Maintenance Cost

The annual operating costs include the costs of operation and maintenance (O & M) for the various features, the cost of replacing short-life equipment, and administration by the JVA It is expected that the operation and maintenance will be performed by the existing JVA O&M staff The major components of the O & M cost will be for monitoring the system, cleaning and maintenance of the desanding basin, maintenance of the valve house, cleaning the pipeline, and replacement of minor equipment The JVA is currently maintaining the pipelines ZCI and ZCII, originating at the Thahab Weir The staff working on these facilities can be very well used for this new facility However, one or two people will be required for the valve house, and an additional person will be required at the intake/desanding basin Transportation of the additional personnel can be taken care of by the existing transport deployed for the maintenance staff of ZCI and ZCII

Keeping the above factors in view, an annual O & M cost of about JD 55,000 is judged to be reasonable and has been used in the economics analysis

Chapter 7

ECONOMIC AND FINANCIAL ANALYSIS

7 1 Economic Analysis

The economic justification of the Zarqa Conveyance Project has been measured by a comparison of project benefits and project costs over the economic life of the project which has been taken as 50 years

7 1 1 Project Costs

The project costs are based on the criteria and drawings presented in Chapter 4 All costs are measured at the 1995 price level The construction cost includes civil costs, permanent equipment, contingencies, and an allowance for engineering and owner's administrative costs A summary of the construction costs are presented below

Weir and Intake	JD 621,000
Desander	JD 250,000
Pipeline and Crossings	JD 3,559,000
Outlet Facilities	JD 881,000
Total	JD 5,311,000

Construction will take place in one year

The operation and maintenance of the project will be performed as an extension to the existing JVA operation and maintenance group As such, the cost of O&M will be an incremental amount to an existing budget It is estimated that the O&M costs for the project will amount to about JD 55,000 per year This cost will include labor materials, administration, and general expenses

7 1 2 Project Benefits

The project benefits accrue from the supply of better quality water to the KAC The benefits will be measured in terms of improved yields and a reduction in damage to the crops The area directly affected by water quality changes associated with the project is the "18-km Extension Project," an area of about 36,915 dunum (du) that receives water from KAC (after receiving water from Abu Zeighan Canal) This area is a part of Southern Jordan Valley, which also includes the Hisban-Kafrein Project (about 15,947 du, not affected by the pipeline) and 14 5-km Extension Project The 14 5-km Extension Project, which is presently under development, includes an irrigation area of about 60,000 du and Karameh Reservoir, which is designed to temporarily store excess water from the KAC and side wadis during the winter and return those flows to the KAC during spring and summer The 14 5-km extension will thus be indirectly affected by the pipeline

Water salinity (as measured by electrical conductivity, EC) was used as the water quality parameter to compare yield realized under existing conditions with potential yields under with-project

conditions Both crop tolerance and yield are influenced by the irrigation water quality In terms of EC values, the data given in Table 7 1 can serve as a guide to relative tolerance of crops The values presented are averages of several crops grown in Jordan Valley in the indicated category

Table 7 1

CROP TOLERANCE AND YIELD POTENTIAL AS INFLUENCED BY IRRIGATION WATER SALINITY (EC, MMOHS/CM)
per Ayers and Westcot (1985)

Yield Potential as % of Maximum	100	90	75	50
EC Values, mmhos/cm				
Vegetables	1 40	2 00	2 90	4 30
Citrus	1 10	1 60	2 20	3 20

7 1 2 1 Average Water Quality Conditions

The irrigation releases from KTD are mixed with the saline water from springs along the Zarqa River reach between the Hwaret Weir and the Abu Zeighan Weir This mixing lowers the quality of the releases from KTD Monthly EC values, averaged over a 6-year period from 1989 to 1994 and presented in Table 7 2, indicate the effect of the mixing The water released from KTD is mixed with the saline springs and seeps just upstream from the Abu Zeighan Canal and then mixed with the water of the KAC before being used for irrigation The averaged EC values at KAC-Sawalha, which is upstream of the diversion from the Abu Zeighan Canal, and at KAC-Maadi, which is after mixing with the diversion from the Abu Zeighan Canal, give a clear indication of the deterioration in water quality due to the saline springs along the Zarqa River

Table 7 2

AVERAGE EC VALUES FOR 1989-1994

Month	KTD Site	Abu Zeighan Canal	KAC Sawalha	KAC Maadi
January	2 48	3 06	0 79	1 41
February	1 95	2 79	0 79	1 50
March	1 87	2.29	0 81	1 67
April	1 81	1 82	0 88	1 84
May	1 73	2 00	0 93	1 94
June	1 65	2 04	0 84	1 95
July	1 61	2 16	0 92	1 97
August	1 79	2 12	0 78	2 08
September	1 92	2 24	0 90	2 09
October	2 10	2 35	0 94	2 23
November	2 37	2 71	1 01	2 10
December	2 19	2 69	0 86	1 65

7 1 2 2 Approach to the Derivation of Economic Benefits

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,

Economic data obtained from results of two surveys of randomly selected farms in the central and southern Jordan Valley, and

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 the effect of EC on the 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-Maadi and the information in Table 7 1 were used to estimate the percentage of the theoretical maximum yield that was obtained under actual conditions Predicted EC data (Exhibit 7 1) were used to estimate the percentage of maximum yield that would have been obtained had the project been in operation during those growing seasons The ratios of the percentage yields with and

without the project were then used to estimate the change in economic returns that could be attributed to the project

The economic data used in the study came from two sources covering different periods and areas in the Jordan Valley For the 1991-1992 season in the southern Jordan Valley, economic data were collected from Salman (1994) and for the 1993-1994 season in the central Jordan Valley from the Water & Environment Research & Study Center (1995) 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 period was considered as a wet period when EC's in the KAC, even after mixing with the diversion from the Abu Zeighan Canal, 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 the assumed salinity vs crop production relationships

The 1993-94 season was considered to be relatively dry, and the EC values were relatively high The economic data collected as a result of the central Jordan Valley study were from an area that presently receives water that is diverted from the Zarqa River at Thahab Weir The total area of agricultural production in the southern Jordan Valley during this study was low relative to the 1991-92 season due to a lack of sufficient rainfall to supplement supplies from the irrigation system Based on the assumed salinity vs crop production relationships, production of most crops in the study area was in the 60-95 percent range

In the assessment of project benefits, 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 that the maximum impact of the project on overall yield is an increase on the order of 10 percent

The assessment approach involved the following analyses

- Monthly average EC data were collected at four key location , at the KAC south of or downstream from the diversion from the Abu Zeighan Canal or KAC-Maadi (KAC-s), at the KAC north of or upstream from the diversion from the Abu Zeighan canal or KAC-Sawalha (KAC-n), at the Abu Zeighan Canal, and at KTD from the beginning of the growing season in the 1991 water year (September 1990) through the end of 1995 These data were analyzed to determine the average monthly mixing ratio between KAC-n and water from the Zarqa River that was diverted through the Abu Zeighan Canal to 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

Hwaret 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 provided in Table 71, (Ayers and Westcot,1985) 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

- Cropping pattern data for individual crops grown in the southern Jordan Valley (Shuna Janobia) were obtained for 1990 (Annual Agricultural Statistics, 1990, as reported in Salman, 1994) and for 1994 (Water & Environment Research & Study Center, 1995)

- The cropping data represents the 18-km extension which will be affected by the Zarqa Conveyance Project, and the Hisban-Kafrein irrigation area that will not be affected by the Zarqa Conveyance Project Data provided by JVA for areas of general crop types (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 from Salman (1994) and Water & Environment Research & Study Center - University of Jordan (1995) 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, 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 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

- Gross benefit estimates were divided by the total cropped area to obtain estimates of the mean unit benefit (JD/du) provided by the project

Table 7 3 summarizes the results of this assessment Detailed breakdowns of crop production estimates are provided on Exhibits 7 2 through 7 7

Table 7 3 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 releases from the KTD are relatively low (1993-1994 and 1994-1995)

Table 7 3

SUMMARY OF ANALYSIS OF ESTIMATED FARM-LEVEL ECONOMIC RETURNS (J D) RESULTING FROM PROJECT IMPLEMENTATION

Input Data Used for Economic Analysis	Growing Season				
	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
1991 92 Economics 1994 Cropping	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
1993 94 Economics 1990 Cropping	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
1993 94 Economics 1994 Cropping	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

The economic returns do not include direct effects of the project on the areas in two of the irrigation development areas (DA 25 and 30) that are located immediately north of the 18-km extension and that receive water directly from the KAC The returns also do not consider the indirect effect of project operation on the 14 5-km Extension project Assuming that directly affected areas in DA 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 and partly from other sources, including the Zarqa River 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

7 1 2 3 Economic Benefit

As shown in Table 7 3, the total benefits indicate a wide range Under current operating conditions, represented by the values for 1993-94 and 1994-95, much of the water in the KAC in the summer months is diverted to Amman for municipal and industrial use This is likely to continue as long as supplies are scarce in Jordan An average of the values for 1993-94 and 1994-95 increased by 15 percent to include DA 25 and 30 (JD 1 7 million/year) would be representative of this operating condition as they include a dry year and a wet year cropping pattern and area irrigated If the diversion to Amman varies depending on other supplies, an average of all of the values (JD 860,000) would be more representative of the project benefits The economic analysis was performed for both values The indirect benefits are not considered

7 1 3 Benefit Build-up Period

Project benefits will be realized in the first year after the project is completed, which is scheduled to be functional after about 12 months from start of construction Therefore, no buildup period is assumed

7 1.4 Economic Justification

The economic justification of the project is evaluated using net present value and benefit-cost ratio criteria These criteria were computed using a 10 percent discount rate and a 50-year period of analysis Based on a construction cost of JD 5 3 million and benefits amounting to JD 1 7 million per year, the project is economically justified with a benefit cost ratio of 2 9 and a net present value of about JD 10 million

7 1 5 Sensitivity Analysis

Sensitivity analyses were performed to evaluate the effect of changes in interest rate, cost, and the value of benefits on the project economics To evaluate the sensitivity of project economics to discount rates, the discount rate was adjusted from 10 percent to 8 and 12 percent To evaluate the sensitivity to cost, the construction cost was adjusted upward by 10 percent and downward by 10 percent In a third adjustment, the benefits representing conditions over the last five years, which included a period of major diversion from the KAC for use in Amman, as well as a period when more of the water was used for irrigation were considered Finally, a worst case was considered which included all of the conservative assumptions, i e 12 percent interest, a high cost, and a low benefit The results of these sensitivity analyses are presented in Table 7 4

Table 7 4

SENSITIVITY ANALYSIS

Case Description	Interest Rate (percent)	Project Cost (Million JD)	Project Benefit (1000 JD/yr)	B / C	NPV (1000 JD)
Base Case	10	5 311	1,700	2 9	10,000
Interest Rate Adjustment	8	5 311	1,700	3 5	13,700
Interest Rate Adjustment	12	5 311	1,700	2 4	7,500
Cost Adjustment	10	5 311+10%	1,700	2 6	9,500
Cost Adjustment	10	5 311-10%	1,700	3 2	10,500
Benefit Adjustment	10	5 311	860	1 5	2,428
Worst Case	12	5 311+10%	860	1 1	750

7 2 Financial Analysis

The financial analysis includes a cash flow analysis based on assumed financial criteria and the computation of an equalization revenue which measures the annual revenue required to repay the Project capital and operating costs over a 20-year period

7 2 1 Investment Cost

The investment cost includes the estimate of the construction cost, inflation to the beginning of construction and interest during construction The total debt investment includes the investment cost, the first-years O&M, and a financing fee The total debt investment is shown below

Construction Cost	JD 5 311 million
Escalation to the beginning of construction @ 4%	0 433

EXHIBITS

Interest during construction @ 6%	0 185
O&M account	0 058
Financing fee @ 3%	0 185
Total Debt Investment(rounded)	JD 6 173 million

A cost stream, showing the total of O&M costs, interest and principal charges is presented in Exhibit 7 8

7 2 2 Repayment

An analysis was performed to estimate the annual "equalization revenue" required to result in a cumulative present value of the cash flow equal to zero This approach was taken rather than the conventional financial analysis because it is difficult to estimate the revenue to the nation (the vehicle for repayment) as a result of the implementation of this project and, therefore, the derivation of a financial rate of return is not relevant The ratio of this annual equalization revenue to the total net benefit provides an indication of the "coverage" that the Project improvements provide Allowing for 100 percent debt financing, a 6 0 percent cost of debt (based on the assumption of a soft loan), and a debt repayment period of 20 years, the equalization revenue would be about JD 455,000 (in 1995 JD) per year which is about 27 percent of the annual benefit of JD 1 7 million (see Exhibit 7 8) Therefore, taxes in the amount of 27 percent of the additional income would repay the Project loan and operating costs in 20 years

Based on the low estimate of benefit, the coverage is about 50 percent of the benefit If a debt cost of money equal to 10 percent is used in the analysis, the equalizing revenue value is increased to about JD 624,000 per year which is about 35 percent of the expected average annual net benefit and about 70 percent of the low estimate of benefits

Based on this analysis, it is concluded that if the MWI desires to recover the funds expended on the Project, the gross returns to the farmers in the area will be sufficient to repay the Project costs under the assumed financing conditions

Chapter 8

PROJECT IMPLEMENTATION AND CONSTRUCTION

It is the intention of the JVA to implement the project as soon as feasible, preferably by the middle of 1997 so that better quality water will become during the period when significant diversions will be made from the KAC for supply to Amman Following this feasibility report and preliminary design, the major steps for the implementation of the project will include

1 Funding
2 Final design
3 Prequalification of contractors
4 Preparation of contract documents
5 Bid preparation
6 Contract award
7 Order and furnish pipe and accessories
8 Construction activities

It is expected that the prequalification activities, excluding the furnishing of the pipe will take about five to six months During this period, it is necessary to secure the funding for the project and to order the pipe The provision of the pipe, whether from the USA, southern Europe, or the Far East, is on the critical path The construction should be completed in about six or seven months A schedule for the implementation of the project is shown on Exhibit 8 1

8 1 Project Organization

The JVA has sufficient experience to be able to administer the construction of the project A consultant will be required for the final design, preparation of contract documents and other processes leading to the selection of a contractor Because of relatively small size of the project, it is expected that a local contractor will construct the project Operation and maintenance of the project can also be performed by the JVA staff The team that currently takes care of ZCI and ZCII can also be responsible for this project with the addition of several people

8 2 Preconstruction Activities

The initial steps for project implementation will be the final discussion and financing negotiations by the JVA It is expected that the JVA will secure the funds from a donor country at favorable rates The design must be started immediately after submission of the feasibility report The design phase of the project may require limited detailed topographic survey at the locations of some structures and dwellings at the weir site Also some modification in the alignment of the pipeline, especially at the bridge crossing may be needed The JVA will have to order the pipe as soon as funding is secured This will permit the construction of the project within the time constraints established above

8 3 Construction Activities

The major components of the project are

1 Weir

2 Intake
3 Desanding basin
4 Pipeline
5 Outlet works

The plan for control of the river during construction has been described in Chapter 5 as required by the scope of work The right side of the existing weir will be removed and the new weir constructed behind the first stage of the cofferdam The left side of the weir will be removed and replaced and the intake constructed behind the second stage cofferdam The desanding basin, pipeline, river crossings, and outlet facilities all can be constructed at the same time Delays may occur during the rainy season between January and April, however, they are not expected to be significant because the KTR effectively controls floods up to a return interval of 100 years The intervening area is too small, with low rainfall, to cause any flooding

Chapter 9

ENVIRONMENTAL ASSESSMENT

A stand-alone report entitled, "Environmental Assessment, March 1996," has been issued by Harza-CC as a part of this project feasibility study The report provides detailed of all alternatives considered at the conceptual level and their potential environmental impacts This chapter provides a brief summary of the major findings and recommendations of the report, related to the proposed project, other alternatives similar to the proposed project and the "no action" alternative The major items covered in this chapter are

- Description of the environment or areas that will be affected by the alternatives under consideration

- Description of the environmental consequences of undertaking any of the alternatives including direct and indirect effects, and possible mitigation measures

- Identification of monitoring required to measure changes in environmental quality resulting from implementation of the proposed project

9.1 Alternatives Included for Environmental Assessment

Alternatives retained for environmental consideration include

- Construction of a pipeline from the Hwaret Weir to the Abu Zeighan Weir (Proposed project– IRR3a)

- Construction of canal-pipe combination from the Hwaret Weir to the Abu Zeighan Weir (IRR3b)

- Construction of pipeline from the Thahab Weir to the Abu Zeighan Weir (IRR1)

- No-action

9 2 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 the Hwaret Weir) downstream to the Abu Zeighan Weir

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

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

57

• 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", 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 (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

9.3 Comparison of Environmental Effects

The environmental effects of proposed project and the feasible alternatives, including the no-action alternative, and the proposed project with recommended mitigation are compared 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 project and all feasible alternatives will have the same level of benefits relative to the no-action alternative

9 3 1 Construction and Operation Effects on Land Use (Exhibit 9.1)

The no-action alternative will not affect land use and dwellings Construction of the proposed project 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 the Hwaret canal-pipeline alternative are similar to those of the proposed project, 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

9.3 2 Operation Effects on Streamflow (Exhibit 9.2)

The proposed project 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 the Hwaret Weir Operation of a settling basin for desanding water delivered to the pipeline (similar to the basin at the 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 The 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 Hwaret canal-pipeline alternative would have be equivalent to the proposed project 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 the 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 project and feasible alternatives would increase that flow to 150-300 L/s because all spring inflow would be passed at the weir.

9 3.3 Operation Effects on Water Quality (Exhibit 9.3)

The proposed project 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 project 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 the Hwaret 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 project 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

9 3 4 Operation Effects on Aquatic Life, Vegetation and Migratory and Resident Bird Habitat (Exhibit 9 4)

59

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 project will reduce flows to low levels (0-20 L/s) in the 1 5 km stream segment immediately downstream of the Hwaret 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

With the minimum flow release proposed as a mitigation measure, the proposed project 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 project without mitigation Effects on the brackish water segment would be similar to the proposed project

The Hwaret canal-pipeline alternative would have the same effects as the proposed project The Thahab pipeline alternative would affect an additional 5 2 km of freshwater stream channel, compared to the proposed project 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 project The greater extent of the effects on aquatic life and vegetation would reduce habitat suitability for birds compared to the proposed project

9.3.5 Operation Effects on Human Uses of Water in the Zarqa River and Irrigated Areas (Exhibit 9 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 the Abu Zeighan Weirs that pump water directly from the river for irrigation purposes All farms along the river downstream from the 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 the Abu Zeighan Weir The water quality for livestock is typically in the "very satisfactory" range (Ayers, 1985) upstream from the saline inflows (when there is flow below the Thahab Weir) and, depending on the flow past the Thahab Weir, may be in the "very satisfactory" or "satisfactory" range above the Abu Zeighan Weir Below The 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 (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 the Abu Zeighan Weir thus the salinity does not appear to be great enough to restrict those uses

The proposed project 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

9 3 6 Selected Alternatives

Effects of the Hwaret canal-pipeline alternative are equivalent to those of the proposed project However, the open canal system will have additional potential effects and also there will be maintenance problems 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 Therefore, the proposed project has the minimal environmental effects

9 4 Environmental Consequences

The environmental consequences are considered on the following resources for the proposed project and no-action alternative

- Streamflow and Water Quality
- Groundwater
- Wildlife and Aquatic Resources
- Suitability of water for Agriculture and Other Uses
- Productivity of Affected Lands

The proposed project 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 (the 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.

9.4 1 Construction Effects

Proposed Project

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 the Hwaret 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

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

62

For the final 0 4 km segment to the 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

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

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

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

Pipeline from the 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 the 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

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 The canal presently occupies about 2 7 du of land in cultivated area, therefore, the proposed project will involve removal of an additional 1 1 du from cultivation

9.4 2 Effects on Streamflow and Water Quality

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 the Thahab Weir Flow in excess of the irrigation requirement for ZC I and II is passed at the Thahab Weir and continues downstream

approximately 9 9 km to the Abu Zeighan Weir where it is diverted, via Abu Zeighan Canal, to KAC The present diversion affects the Zarqa River between the 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 the 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 the Abu Zeighan Weir

The river segment from the Thahab Weir to the 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 the Thahab Weir is from 160 L/s to approximately 1 6 m^3/s with peak flows of about 2 5 m^3/s (Harza, 1996) Natural flood flows are higher, but occur infrequently Low flows often occur during periods of natural rainfall and there may be no release at the Thahab Weir for extended periods during the winter months Operation of ZC I and II may result in diversion of all flow reaching the Thahab Weir except for a small overflow from the settling basin. The settling basin overflow return channel enters the Zarqa about 2 3 km downstream of the Thahab Weir, thus the 2.3 km reach below the Thahab Weir experiences complete dessication from time to time The vegetation in the reach between the 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 the Hwaret Weir to the 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 the Hwaret Weir Total flow accumulation at the Abu Zeighan Weir is 150-300 L/s from springs in the segment below the Hwaret 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 the 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 the 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 the 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

Diversion at the Hwaret Weir

The proposed project would involve a diversion at the Hwaret Weir The existing diversion at the Thahab Weir would continue to operate The reach of the Zarqa River between the Thahab Weir and the Hwaret 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 the Hwaret Weir and the Abu Zeighan Weir

The 4.7 km reach of the Zarqa River between the Hwaret Weir and the 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 the Hwaret 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

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

Zarqa River between the Abu Zeighan Weir and the Jordan River

Water entering the channel between the Hwaret and the Abu Zeighan Weirs from seeps and springs will be passed over the 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 the Abu Zeighan Weir compared to the No-Action Alternative No information on water quality in the reach below the Abu Zeighan Weir was available, however, some springs are known to occur along the river channel below the Abu Zeighan Weir Water quality is likely to be similar to that in the reach above the weir

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 (Harza, 1995) 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 Exhibit 9 6 presents the annual average EC's and the average EC's for typical winter and summer growing periods

The results presented in Exhibit 9 6 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 the 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 the 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 the 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 the 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 (Ayer, 1985) Even at the project design flow of 4,500 L/s, the decrease in EC is greater than 0 3 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 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 the Thahab Weir and the 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 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 (University of Jordan, 1995) 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 (University of Jordan, 1995) Project operation is not expected to affect trace metal concentrations

9.4 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 the Hwaret and the 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

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 (University pf Jordan, 1995b) and appreciable recharge probably is not occurring

9.4.4 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.

Diversion at The Hwaret Weir

The proposed project and the canal-pipeline alternative will divert water from approximately 4 7 km of river channel between the Hwaret and the 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 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

Habitat Downstream of the Abu Zeighan Weir

Increased flow in the river channel downstream of the 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

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

9 4 5 Suitability of Water for Agriture 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

Cultivated Areas

The proposed project 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)

Pastoral Uses

Diversion of KTD water will result in reduced availability of water for livestock use along the river channel between the Hwaret Weir and the Abu Zeighan Weir Available water will derive from saline springs an seeps in the area downstream of the Hwaret 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 (Ayer, 1985) 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

71

on the order of 5-10 dS/m Daily monitoring at the 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 the 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 the Hwaret 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 the 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.

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

9.4 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 (Rassem Anshasi, JVA, Water Quality Laboratory, Personal communication)

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

9 4,7 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

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

9.4.8 Human Population

Employment

Effects of the proposed project 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

Human Health

The effects of water development projects on the incidence of water-borne diseases is often a concern. The proposed project 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 the 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

9.5 Recommended Mitigation Measures

9 5 1 Construction Impacts

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

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

Stream Channel Construction

Excavation of the streambed for rehabilitation of the Hwaret 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.

Antiquities

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
- an archaeologist should be present during construction in areas where remains may occur but the need for archaeological preservation/excavation can not be established until construction excavation is underway.

9.5 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 the Hwaret 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 the Thahab Weir This quantity of flow is often the only flow below the 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 the Hwaret Weir and provide a source of water for livestock use in 1 3 km of stream channel below the Hwaret Weir The minimum flow would also provide a small reduction in EC of the saline spring water flowing in
requirement, which is estimated at 1,100 L/s or 35 Mm^3/yr

9 6 Monitoring

Water quality monitoring of the Zarqa River and KAC is institutionalized in the JVA. Four measurements of a limited set of parameters (EC, temperature, pH) are obtained each month from a number of sites Water samples are collected semi-annually (April and October) for analysis for major cations and anions, nutrients and selected metals This program should be continued with addition of parameters to address effects of project operation Monitoring of dissolved oxygen and total and fecal coliform bacteria should be incorporated into the monthly monitoring program for the Zarqa River One additional monitoring station should be added to those presently monitored to assess the quality of water in the river downstream of the Abu Zeighan Weir Monitoring conducted in the vicinity of the Yarmouk-Dead Sea Road bridge over the Zarqa would provide such information

To determine whether the expected economic benefits are realized from the project, an economic survey program should be established in the 18 km Extension Project area The methodology should be similar to that used by the University of Jordan for the irrigation management study of the central Jordan Valley A survey conducted prior to project implementation, followed by a survey one to two years after project completion would be appropriate

Chapter 10

PROJECT IMPLEMENTATION AND CONSTRUCTION

It is the intention of the JVA to implement the project as soon as feasible, preferably by the middle of 1997 so that better quality water will become during the period when significant diversions will be made from the KAC for supply to Amman Following this feasibility report and preliminary design, the major steps for the implementation of the project will include·

1 Funding
2 Final design
3 Prequalification of contractors
4 Preparation of contract documents
5 Bid preparation
6 Contract award
7 Order and furnish pipe and accessories
8 Construction activities

It is expected that the prequalification activities, excluding the furnishing of the pipe will take about five to six months During this period, it is necessary to secure the funding for the project and to order the pipe The provision of the pipe, whether from the USA, southern Europe, or the Far East, is on the critical path The construction should be completed in about six or seven months A schedule for the implementation of the project is shown on Exhibit 10 1

10.1 Project Organization

The JVA has sufficient experience to be able to administer the construction of the project A consultant will be required for the final design, preparation of contract documents and other processes leading to the selection of a contractor Because of relatively small size of the project, it is expected that a local contractor will construct the project Operation and maintenance of the project can also be performed by the JVA staff The team that currently takes care of ZCI and ZCII can also be responsible for this project with the addition of several people

10.2 Preconstruction Activities

The initial steps for project implementation will be the final discussion and financing negotiations by the JVA. It is expected that the JVA will secure the funds from a donor country at favorable rates The design must be started immediately after submission of the feasibility report The design phase of the project may require limited detailed topographic survey at the locations of some structures and dwellings at the weir site Also some modification in the alignment of the pipeline, especially at the bridge crossing may be needed The JVA will have to order the pipe as soon as funding is secured This will permit the construction of the project within the time constraints established above

10 3 Construction Activities

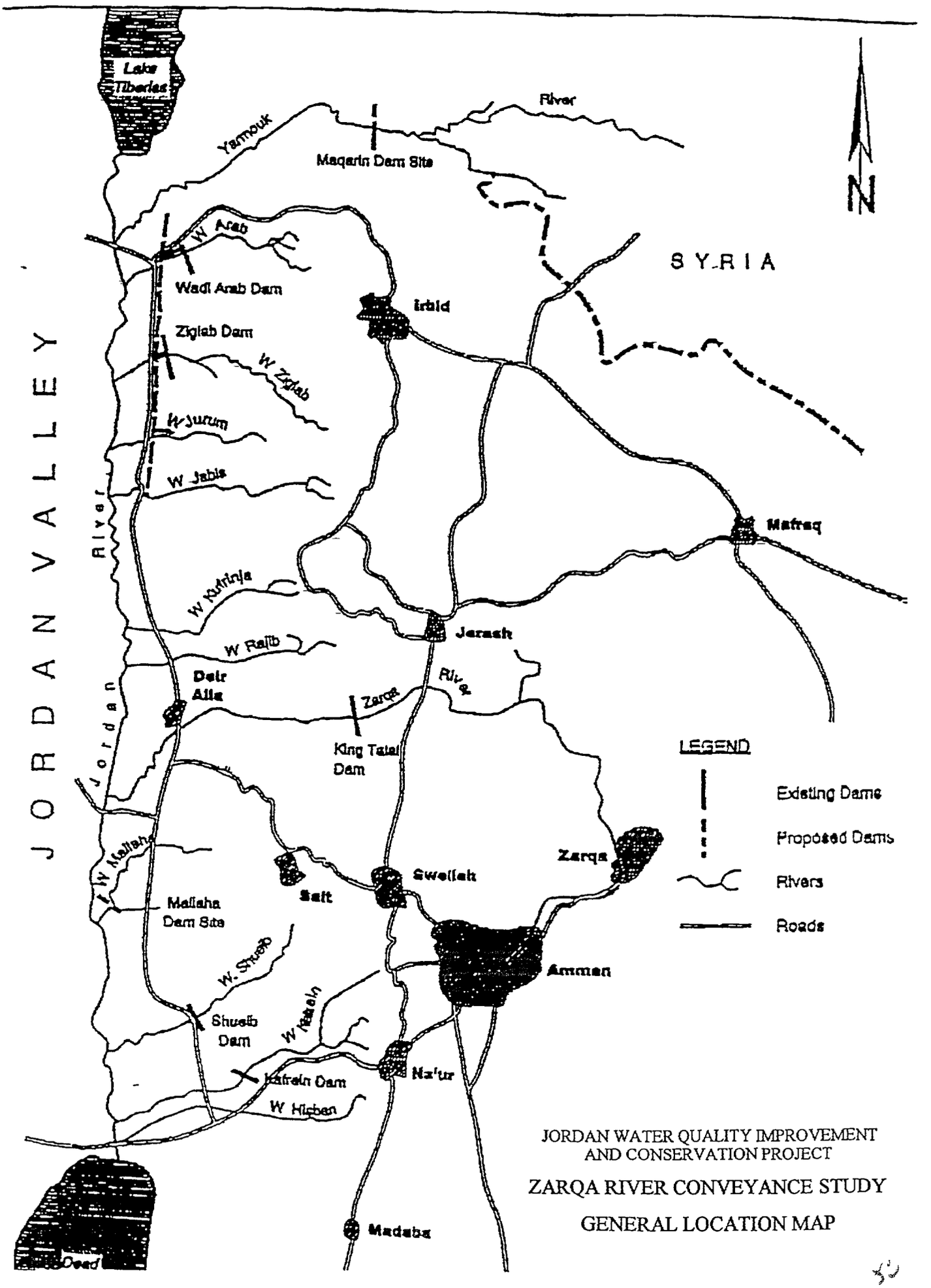
The major components of the project are

1 Weir
2 Intake
3 Desanding basin
4 Pipeline
5 Outlet works

The plan for control of the river during construction has been described in Chapter 5 as required by the scope of work. The right side of the existing weir will be removed and the new weir constructed behind the first stage of the cofferdam The left side of the weir will be removed and replaced and the intake constructed behind the second stage cofferdam. The desanding basin, pipeline, river crossings, and outlet facilities all can be constructed at the same time Delays may occur during the rainy season between January and April, however, they are not expected to be significant because the KTR effectively controls floods up to a return interval of 100 years. The intervening area is too small, with low rainfall, to cause any flooding

EXHIBITS

EXHIBIT 1 1

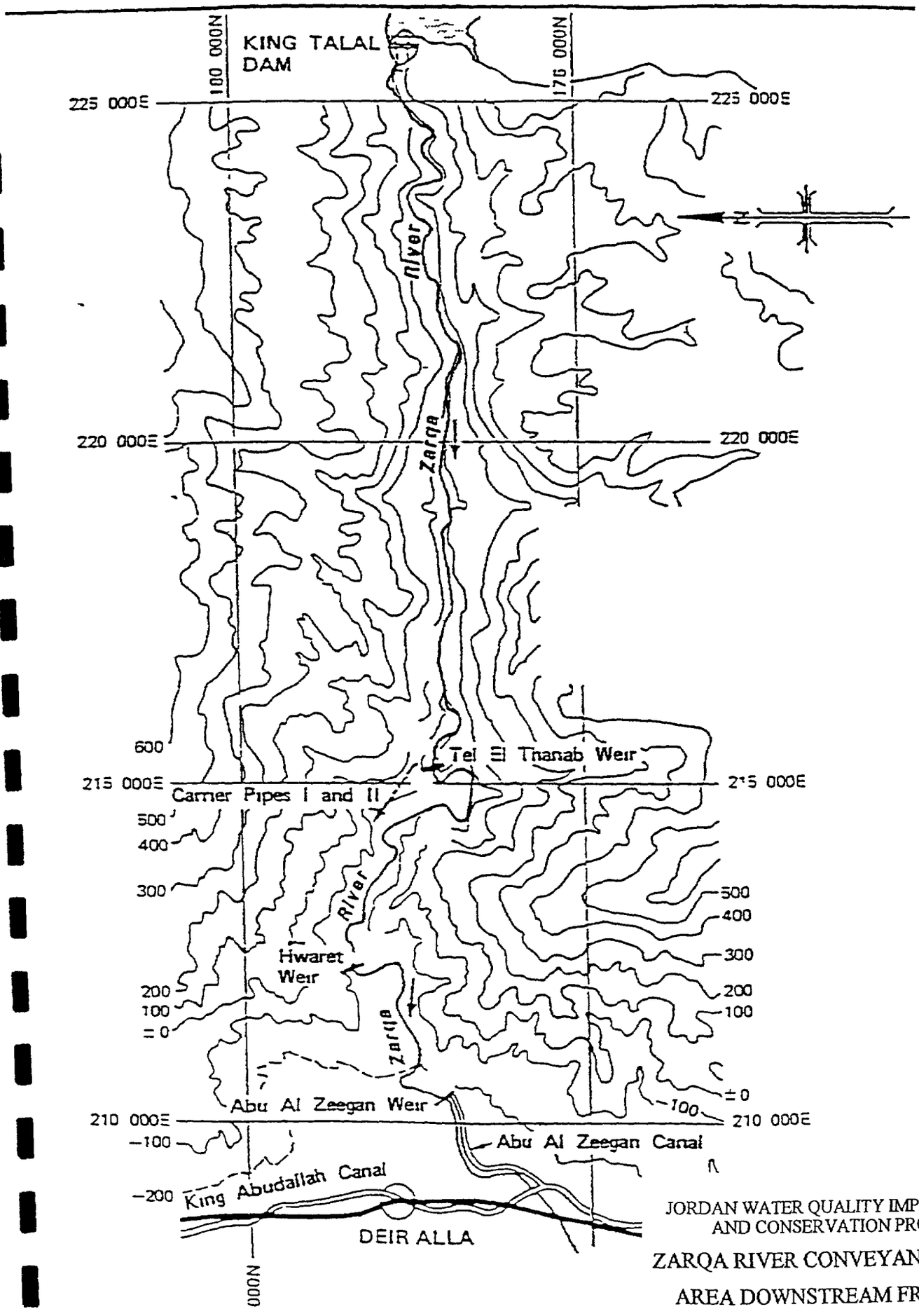


JORDAN WATER QUALITY IMPROVEMENT AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

GENERAL LOCATION MAP

EXHIBIT 1 2



JORDAN WATER QUALITY IMPROVEMENT AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

AREA DOWNSTREAM FROM KTD

EXHIBIT 1 3

HISTORICAL MONTHLY STREAMFLOW (CMS)
ZARQA RIVER AT KTD
PERIOD WY 1954–1994

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
1954	1 90	2 16	1 94	2 43	4 88	2 69	1 77	1 94	1 89	1 57	1 57	1 77	2 21
1955	1 83	1 89	2 61	2 17	1 57	1 49	1 31	1.23	0.96	0 78	0 75	0.96	1 46
1956	1 27	3 67	2 91	2 20	1 52	2 13	2 04	1 57	1 35	1 27	1 19	1 12	1 85
1957	1 23	1 16	2 43	2 28	8 89	6 72	1 97	2 09	1 77	1 46	1 38	1 35	2.73
1958	1 49	1 85	2 17	2 69	8 27	1 61	1 62	1 49	1 27	1 08	1 08	1 23	2 15
1959	1 27	1 23	1 27	4 93	3 22	3 25	1 12	1 12	0 96	1 01	0 93	1 04	1 78
1960	1 08	1 12	1 42	1 72	1 28	1 27	1 04	0 56	0 50	0 41	0 78	0 81	1 00
1961	0 78	1 12	1 49	3 62	5 00	1 57	1 81	1 38	0 39	0 67	0 71	0 69	1 60
1962	1 05	1 81	6 35	4 41	6 16	1 90	0 93	0 90	0 96	1 08	1 31	1 43	2 36
1963	1 27	1 31	1 75	1 72	8.23	1 64	1 43	4 52	1 12	1 05	1 08	1 08	2 18
1964	2 10	2 52	7 55	3 83	6 69	4 34	1 86	1 11	1 09	0 74	0 73	0 81	2 78
1965	1 85	1 22	6 05	9 41	6 27	3 30	5 15	2 83	2 36	1 56	1 62	2 19	3 65
1966	1 16	0 54	0 71	0 72	0 75	9 38	1 40	1 06	1 00	0 83	0 80	0 87	1 60
1967	1 01	1 43	2 69	5 49	3 89	3 10	1 81	1 12	1 04	0 93	0 93	1 08	2 04
1968	1 01	0 93	3 92	7 54	4 83	3 17	2 16	1 46	1 23	0 93	0 93	0 81	2 41
1969	1 16	2 32	1 91	3 10	3 30	13 30	3 14	2 23	1 58	1 25	0 99	1 28	2 96
1970	1 50	1 60	1 61	2 82	2 05	3 70	1 79	1 52	1 44	1 23	1 94	2 12	1 94
1971	1 25	1 37	1 64	2 57	1 46	1 73	11 82	0 55	0 37	0 32	0 28	0 42	1 98
1972	0 82	1 08	3 60	1 90	2 59	2 25	2 15	0 51	0 31	0 37	0 53	0 53	1 39
1973	0 52	1 20	0 75	2 00	1 17	1 56	0 63	0 64	0 69	0 62	0 54	0 46	0 90
1974	0 48	1 50	1 09	21 28	12 07	5 78	3 69	1 99	1 23	0 95	0 77	0 78	4 30
1975	0 58	1 22	1 69	1 46	4 73	2 23	3 44	0 53	0 35	0 30	0 32	0 34	1 43
1976	0 34	0 86	1 28	1 61	1 80	5 92	0 75	0 68	0 55	0 52	0 47	0 42	1 27
1977	0 53	0 74	0 87	1 55	1 55	1 29	0 98	0 47	0 27	0 22	0 30	0 31	0 76
1978	1 36	0 66	2 03	2 00	1 05	1 90	0 73	0 37	0 10	0 12	0 16	0 18	0 89
1979	0 28	0 41	1 16	1 01	0 66	0 90	0 49	0 11	0 07	0 10	0 38	0 33	0 49
1980	1 97	17 96	9 68	5 11	4 59	13 05	3 43	1 90	1 19	0 82	0 71	0 77	5 10
1981	0 80	1 04	11 54	2 77	4 08	3 23	1 86	1 15	0 81	0 74	0 93	0 93	2 49
1982	0 90	1 15	1 09	1 55	4 42	2 12	5 74	3 97	0 94	0 92	1 09	0 74	2 05
1983	1 26	1 85	1 46	4 04	7 18	11 17	3 36	2 72	1 59	1 54	0 92	1 06	3 18
1984	1 24	3 28	1 57	2 83	2 41	3 75	2 03	1 59	1 27	1 09	1 03	0 93	1 92
1985	1 54	3 51	3 34	1 19	10 35	3 52	1 92	1 10	0 50	0 41	0 40	0 68	2 37
1986	0 81	0 98	1 32	1 83	2 99	1 36	1 74	1 02	0 84	0 89	0 79	0 96	1 29
1987	1 10	8 71	1 84	2 79	1 71	1 40	0 71	0 76	0 76	0 77	0 71	0 77	1 84
1988	6 96	1 32	2 21	4 36	15 48	7 89	2 04	1 65	1 25	1 12	1 23	1 55	3 92
1989	1 44	1 51	6 47	2 59	2 11	2 53	1 62	1 42	1 28	1 17	1 26	1 36	2 06
1990	1 31	2 17	2 87	3 07	3 35	3 06	2 23	1 52	1 28	1 40	1 39	1 28	2 08
1991	1 37	1 52	1 65	3 24	3 05	3 89	1 68	1 58	1 36	1 16	1 18	1 20	1 91
1992	1 30	1 65	13 71	9 85	30 29	11 73	6 28	4 12	3 60	2 77	2 64	2 56	7 54
1993	2 62	3 47	5 93	5 90	5 40	4 32	3 68	3 55	3 63	2 10	2 16	2 12	3 74
1994	2 23	3 26	2 93	4 13	3 88	3 44	2 25	1 90	1 73	1 39	1 59	1 46	2 52
AVG	1 37	2 20	3 18	3 70	5 00	4 01	2 38	1 56	1 14	0 97	0 99	1 04	2 30

EXHIBIT 1 4

HISTORICAL MONTHLY INTERVENING FLOW (CMS)
KTD TO ABU ZEIGHAN WEIR
PERIOD WY 1954–1994

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
1954	0 11	0 12	0 11	0 11	0 25	0 15	0 08	0 07	0 08	0 07	0 07	0 08	0 11
1955	0 11	0 12	0 15	0 11	0.08	0.07	0 08	0 07	0 04	0 04	0.04	0 04	0 08
1956	0 07	0 19	0 15	0 11	0 08	0 11	0 12	0 07	0 08	0 07	0 07	0 08	0 10
1957	0 07	0 08	0 11	0 11	0 45	0 37	0 12	0 11	0 08	0 07	0 07	0 08	0 14
1958	0 07	0 08	0 11	0 15	0 45	0 07	0 08	0 07	0 08	0 07	0.07	0.08	0 12
1959	0 07	0 08	0 07	0 26	0 17	0 19	0 08	0 07	0 04	0 04	0 04	0.04	0 10
1960	0 07	0 08	0 07	0 07	0 08	0.07	0 04	0 04	0 04	0 04	0 04	0 04	0 06
1961	0 04	0 08	0 07	0 19	0 25	0 07	0 08	0.07	0 04	0 04	0 04	0 04	0 08
1962	0 04	0 08	0 34	0 22	0 33	0 11	0 04	0 04	0 04	0 07	0 07	0 08	0 12
1963	0.07	0.08	0.07	0.07	0.45	0.07	0.08	0.22	0.08	0.04	0.04	0.04	0.11
1964	0 12	0 14	0 43	0 22	0 38	0 25	0 10	0.06	0 06	0 04	0 04	0 05	0 16
1965	0 10	0 07	0 34	0 53	0 36	0 19	0 29	0 16	0 13	0 09	0 09	0 12	0.21
1966	0 07	0 03	0 04	0 04	0 04	0 53	0 08	0 06	0.06	0 05	0 04	0 05	0 09
1967	0 04	0 08	0 15	0 30	0 21	0 15	0 08	0 07	0 04	0 04	0 04	0 04	0 10
1968	0 04	0 04	0 22	0 41	0 24	0 15	0 12	0 07	0.08	0 04	0 04	0 04	0 12
1969	0.07	0.13	0 11	0 18	0 19	0 76	0 18	0 13	0 09	0 07	0 06	0 07	0 17
1970	0 09	0 09	0 09	0 16	0 12	0 21	0 10	0.09	0 08	0 07	0 11	0 12	0 11
1971	0 07	0 08	0 09	0 15	0 08	0 10	0 67	0 03	0 02	0 02	0 01	0 02	0 11
1972	0 05	0 06	0 21	0 11	0 15	0 13	0 12	0 03	0 02	0 02	0 03	0 03	0 08
1973	0 03	0 07	0 04	0 12	0 07	0 09	0 03	0 04	0 04	0 03	0 03	0 03	0 05
1974	0 03	0 08	0 06	1 21	0 69	0 33	0 21	0 11	0 07	0 05	0 04	0 05	0 24
1975	0 03	0 07	0 10	0 08	0 27	0 13	0 20	0 03	0 02	0 02	0 02	0 02	0 08
1976	0 02	0 05	0 07	0 09	0 10	0 34	0 04	0 04	0 03	0 03	0 03	0 02	0 07
1977	0 03	0 04	0 05	0 09	0 09	0 09	0 05	0 03	0 01	0 01	0 01	0 02	0 04
1978	0 08	0 03	0 15	0 15	0 07	0 18	0 05	0 02	0 00	0 01	0 01	0 01	0 06
1979	0 02	0 03	0 10	0 10	0 04	0 05	0 02	0 01	0 01	0 01	0 01	0 01	0 03
1980	0 39	1 13	1 03	0 40	0 24	0 77	0 10	0 07	0 07	0 06	0 06	0 05	0 36
1981	0 04	0 05	0 79	0 14	0 23	0 16	0 10	0 06	0 05	0 05	0 06	0 05	0 15
1982	0 06	0 07	0 07	0 08	0 24	0 15	0 51	0 33	0 05	0 04	0 04	0 04	0 14
1983	0 06	0 09	0 09	0 29	0 48	0 64	0 16	0 14	0 14	0 11	0 13	0 13	0 21
1984	0 09	0 10	0 09	0 14	0 11	0 18	0 10	0 09	0 07	0 05	0 06	0 07	0 10
1985	0 11	0 25	0 24	0 09	0 74	0 25	0 14	0 08	0 03	0 03	0 03	0 05	0 17
1986	0 05	0 07	0 11	0 12	0 15	0 14	0 08	0 05	0 03	0 03	0 03	0 03	0 07
1987	0 06	0 10	0 16	0 18	0 21	0 19	0 12	0 07	0 05	0 04	0 04	0 05	0 11
1988	0 14	0 22	0 34	0 38	0 44	0 41	0 25	0 15	0 10	0 09	0 09	0 10	0 22
1989	0 07	0 12	0 18	0 20	0 24	0 22	0 13	0 08	0 05	0 05	0 05	0 05	0 12
1990	0 07	0 12	0 18	0 20	0 24	0 22	0 13	0 08	0 05	0 05	0 05	0 05	0 12
1991	0 07	0 11	0 17	0 18	0 22	0 20	0 12	0 07	0 05	0 04	0 04	0 05	0 11
1992	0 26	0 42	0 64	0 72	0 83	0 79	0 47	0 29	0 19	0 17	0 17	0 18	0 43
1993	0 13	0 21	0 32	0 36	0 43	0 40	0 23	0 15	0 10	0 08	0 09	0 09	0 22
1994	0 09	0 14	0 22	0 24	0 29	0 27	0 16	0 10	0 07	0 06	0 06	0 06	0 15
AVG	0 08	0 13	0 20	0 22	0 26	0 24	0 14	0 09	0 06	0 05	0 05	0 06	0 13

EXHIBIT 1 5

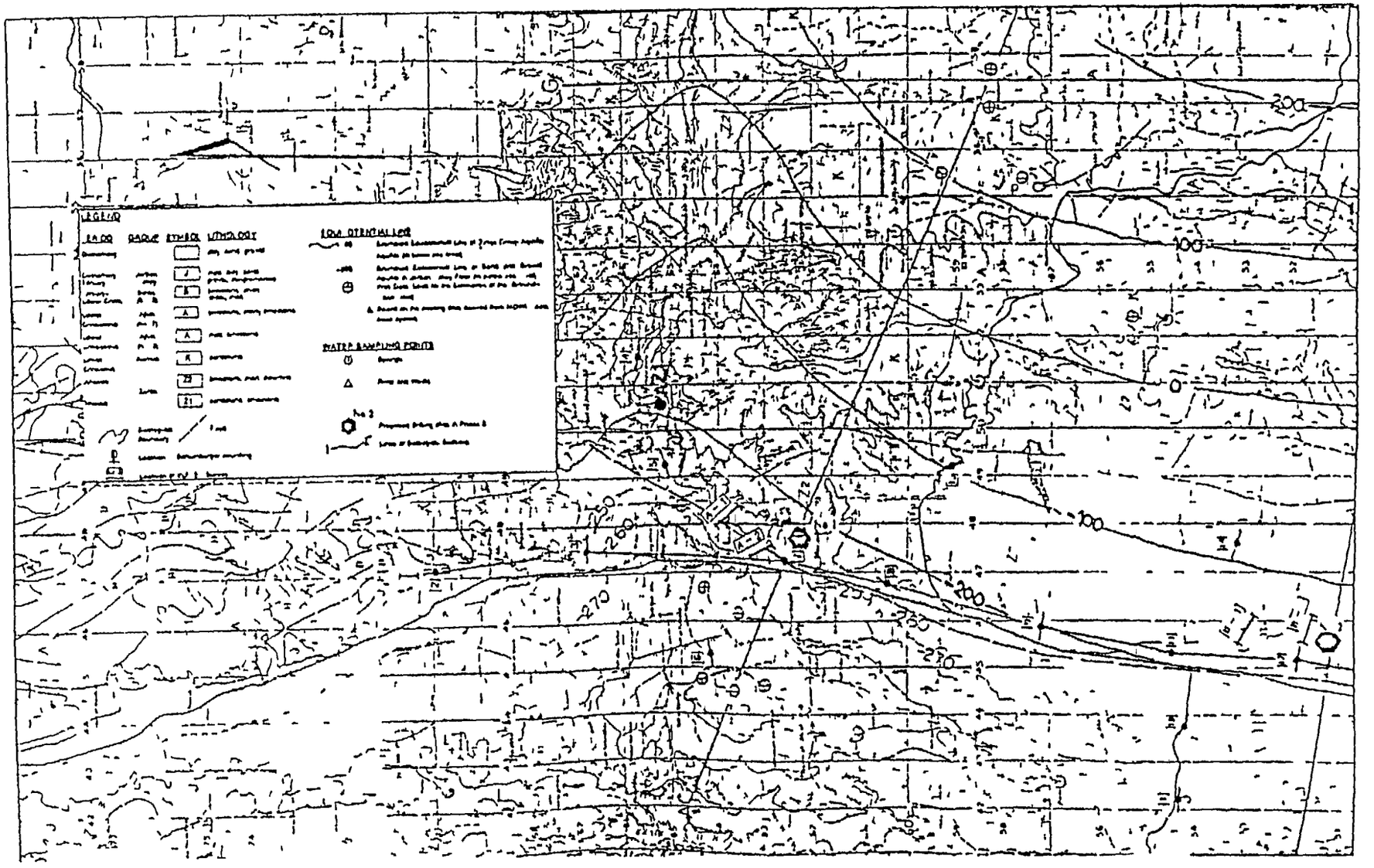
HISTORICAL MONTHLY INTERVENING FLOW (CMS)
KTD TO THAHAB WEIR
PERIOD WY 1954–1994

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
1954	0 08	0 08	0 08	0 08	0 17	0 10	0 05	0 05	0 05	0 05	0 05	0 05	0 08
1955	0 08	0 08	0 10	0 08	0 06	0 05	0 05	0 05	0 03	0 03	0 03	0 03	0 06
1956	0 05	0 14	0 10	0 08	0 06	0 08	0 08	0 05	0 05	0 05	0 05	0 05	0 07
1957	0 05	0 05	0 08	0 08	0 32	0 26	0 08	0 08	0 05	0 05	0 05	0 05	0 10
1958	0 05	0 05	0 08	0 10	0 32	0 05	0 05	0 05	0 05	0 05	0.05	0 05	0.08
1959	0 05	0 05	0 05	0 18	0.12	0 13	0 05	0 05	0 03	0 03	0 03	0 03	0 07
1960	0 05	0 05	0.05	0 05	0 06	0 05	0 03	0 03	0 03	0 03	0 03	0 03	0 04
1961	0 03	0 05	0 05	0 13	0 17	0 05	0 05	0 05	0 03	0 03	0 03	0 03	0 06
1962	0 03	0 05	0 24	0 16	0 23	0 08	0 03	0 03	0 03	0 05	0 05	0 05	0 09
1963	0 05	0 05	0 05	0 05	0 32	0 05	0 05	0 16	0 05	0 03	0 03	0 03	0 08
1964	0 08	0 10	0 30	0 15	0 27	0 17	0 07	0 04	0 04	0 03	0 03	0 03	0 11
1965	0 07	0 05	0 24	0 37	0 25	0 13	0 21	0 11	0 09	0 06	0 07	0 09	0 14
1966	0 05	0 02	0 03	0 03	0 03	0 37	0 06	0 04	0.04	0 03	0 03	0 04	0 06
1967	0 03	0 05	0 10	0 21	0 14	0 10	0 05	0 05	0 03	0 03	0 03	0 03	0 07
1968	0 03	0 03	0 16	0 29	0 17	0 10	0 08	0 05	0 05	0 03	0 03	0 03	0 09
1969	0 05	0 09	0 08	0 12	0 13	0 53	0 12	0 09	0 06	0 05	0 04	0.05	0 12
1970	0 06	0 06	0 06	0 11	0 08	0 15	0 07	0 06	0.06	0.05	0 08	0 08	0 08
1971	0 05	0 05	0 07	0 10	0 06	0 07	0 47	0 02	0 02	0 01	0 01	0 02	0 08
1972	0 03	0 04	0 14	0 08	0 10	0 09	0 09	0 02	0 01	0 02	0 02	0 02	0 06
1973	0 02	0 05	0 03	0 08	0 05	0 06	0 02	0 03	0 03	0 02	0 02	0 02	0 04
1974	0 02	0 06	0 04	0 85	0 48	0 23	0 15	0 08	0 05	0 04	0 03	0 03	0 17
1975	0 02	0 05	0 07	0 06	0 19	0 09	0 14	0 02	0 01	0 01	0 01	0 01	0 06
1976	0 01	0 04	0 05	0 06	0 07	0 24	0 03	0 03	0 02	0 02	0 02	0 02	0 05
1977	0 02	0 03	0 03	0 06	0 06	0 06	0 04	0 02	0 01	0 01	0 01	0 01	0 03
1978	0 05	0 02	0 10	0 11	0 05	0 13	0 03	0 02	0 00	0 01	0 01	0 01	0 04
1979	0 01	0 02	0 07	0 07	0 03	0 03	0 01	0 01	0 01	0 01	0 01	0 01	0 02
1980	0 27	0 79	0 72	0 28	0 17	0 54	0 07	0 05	0 05	0 04	0 04	0 04	0 25
1981	0 03	0 04	0 55	0 10	0 16	0 11	0 07	0 04	0 03	0 04	0 04	0 04	0 10
1982	0 04	0 05	0 05	0 06	0 17	0 10	0 35	0 23	0 04	0 03	0 03	0 03	0 10
1983	0 04	0 06	0 06	0 20	0 34	0 45	0 11	0 10	0 10	0 08	0 09	0 09	0 14
1984	0 06	0 07	0 07	0 10	0 08	0 12	0 07	0 07	0 05	0 04	0 04	0 05	0 07
1985	0 08	0 18	0 17	0 06	0 52	0 18	0 10	0 05	0 02	0 02	0 02	0 04	0 12
1986	0 03	0 05	0 08	0 09	0 10	0 10	0 06	0 04	0 02	0 02	0 02	0 02	0 05
1987	0 05	0 07	0 11	0 12	0 15	0 14	0 08	0 05	0 03	0 03	0 03	0 03	0 07
1988	0 10	0 15	0 24	0 26	0 31	0 29	0 17	0 11	0 07	0 06	0 06	0 07	0 16
1989	0 05	0 08	0 13	0 14	0 17	0 15	0 09	0 06	0 04	0 03	0 03	0 04	0 08
1990	0 05	0 08	0 13	0 14	0 17	0 15	0 09	0 06	0 04	0 03	0 03	0 04	0 08
1991	0 05	0 07	0 12	0 13	0 15	0 14	0 08	0 05	0 03	0 03	0 03	0 03	0 08
1992	0 18	0 29	0 45	0 50	0 58	0 55	0 33	0 20	0 13	0 12	0 12	0 13	0 30
1993	0 09	0 15	0 23	0 25	0 30	0 28	0 16	0 10	0 07	0 06	0 06	0 07	0 15
1994	0 06	0 10	0 15	0 17	0 20	0 19	0 11	0 07	0 05	0 04	0 04	0 04	0 10
AVG	0 06	0 09	0 14	0 15	0 18	0 17	0 10	0 06	0 04	0 04	0 04	0 04	0 09

EXHIBIT 1 6

HISTORICAL MONTHLY INTERVENING FLOW (CMS)
KTD TO HWARET WEIR
PERIOD WY 1954-1994

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
1954	0 10	0 11	0 10	0 10	0 23	0 14	0 07	0 07	0 07	0 07	0 07	0 07	0 10
1955	0 10	0 11	0 14	0 10	0 08	0 07	0 07	0 07	0 04	0 03	0 03	0 04	0 07
1956	0.07	0 18	0 14	0 10	0 07	0 10	0 11	0 07	0 07	0 07	0 07	0 07	0 09
1957	0 07	0 07	0 10	0.10	0 43	0 35	0 11	0 10	0 07	0 07	0 07	0 07	0 14
1958	0 07	0 07	0 10	0 14	0 43	0.07	0 07	0 07	0 07	0 07	0 07	0 07	0 11
1959	0 07	0 07	0 07	0 24	0 15	0 17	0 07	0 07	0 04	0 03	0 03	0 04	0 09
1960	0 07	0 07	0 07	0 07	0 07	0 07	0 04	0 03	0 04	0 03	0 03	0 04	0 05
1961	0 03	0 07	0 07	0 17	0 23	0 07	0 07	0 07	0 04	0 03	0 03	0 04	0 08
1962	0 03	0 07	0 31	0 21	0 31	0 10	0 04	0 03	0 04	0 07	0 07	0 07	0 11
1963	0 07	0 07	0 07	0 07	0 43	0 07	0 07	0 21	0 07	0 03	0 03	0 04	0 10
1964	0 11	0 13	0 40	0 20	0 35	0 23	0 10	0 06	0 06	0 04	0 04	0 04	0 15
1965	0 10	0 06	0 32	0 50	0 33	0 17	0 27	0 15	0 12	0 08	0 09	0 12	0 19
1966	0 06	0.03	0 04	0 04	0 04	0.50	0 08	0 06	0 05	0 05	0 04	0 05	0 09
1967	0 03	0 07	0 14	0 28	0 19	0 14	0 07	0 07	0 04	0 03	0 03	0 04	0 10
1968	0 03	0 04	0 21	0 38	0 22	0 14	0 11	0 07	0 07	0 03	0 03	0 04	0 12
1969	0.06	0.12	0.10	0 16	0 17	0 71	0 17	0 12	0 08	0.07	0 05	0 07	0 16
1970	0 08	0 09	0 08	0 15	0 11	0.20	0 09	0 08	0 08	0 07	0 10	0 11	0 10
1971	0.07	0 07	0 09	0 14	0 08	0 09	0 63	0 03	0 02	0 02	0 01	0 02	0 11
1972	0 05	0 06	0 19	0 10	0 14	0 12	0 12	0 03	0 02	0 02	0 03	0 03	0.07
1973	0 03	0 06	0 04	0 11	0 06	0 08	0 03	0 03	0 04	0 03	0 03	0 03	0 05
1974	0.02	0 08	0 06	1 13	0 64	0 31	0 19	0 10	0 06	0 05	0 04	0 04	0 23
1975	0 03	0 06	0 09	0 08	0 25	0 12	0 18	0 03	0 02	0 02	0 02	0 02	0 08
1976	0 02	0 05	0 07	0 08	0 10	0 31	0 04	0 03	0 03	0 03	0 02	0 02	0 07
1977	0 03	0 04	0 05	0 08	0 08	0 08	0 05	0 03	0 01	0 01	0 01	0 02	0 04
1978	0 07	0 03	0 14	0 14	0 07	0 17	0 04	0 02	0 00	0 01	0 01	0 01	0 06
1979	0 02	0 03	0 09	0 09	0 04	0 05	0 02	0 01	0 01	0 01	0 01	0 01	0 03
1980	0 37	1 06	0 96	0 37	0 23	0 72	0 09	0 06	0 06	0 06	0 05	0 05	0 34
1981	0 03	0 05	0 74	0 13	0 21	0 15	0 09	0 06	0 04	0 05	0 06	0 05	0 14
1982	0 05	0 06	0 06	0 08	0 22	0 14	0 47	0 31	0 05	0 04	0 04	0 04	0 13
1983	0 06	0 08	0 08	0 27	0 45	0 60	0 15	0 13	0 13	0 10	0 13	0 12	0 19
1984	0 08	0 10	0 09	0 13	0 10	0 16	0 09	0 09	0 06	0 05	0 06	0 06	0 09
1985	0 10	0 24	0 22	0 08	0 70	0 24	0 13	0 07	0 03	0 03	0 03	0 05	0 16
1986	0 04	0 07	0 10	0 12	0 14	0 13	0 08	0 05	0 03	0 03	0 03	0 03	0 07
1987	0 06	0 10	0 15	0 17	0 20	0 18	0 11	0 07	0 04	0 04	0 04	0 04	0 10
1988	0 13	0 21	0 32	0 35	0 41	0 39	0 23	0 14	0 09	0 08	0 09	0 09	0 21
1989	0 07	0 11	0 17	0 19	0 23	0 21	0 12	0 08	0 05	0 04	0 05	0 05	0 11
1990	0 07	0 11	0 17	0 19	0 23	0 21	0 12	0 08	0 05	0 04	0 05	0 05	0 11
1991	0 06	0 10	0 15	0 17	0 21	0 19	0 11	0 07	0 05	0 04	0 04	0 04	0 10
1992	0 24	0 39	0 60	0 67	0 78	0 73	0 44	0 27	0 18	0 16	0 16	0 17	0 40
1993	0 12	0 20	0 30	0 34	0 41	0 37	0 22	0 14	0 09	0 08	0 08	0 09	0 20
1994	0 08	0 13	0 20	0 23	0 27	0 25	0 15	0 09	0 06	0 05	0 05	0 06	0 14
AVG	0 08	0 12	0 19	0 21	0 25	0 23	0 13	0 08	0 06	0 05	0 05	0 05	0 12



JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

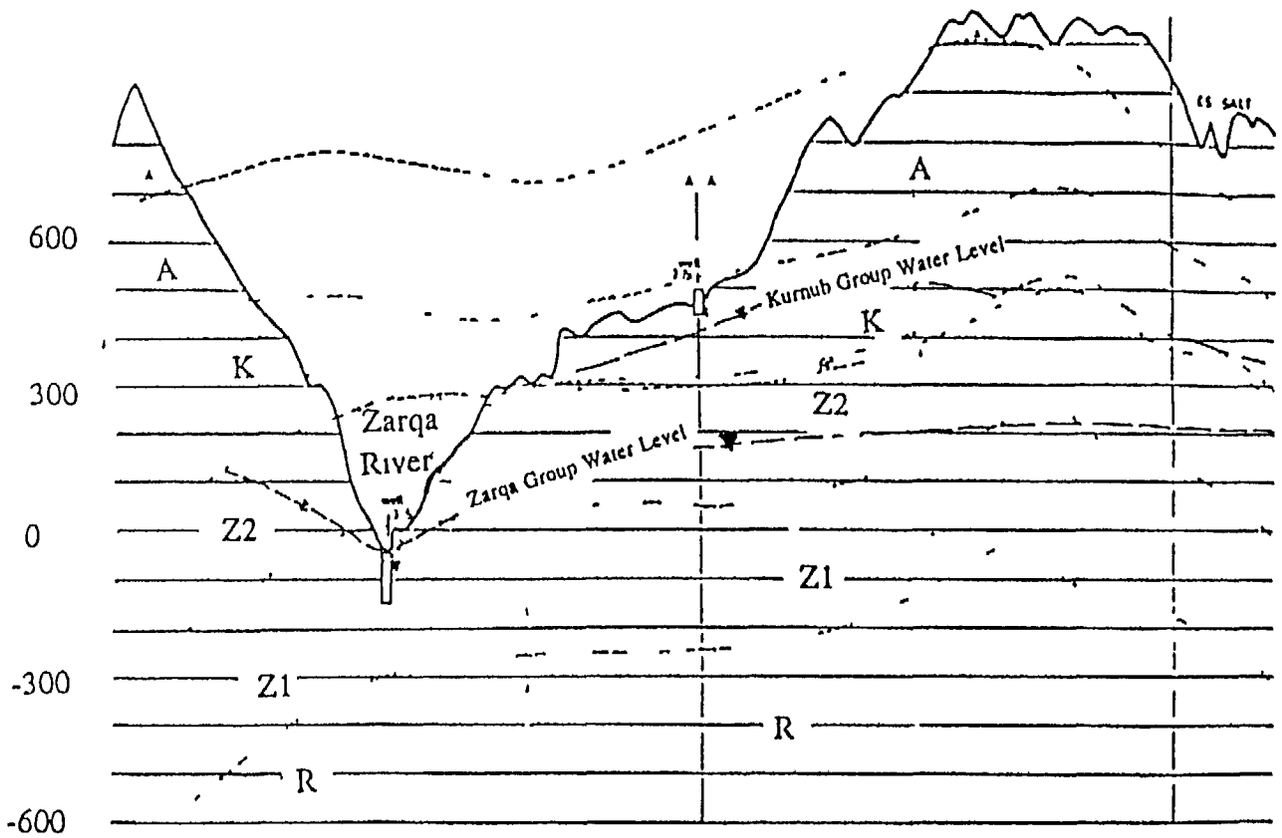
GROUNDWATER EQUIPOTENTIAL LINES
OF THE ZARQA GROUP AQUIFER SYSTEMS

EXHIBIT 1 7

JORDAN WATER QUALITY IMPROVEMENT AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

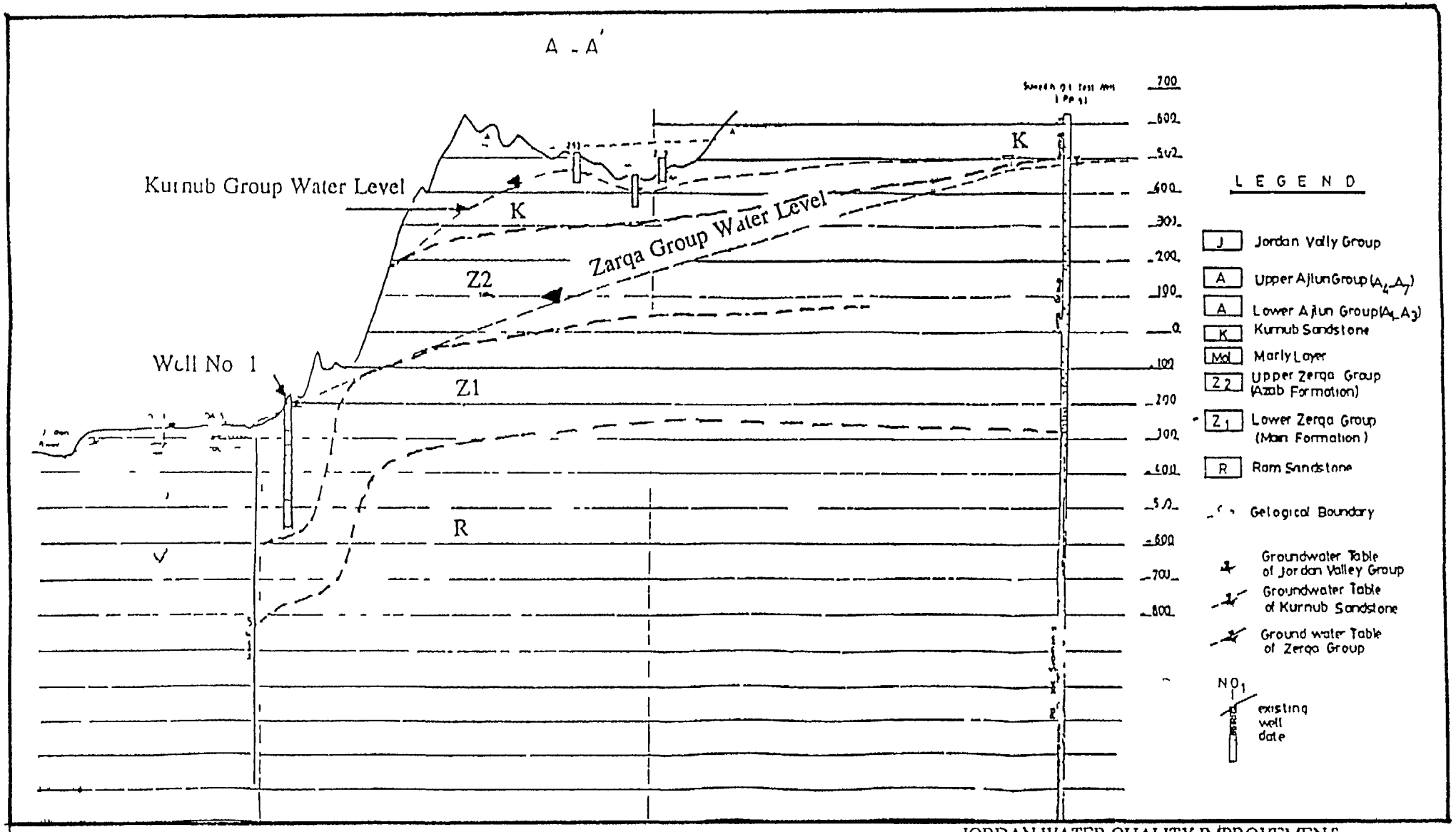
HYDROGEOLOGICAL CROSS SECTION



LEGEND

- A — Upper Ajlun Group (A_4 - A_7)
- A — Lower Ajlun Group (A_1 - A_3)
- K — Kurnub Sandstone
- Mrl — Marly Layer
- Z_2 — Upper Zerqa Group (Azab Formation)
- Z_1 — Lower Zerqa Group (Main Formation)
  - Z_1 Dol — Dolomite Layer
  - Z_1 Dol/Shl — Alternation of Dolomite and Shale
  - Z_1 Shl — Shale Layer
- R — Ram Sandstone
- Geological Boundary
- Groundwater Table of Kurnub Sandstone
- Groundwater Table of Zerqa Group
- NO_1 — existing well data

EXHIBIT 18

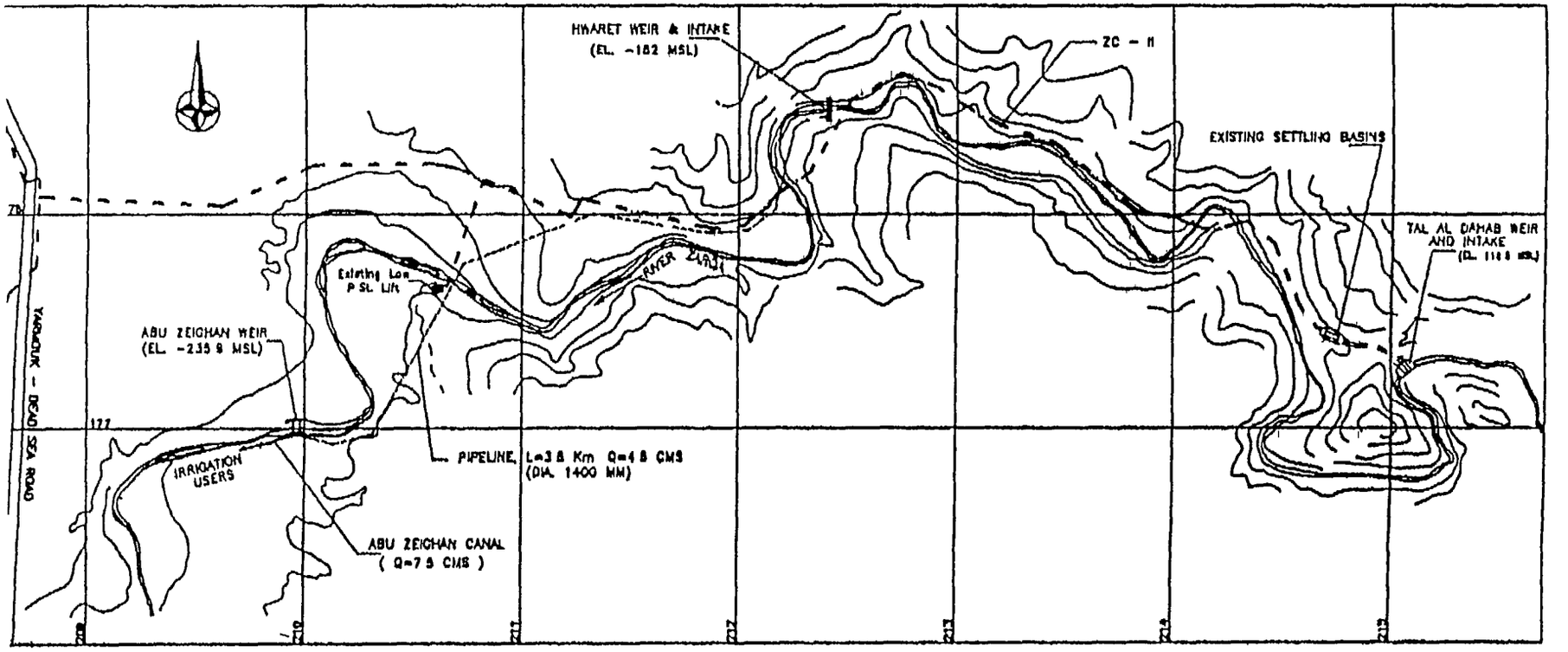


JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

HYDROGEOLOGICAL CROSS SECTION

EXHIBIT 19



JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

LOCATION OF PIPELINE ROUTE

EXHIBIT 1 10

Monthly EC Values

Zarqa River

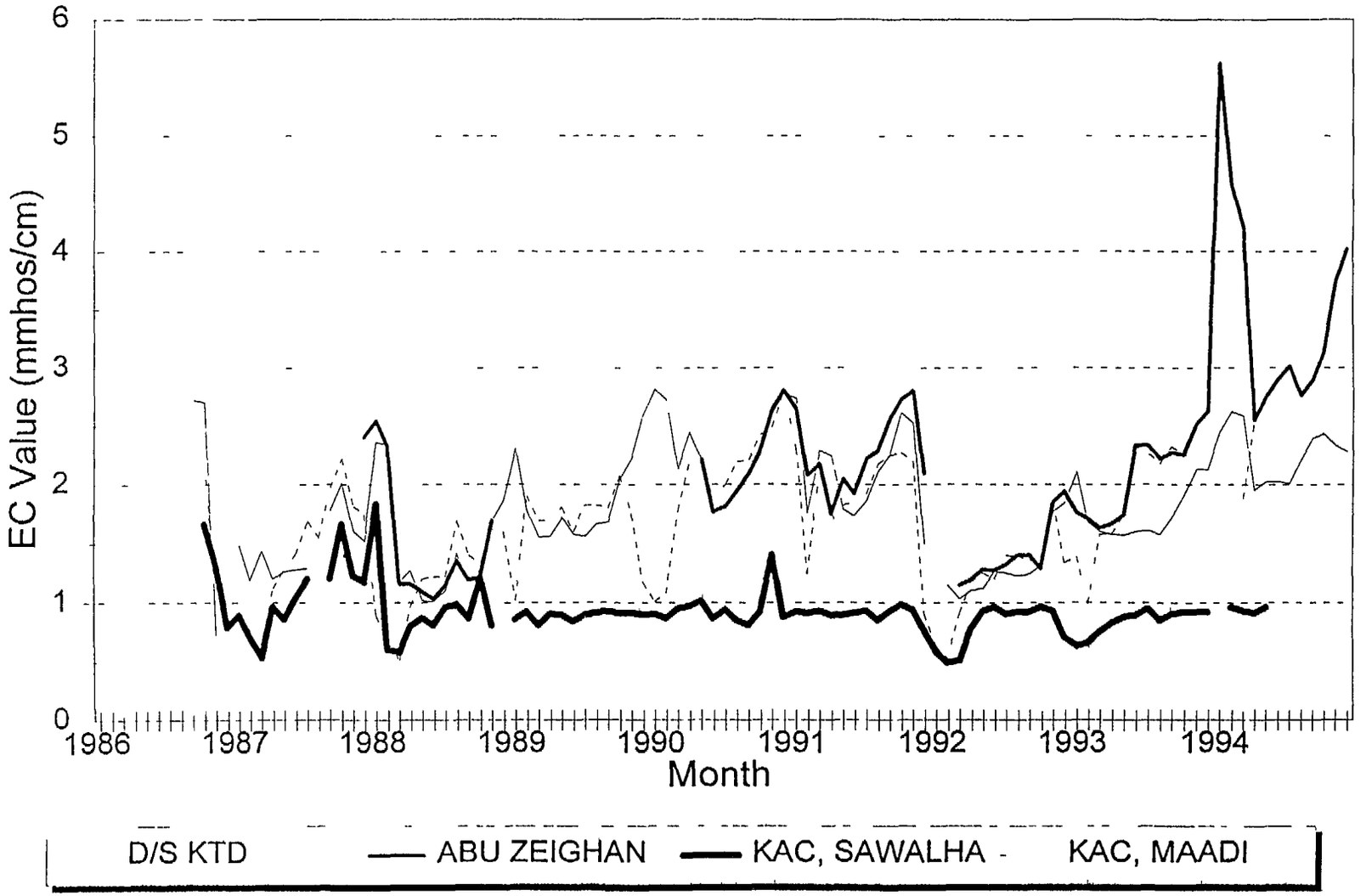
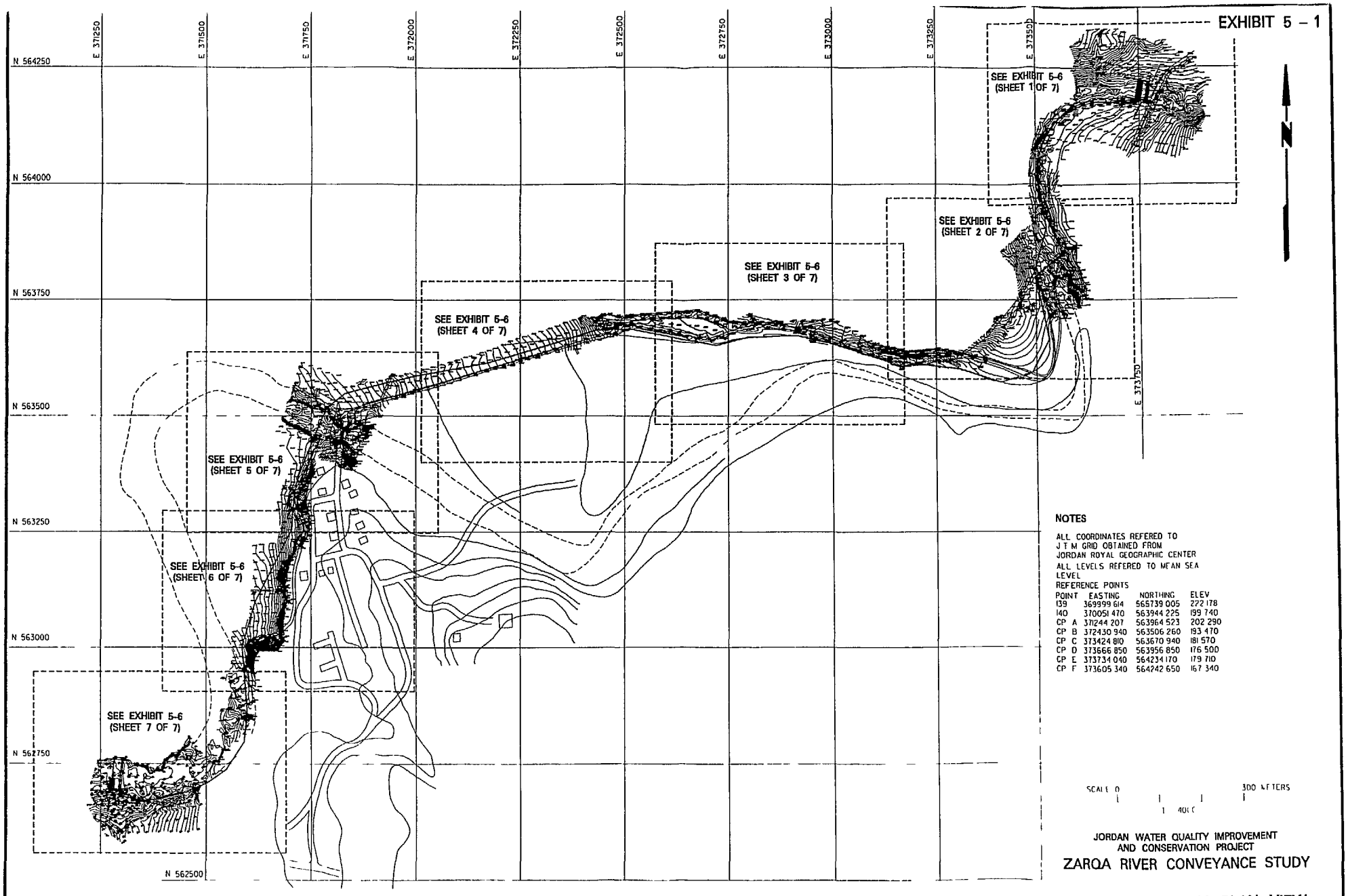


EXHIBIT 21

EXHIBIT 5 – 1



NOTES

ALL COORDINATES REFERED TO J T M GRID OBTAINED FROM JORDAN ROYAL GEOGRAPHIC CENTER

ALL LEVELS REFERED TO MEAN SEA LEVEL

REFERENCE POINTS

POINT	EASTING	NORTHING	ELEV
139	369999 614	565739 005	272 178
140	370051 470	563944 225	199 740
CP A	371244 207	563964 523	202 290
CP B	372430 940	563506 260	193 470
CP C	373424 810	563670 940	181 570
CP D	373666 850	563956 850	176 500
CP E	373734 040	564234 170	179 710
CP F	373605 340	564242 650	167 340

SCALE 0 300 METERS

JORDAN WATER QUALITY IMPROVEMENT AND CONSERVATION PROJECT

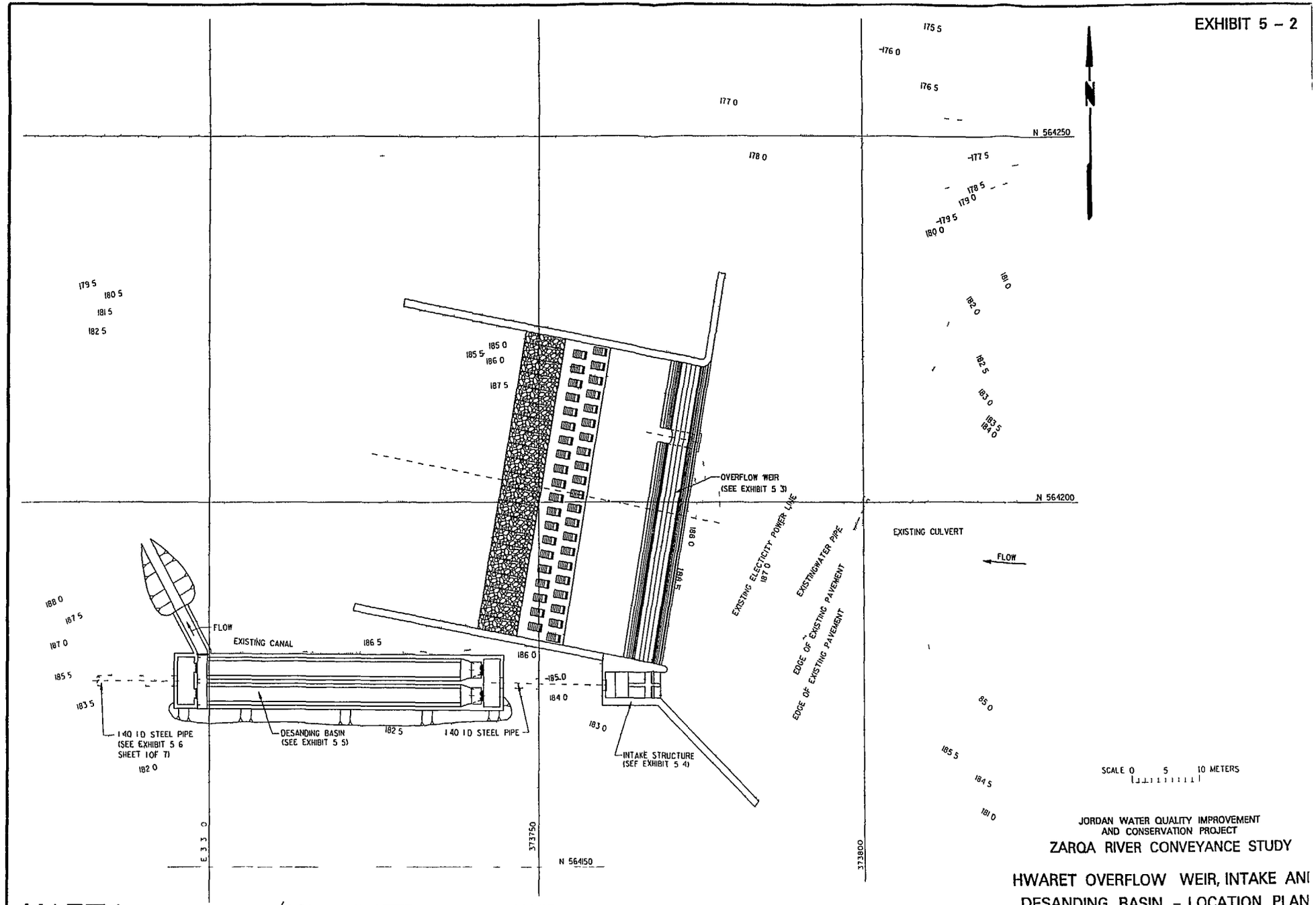
ZARQA RIVER CONVEYANCE STUDY

PROJECT GENERAL PLAN VIEW

HARZA ENGINEERING COMPANY / CONSOLIDATED CONSULTANTS AMMAN JORDAN APRIL 1996

BEST AVAILABLE COPY

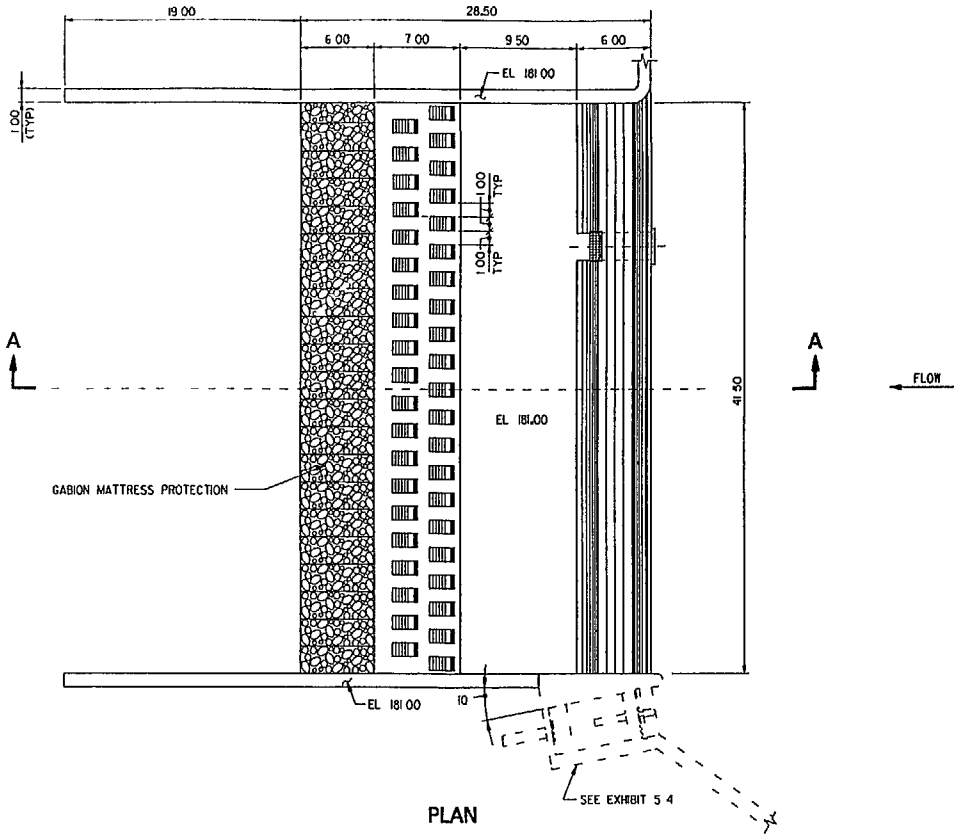
EXHIBIT 5 – 2



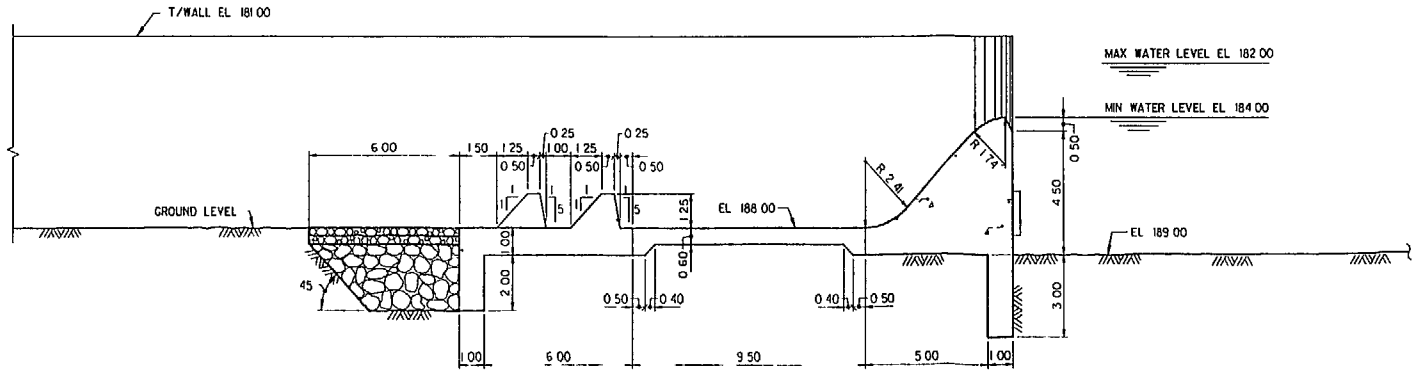
HARZA ENGINEERING COMPANY/CONSOLIDATED CONSULTANTS AMMAN JORDAN APRIL 1996

BEST AVAILABLE COPY

EXHIBIT 5 – 3



PLAN



SECTION A – A

SCALE 0 2 METERS

SCALE 0 5 10 METERS

EXCEPT AS NOTED

JORDAN WATER QUALITY IMPROVEMENT AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

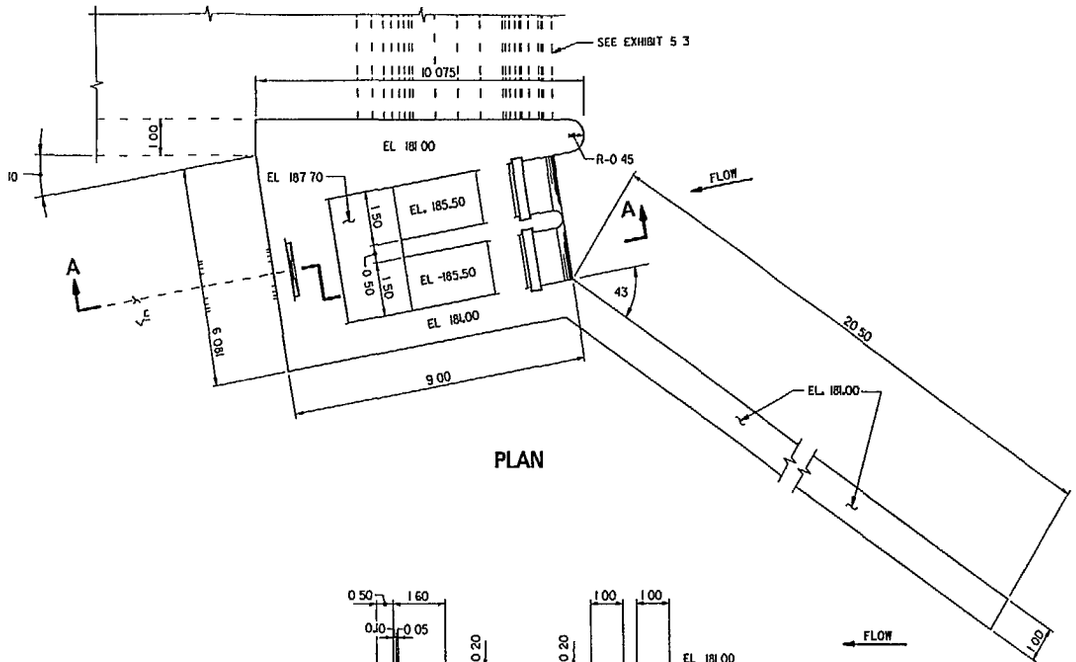
HWARET OVERFLOW WEIR PLAN AND SECTION

HARZA ENGINEERING COMPANY / CONSOLIDATED CONSULTANTS AMMAN-JORDAN APRIL 1996

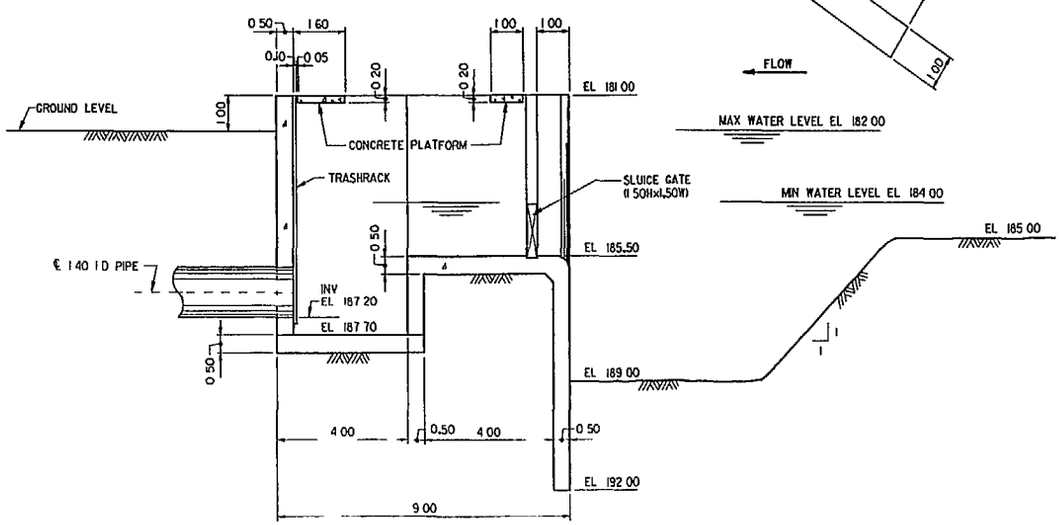
FILE \dgn\5702g\ dg

BEST AVAILABLE COPY

EXHIBIT 5 - 4



PLAN



A - A

SCALE 0 1 2 3 4 5 METERS

JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

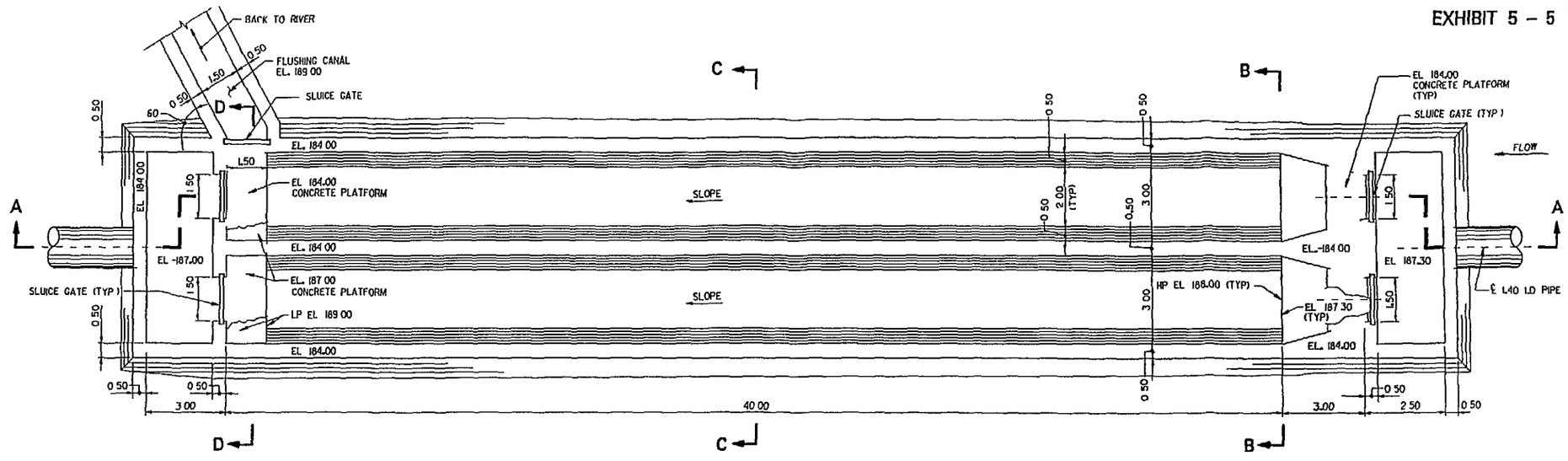
INTAKE STRUCTURE
PLAN AND SECTION

HARZA ENGINEERING COMPANY/CONSOLIDATED CONSULTANTS AMMAN JORDAN APRIL 1996

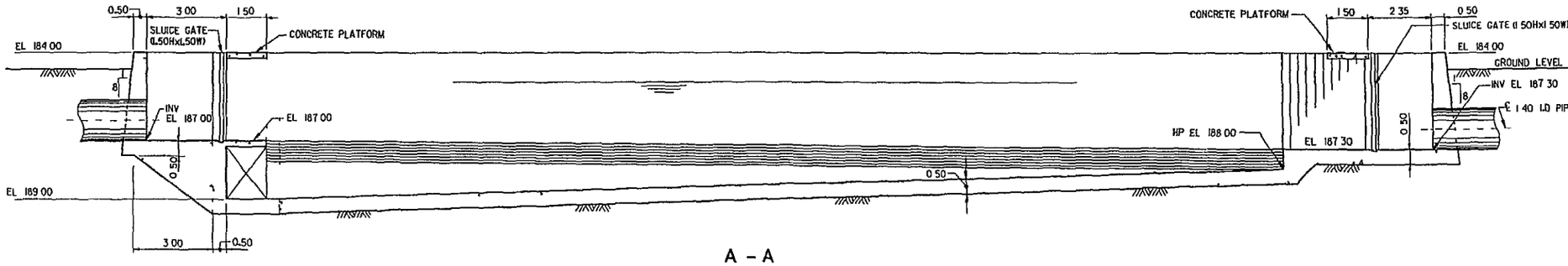
F \dgn 5707g 1 dgn

BEST AVAILABLE COPY

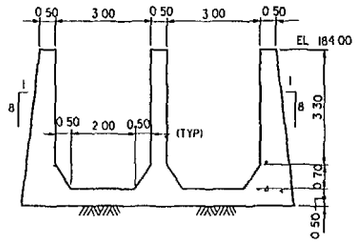
EXHIBIT 5 – 5



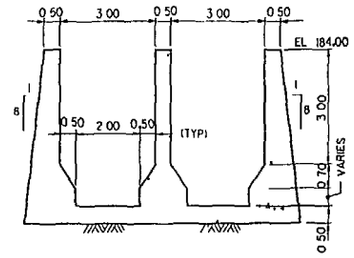
PLAN



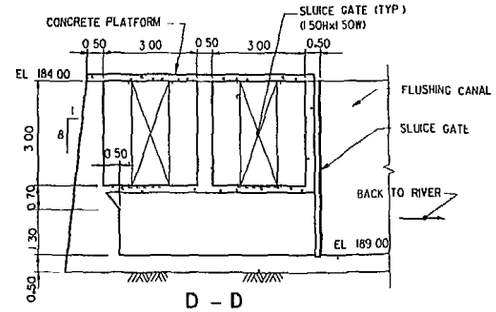
A – A



B – B



C – C



D – D

SCALE 0 1 2 3 4 5 METERS

JORDAN WATER QUALITY IMPROVEMENT AND CONSERVATION PROJECT

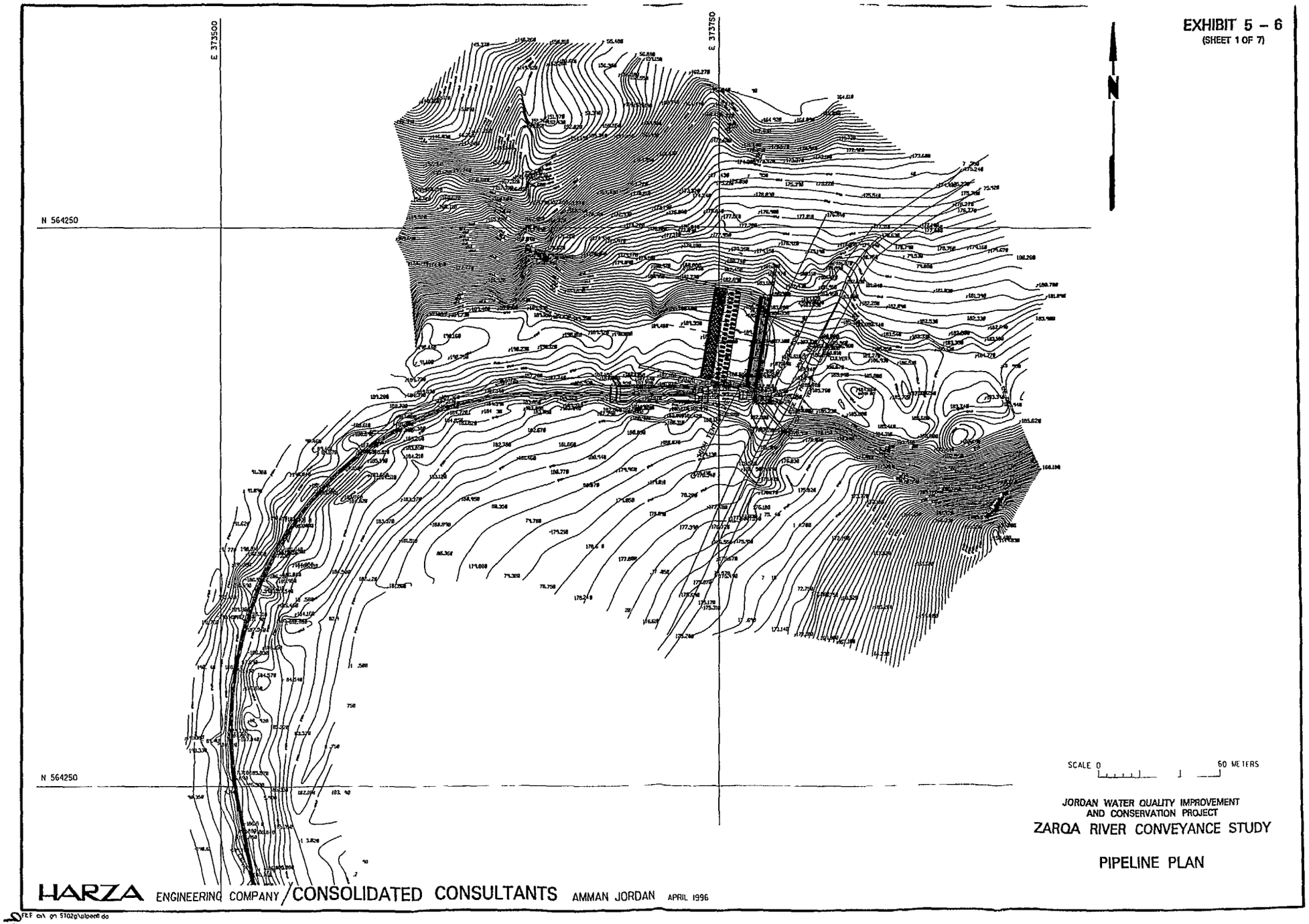
ZARQA RIVER CONVEYANCE STUDY

DESANDING BASIN
PLAN AND SECTION

HARZA ENGINEERING COMPANY/CONSOLIDATED CONSULTANTS AMMAN JORDAN APRIL 1996

BEST AVAILABLE COPY

EXHIBIT 5 – 6
(SHEET 1 OF 7)



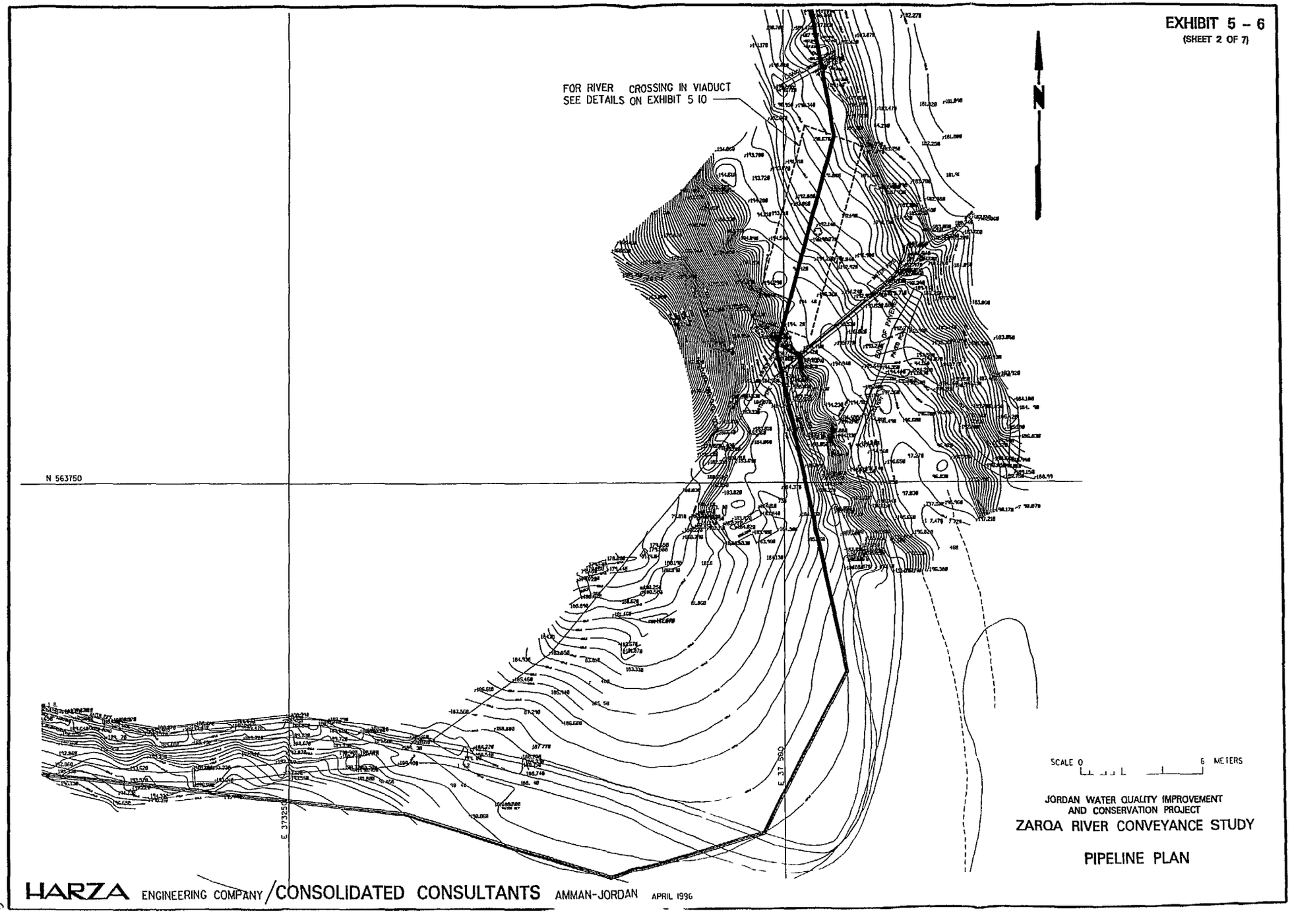
JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

PIPELINE PLAN

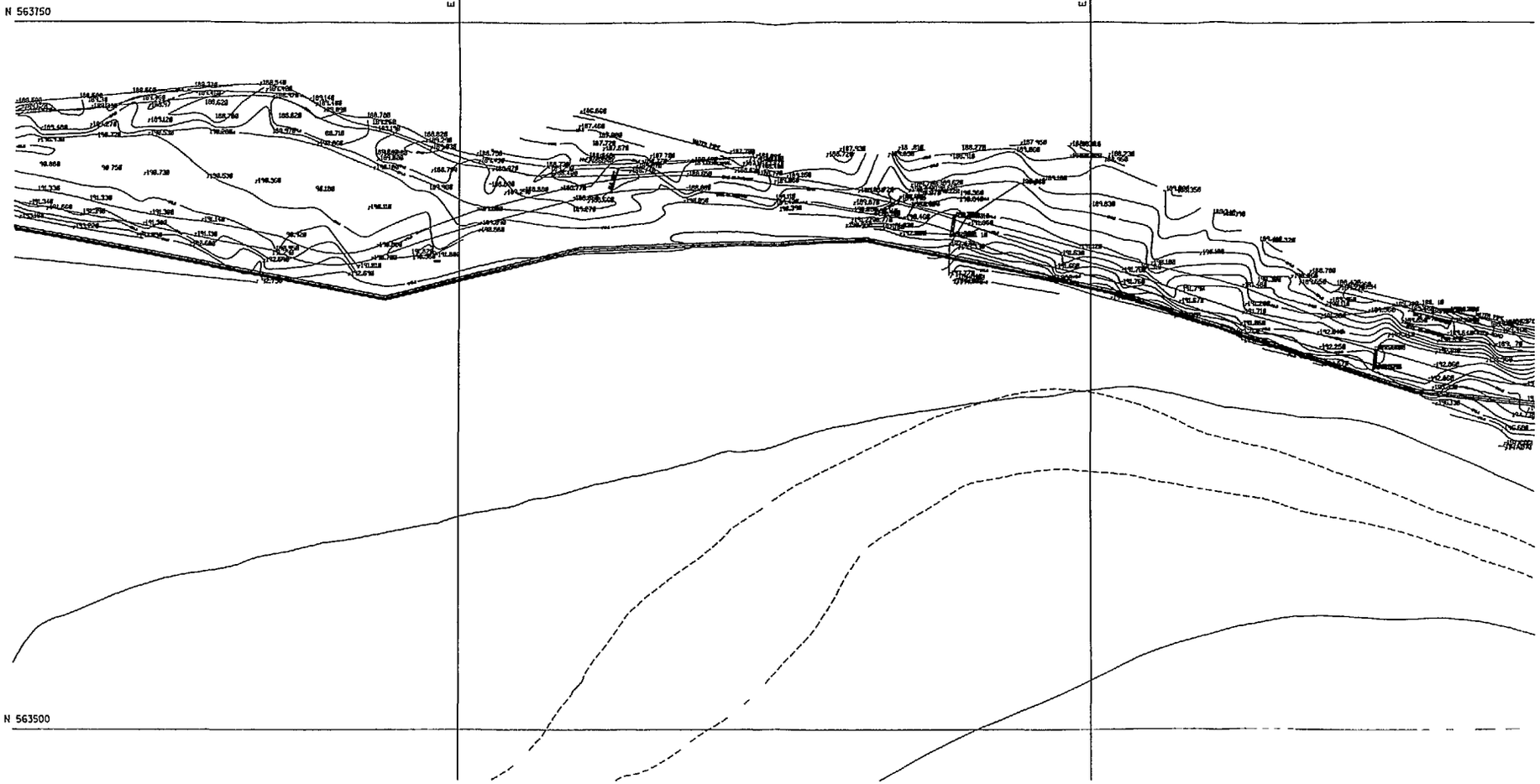
HARZA ENGINEERING COMPANY / CONSOLIDATED CONSULTANTS AMMAN JORDAN APRIL 1996

BEST AVAILABLE COPY



BEST AVAILABLE COPY

EXHIBIT 5 – 6
(SHEET 3 OF 7)



SCALE 0 60 METERS

JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

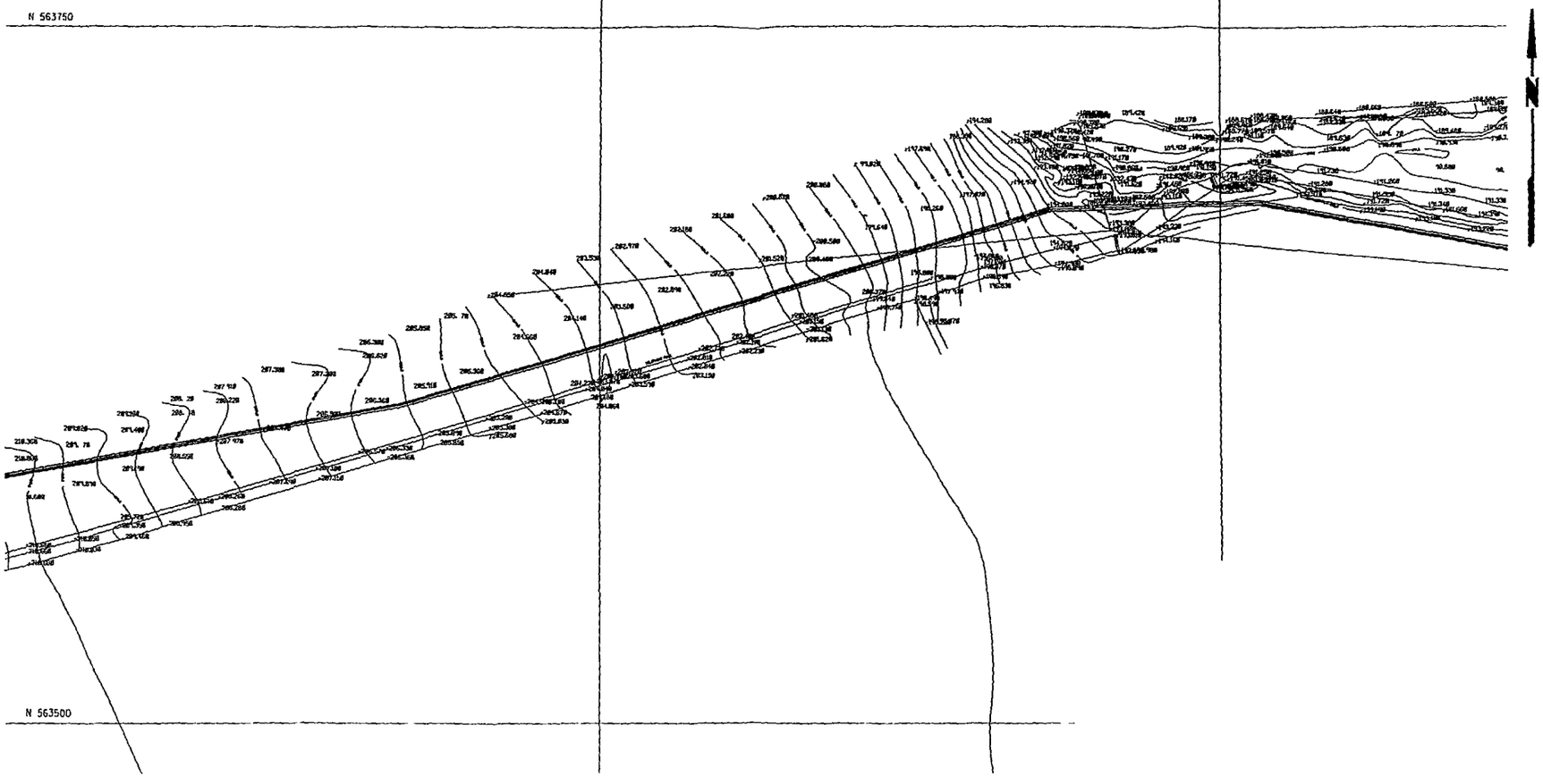
ZARQA RIVER CONVEYANCE STUDY

PIPE LINEPLAN

HARZA ENGINEERING COMPANY / CONSOLIDATED CONSULTANTS AMMAN-JORDAN APRIL 1996

BEST AVAILABLE COPY

EXHIBIT 5 – 6
(SHEET 4 OF 7)



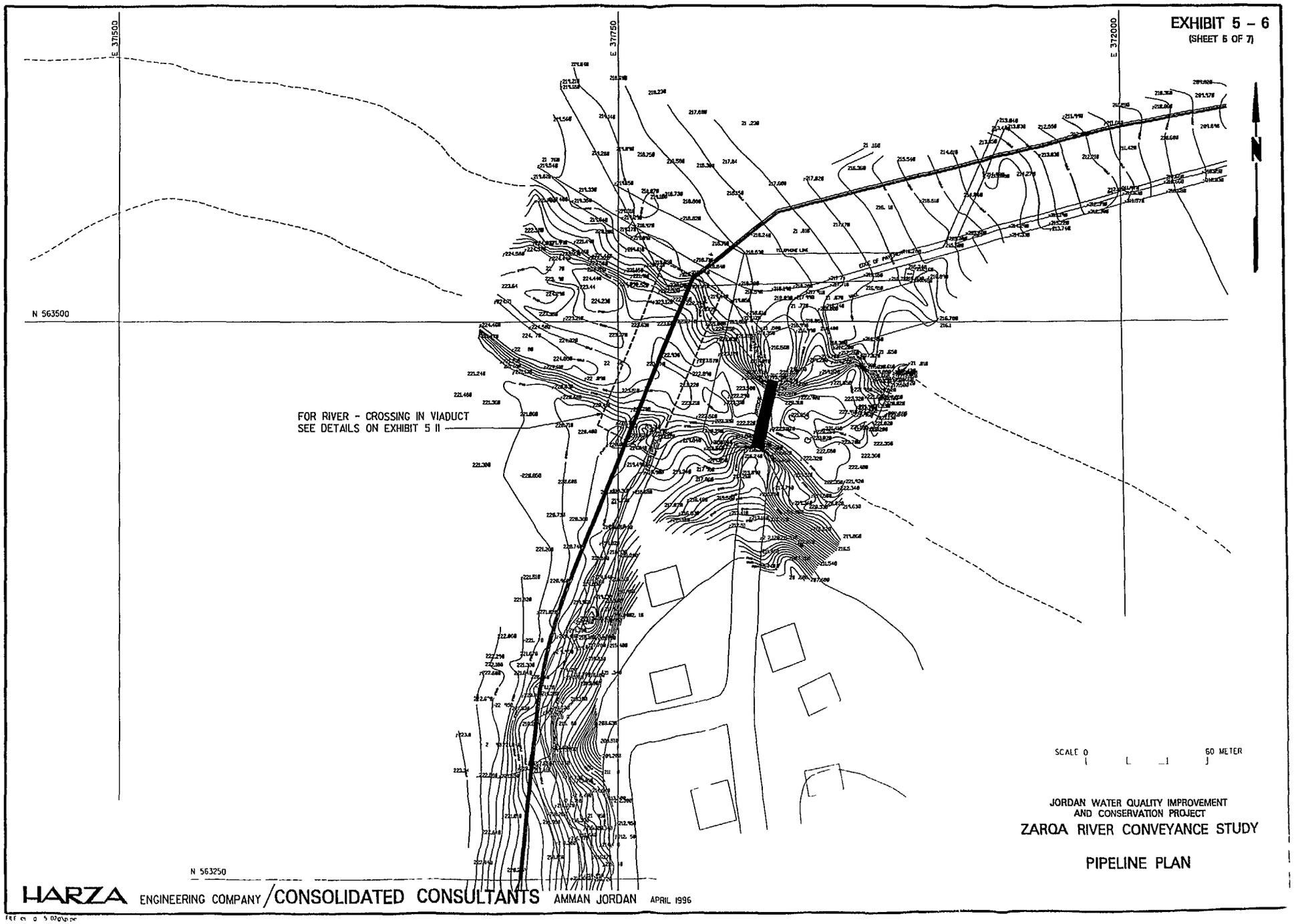
SCALE 0 60 METERS

JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

PIPELINE PLAN

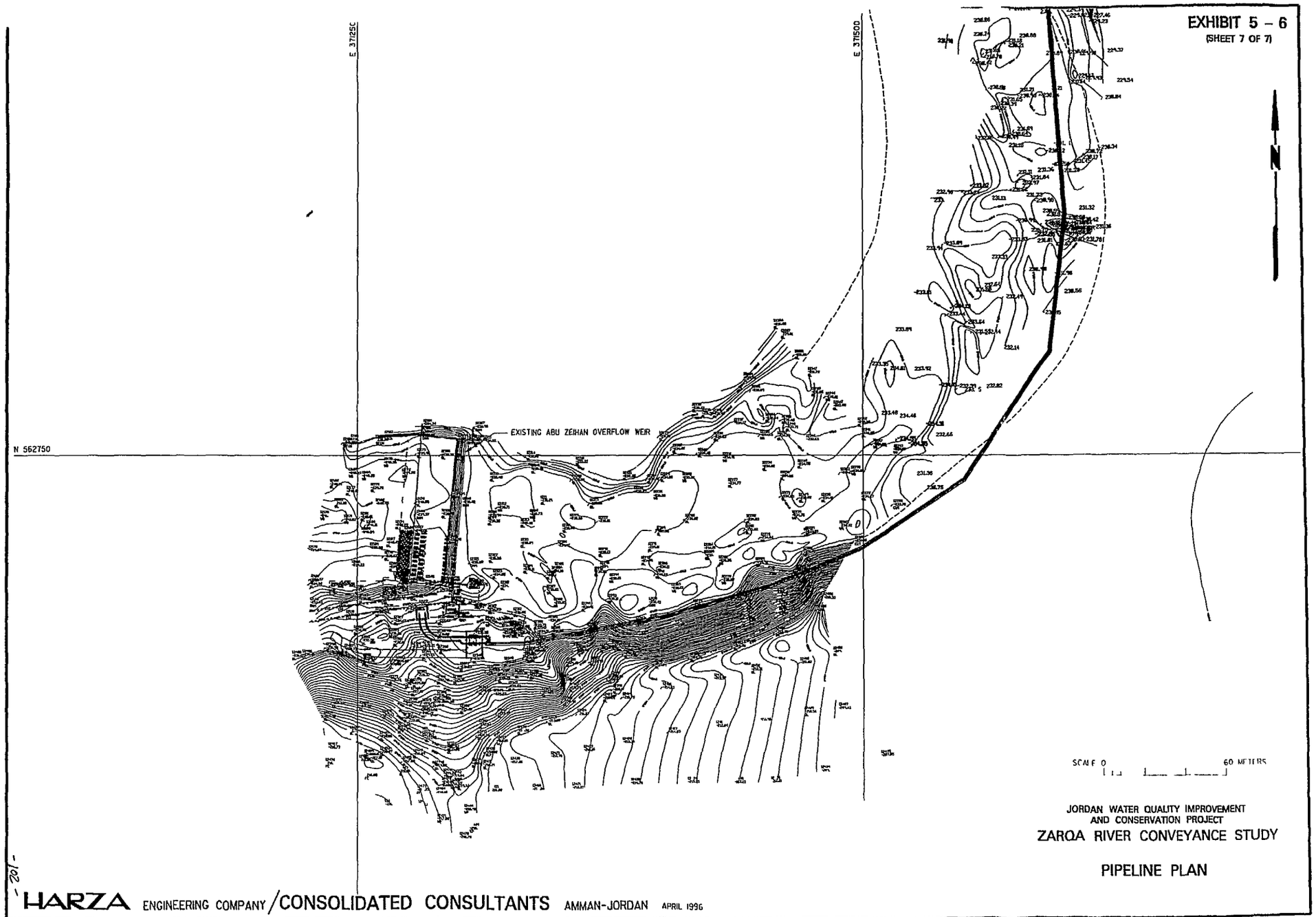
BEST AVAILABLE COPY



BEST AVAILABLE COPY

FILE c:\dgn\5702g\plpepl6.dgn
DATE 8 Apr 9 13:4 bo t v1.1

BEST AVAILABLE COPY



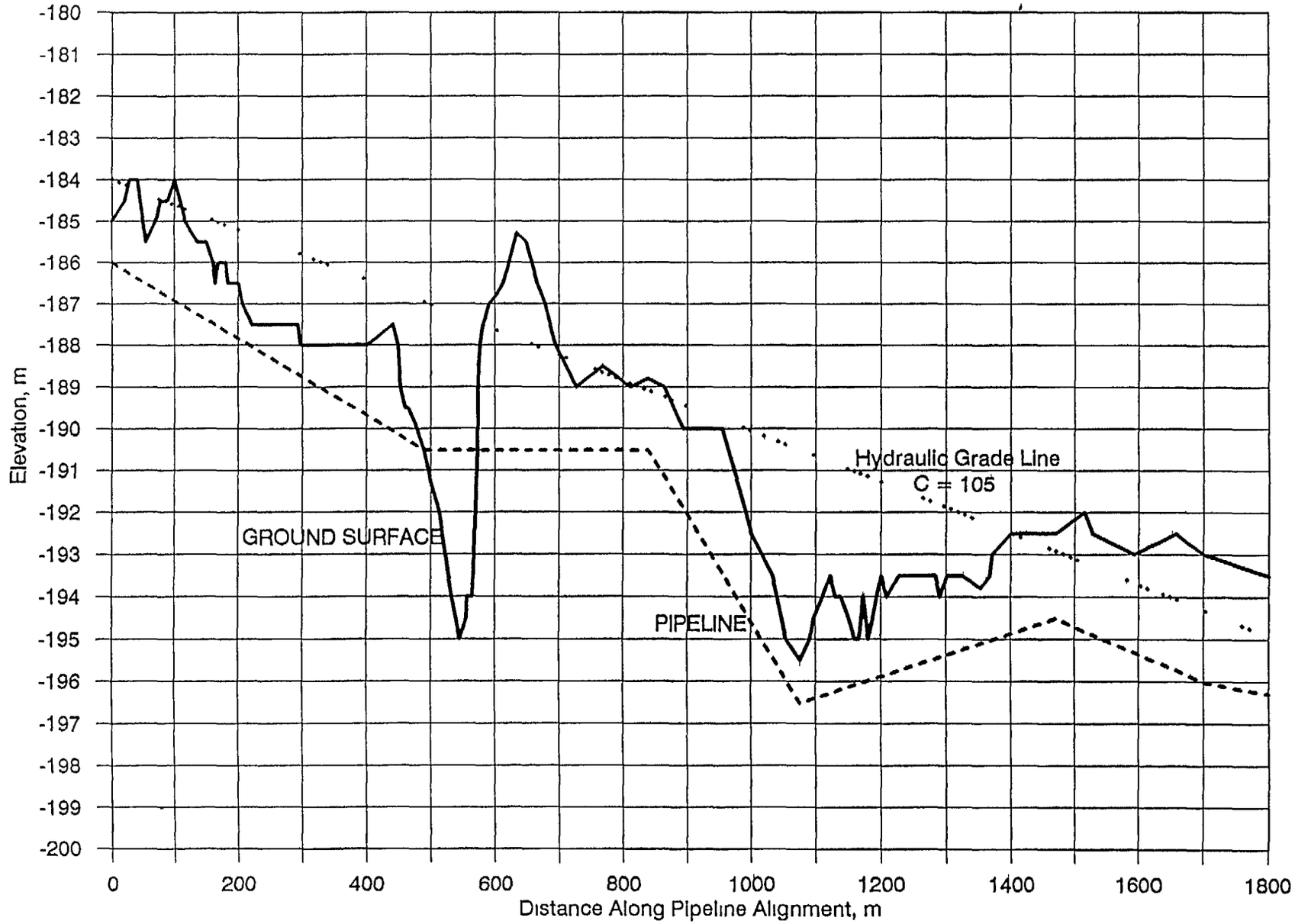
-102-

102

BEST AVAILABLE COPY

PIPELINE AND GROUND SURFACE PROFILE

PIPE DIAMETER = 1 4 M



BEST AVAILABLE COPY

EXHIBIT 5 7
Sheet 1 of 3

PIPELINE AND GROUND SURFACE PROFILE

PIPE DIAMETER = 1 4 M

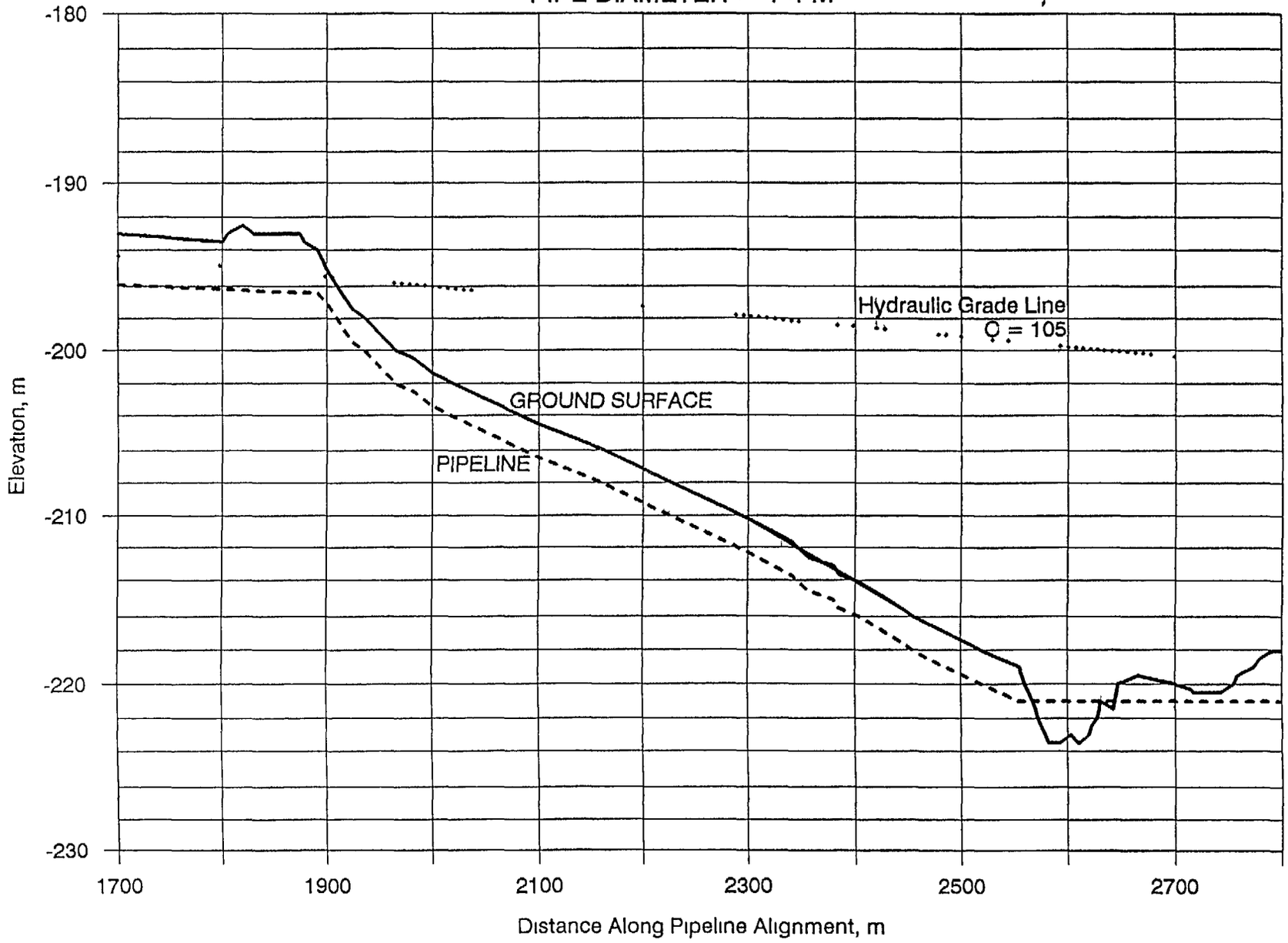


EXHIBIT 5 7
Sheet 2 of 3

BEST AVAILABLE COPY

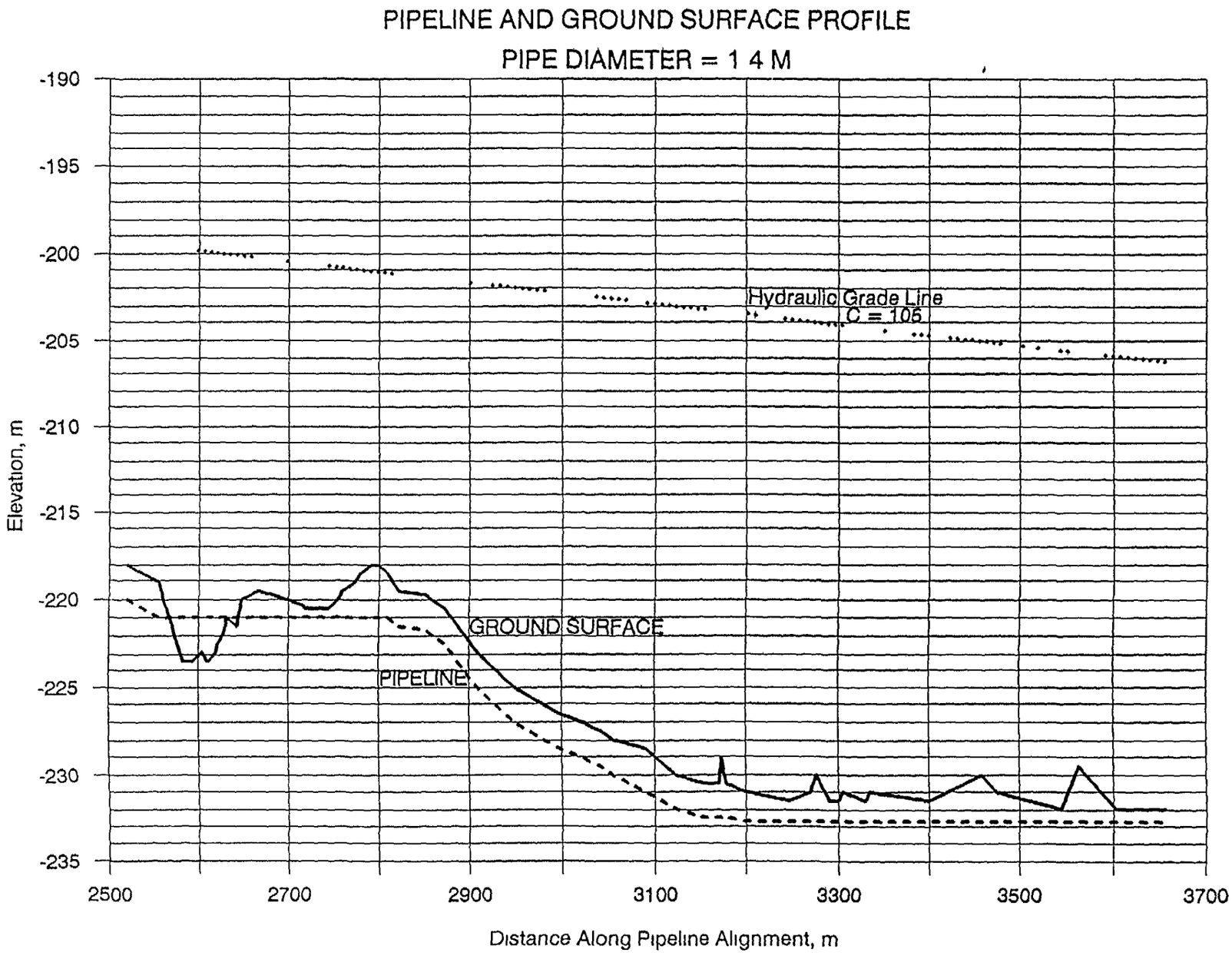


EXHIBIT 5 7
Sheet 3 of 3

BEST AVAILABLE COPY

BEST AVAILABLE COPY

DATA FROM VERTICAL PROFILE OF PIPELINE

Dist Along Pipe Align (m)	Ground Elev (m)	Pipe Elev (m)	Hydraulic Grade Line (m)	Bend Loc (m)	Bend Angle (°)	Excava Depth (m)	Trench Area (m²)	Trench Vol (m3)
0	-185 0	-186 0	-184 0			1 0	3 3	94
20	-184 5	-186 2	-184 1			1 7	6 1	60
28	-184 0	-186 3	-184 2			2 3	8 9	110
40	-184 0	-186 4	-184.2			2 4	9.4	42
45	-184 5	-186 4	-184 3			1 9	7 2	53
55	-185 5	-186 5	-184 3			1 0	3 3	70
70	-185 0	-186 6	-184 4			1 6	6 0	51
77	-184 5	-186 7	-184 5			2 2	8 6	62
84	-184 5	-186 8	-184 5			2 3	9 0	36
88	-184 5	-186 8	-184 5			2 3	9 1	130
100	-184 0	-186 9	-184 6			2 9	12 5	90
108	-184 5	-187 0	-184 7			2.5	10 1	72
116	-185 0	-187 1	-184 7			2 1	7 9	144
136	-185 5	-187 3	-184 8			1 8	6 4	94
150	-185 5	-187 4	-184 9			1 9	7 0	61
160	-186 0	-187 5	-185.0			1 5	5 2	17
164	-186 5	-187 5	-185 0			1 0	3 3	18
168	-186 0	-187 5	-185 0			1 5	5 5	69
180	-186 0	-187 7	-185 1			1 7	6 0	20
184	-186 5	-187 7	-185 1			1 2	4 1	70
200	-186 5	-187 8	-185 2			1 3	4 7	23
206	-187 0	-187 9	-185 3			0 9	2 9	32
220	-187 5	-188 0	-185 3			0 5	1 6	26
234	-187 5	-188 2	-185 4			0 7	2 1	59
258	-187 5	-188 4	-185 6			0 9	2 8	18
264	-187 5	-188 4	-185 6			0 9	3 1	99
292	-187 5	-188 7	-185 8			1 2	4 1	13
296	-188 0	-188 7	-185 8			0 7	2 3	9
300	-188 0	-188 8	-185 8			0 8	2 4	96
332	-188 0	-189 1	-186 0			1 1	3 5	329
400	-188 0	-189 7	-186 4	412	11 1/4	1 7	6 2	332
440	-187 5	-190 1	-186 7			2 6	10 4	75
448	-188 0	-190 1	-186 7			2 1	8 2	24
452	-189 0	-190 2	-186 7			1 2	4 0	25
460	-189 5	-190 2	-186 8			0 7	2 4	10
464	-189 5	-190 3	-186 8			0 8	2 5	26
478	-190 0	-190 4	-186 9	476	22 1/2	0 4	1 2	6
488	-190 5	-190 5	-187 0			0 0	0 0	0
500	-191 3	-190 5	-187 0			0 0	0 0	0
512	-192 0	-190 5	-187 1			0 0	0 0	0
532	-194 0	-190 5	-187 2			0 0	0 0	0
544	-195 0	-190 5	-187 3			0 0	0 0	0
554	-194 5	-190 5	-187 4			0 0	0 0	0
556	-194 0	-190 5	-187 4			0 0	0 0	0

BEST AVAILABLE COPY

DATA FROM VERTICAL PROFILE OF PIPELINE

Dist Along Pipe Align (m)	Ground Elev (m)	Pipe Elev (m)	Hydraulic Grade Line (m)	Bend Loc (m)	Bend Angle (°)	Excava Depth (m)	Trench Area (m²)	Trench Vol (m3)
564	-194 0	-190 5	-187 4			0 0	0 0	0
572	-190 5	-190 5	-187 5			0 0	0 0	52
580	-187 5	-190 5	-187 5			3 0	12 9	144
590	-187 0	-190 5	-187 6			3 5	15 9	182
601	-186.8	-190 5	-187 7			3.7	17 2	200
612	-186 5	-190 5	-187 7			4 0	19 2	520
634	-185 3	-190 5	-187 9			5 2	28 1	382
648	-185 5	-190 5	-187 9			5 0	26 5	388
665	-186 5	-190 5	-188 0			4 0	19 2	228
678	-187 0	-190 5	-188 1			3 5	15 9	208
694	-188 0	-190 5	-188 2			2 5	10 1	247
726	-189 0	-190 5	-188.4	726	45	1 5	5 3	265
767	-188 5	-190 5	-188 7			2 0	7 6	278
810	-189 0	-190 5	-188 9	810	45	1 5	5 3	161
838	-188 8	-190 5	-189.1			1 7	6.2	181
863	-189 0	-191 1	-189 2			2 1	8 2	230
893	-190 0	-191 9	-189 4	893	30	1 9	7 1	690
954	-190 0	-193 4	-189 8			3 4	15 5	543
1000	-192 5	-194 6	-190 1	1000	11 1/4	2 1	8 1	244
1032	-193 5	-195 4	-190 3			1 9	7 2	114
1054	-195 0	-196 0	-190 4			1 0	3 2	68
1075	-195 5	-196 5	-190 5			1 0	3 3	62
1090	-195 0	-196 4	-190 6			1 4	5 0	30
1095	-194 5	-196 4	-190 7			1 9	7 1	122
1110	-194 0	-196 3	-190 7			2 3	9 2	114
1121	-193 5	-196 3	-190 8			2 8	11 6	81
1129	-194 0	-196 2	-190 9			2 2	8 7	77
1138	-194 0	-196 2	-190 9			2 2	8 5	79
1149	-194 5	-196 1	-191 0			1 6	5 9	47
1159	-195 0	-196 1	-191 0			1 1	3 6	25
1166	-195 0	-196 0	-191 1			1 0	3 4	33
1172	-194 0	-196 0	-191 1			2 0	7 6	43
1180	-195 0	-196 0	-191 2	1180	11 1/4	1 0	3 2	126
1200	-193 5	-195 9	-191 3			2 4	9 4	65
1208	-194 0	-195 8	-191 3			1 8	6 8	147
1227	-193 5	-195 7	-191 5			2 2	8 7	69
1235	-193 5	-195 7	-191 5			2 2	8 5	221
1262	-193 5	-195 6	-191 7			2 1	7 9	160
1283	-193 5	-195 4	-191 8			1 9	7 3	43
1290	-194 0	-195 4	-191 8			1 4	4 9	59
1300	-193 5	-195 4	-191 9	1300	5 5/8	1 9	6 9	160
1324	-193 5	-195 2	-192 0			1 7	6 4	157
1353	-193 8	-195 1	-192 2			1 3	4 5	64

BEST AVAILABLE COPY

DATA FROM VERTICAL PROFILE OF PIPELINE

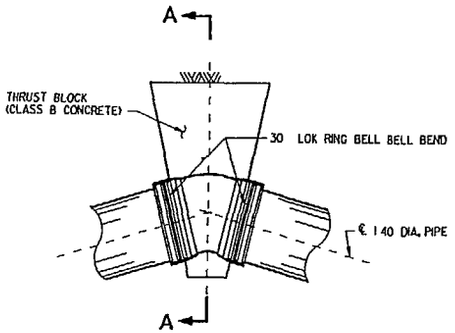
Dist Along Pipe Align (m)	Ground Elev (m)	Pipe Elev (m)	Hydraulic Grade Line (m)	Bend Loc (m)	Bend Angle (°)	Excava Depth (m)	Trench Area (m²)	Trench Vol (m3)
1366	-193 5	-195 0	-192 3			1 5	5 4	26
1370	-193 0	-195 0	-192 3			2 0	7 6	255
1400	-192 5	-194 9	-192 5	1400	11 1/4	2 4	9 4	594
1470	-192.5	-194.5	-192.9			2.0	7 6	2358
1700	-193 0	-196 0	-194 3			3 0	12 9	1228
1800	-193 5	-196 3	-194 9			2 8	11 7	66
1805	-193 0	-196 3	-195 0	1805	11 1/4	3 3	14 7	229
1819	-192 5	-196 3	-195 0			3 8	18 1	182
1830	-193 0	-196 4	-195 1			3 4	15 1	681
1874	-193 0	-196 5	-195 4			3 5	15 9	58
1878	-193 5	-196.5	-195 4			3 0	12 9	138
1890	-194 0	-196.5	-195 5	1890	11 1/4	2.5	10 1	89
1900	-195.2	-197 2	-195 5			2 0	7 6	182
1924	-197 5	-199 5	-195 7			2 0	7 6	84
1935	-198.0	-200.0	-195.8			2 0	7 6	228
1965	-200 0	-202 0	-195 9			2 0	7 6	129
1982	-200 5	-202 5	-196 0			2 0	7 6	137
2000	-201 4	-203 4	-196 1			2 0	7 6	760
2100	-204 5	-206 5	-196 8			2 0	7 6	456
2160	-206 0	-208 0	-197 1	2160	5 5/8	2 0	7 6	304
2200	-207 2	-209 2	-197 4			2 0	7 6	760
2300	-210 2	-212 2	-198 0			2 0	7 6	319
2342	-211 6	-213 6	-198 2	2342	5 5/8	2 0	7 6	106
2356	-212 5	-214 5	-198 3			2 0	7 6	182
2380	-213 0	-215 0	-198 5			2 0	7 6	38
2385	-213 5	-215 5	-198 5			2 0	7 6	152
2405	-214 0	-216 0	-198 6			2 0	7 6	289
2443	-215 5	-217 5	-198 8			2 0	7 6	91
2455	-216 0	-218 0	-198 9			2 0	7 6	122
2471	-216 5	-218 5	-199 0	2509	22 1/2	2 0	7 6	372
2520	-218 0	-220 0	-199 3			2 0	7 6	266
2555	-219 0	-221 0	-199 5			2 0	7 6	27
2560	-220 0	-221 0	-199 5	2560	30	1 0	3 3	12
2567	-221 0	-221 0	-199 6			0 0	0 0	0
2570	-221 5	-221 0	-199 6			0 0	0 0	0
2572	-222 0	-221 0	-199 6			0 0	0 0	0
2582	-223 5	-221 0	-199 7			0 0	0 0	0
2593	-223 5	-221 0	-199 7			0 0	0 0	0
2603	-223 0	-221 0	-199 8			0 0	0 0	0
2609	-223 5	-221 0	-199 8			0 0	0 0	0
2611	-223 5	-221 0	-199 9			0 0	0 0	0
2619	-223 0	-221 0	-199 9			0 0	0 0	0
2621	-222 5	-221 0	-199 9			0 0	0 0	0

BEST AVAILABLE COPY

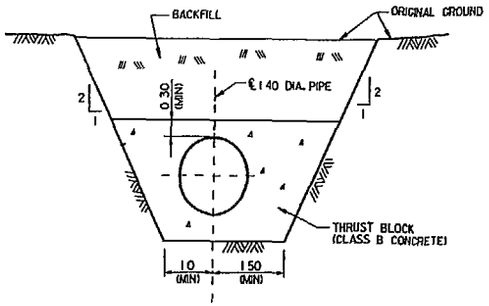
DATA FROM VERTICAL PROFILE OF PIPELINE

Dist Along Pipe Align (m)	Ground Elev (m)	Pipe Elev (m)	Hydraulic Grade Line (m)	Bend Loc (m)	Bend Angle (°)	Excava Depth (m)	Trench Area (m²)	Trench Vol (m3)
2627	-222 0	-221 0	-200 0			0 0	0 0	0
2629	-221 5	-221 0	-200 0			0 0	0 0	0
2630	-221 0	-221 0	-200 0			0 0	0 0	0
2642	-221 5	-221 0	-200 0			0 0	0 0	186
2755	-220 0	-221 0	-200 7			1 0	3 3	13
2758	-219 5	-221 0	-200 8			1 5	5 3	97
2773	-219 0	-221 0	-200 8			2 0	7 6	44
2778	-218.5	-221.0	-200.9			2.5	10 1	150
2791	-218 0	-221 0	-201 0			3 0	12 9	103
2799	-218 0	-221 0	-201 0			3 0	12 9	115
2809	-218 5	-221 0	-201 1			2 5	10 1	106
2821	-219 5	-221 5	-201 1			2 0	7 6	228
2851	-219 7	-221 7	-201 3	2851	22 1/2	2 0	7 6	53
2858	-220 0	-222 0	-201 4			2 0	7 6	106
2872	-220 5	-222 5	-201 4			2 0	7 6	274
2908	-223.0	-225 0	-201 7			2 0	7 6	304
2948	-225 0	-227 0	-201 9			2 0	7 6	365
2996	-226 5	-228 5	-202 2			2 0	7 6	198
3022	-227 0	-229.0	-202 4	3022	11 1/4	2.0	7 6	144
3041	-227 5	-229 5	-202 5			2 0	7 6	99
3054	-228 0	-230 0	-202 5			2 0	7 6	319
3090	-228 5	-231 0	-202 8			2 5	10 1	292
3123	-230 0	-232 0	-203 0	3123	22 1/2	2 0	7 6	228
3153	-230 5	-232 5	-203 2			2 0	7 6	129
3170	-230 5	-232 5	-203 3			2 0	7 6	47
3174	-229 0	-232 5	-203 3			3 5	15 9	47
3178	-230 5	-232 5	-203 3			2 0	7 6	152
3200	-231 0	-232 7	-203 4			1 7	6 2	237
3246	-231 5	-232 7	-203 7			1 2	4 1	118
3269	-231 0	-232 7	-203 9	3269	11 1/4	1 7	6 2	52
3275	-230 0	-232 7	-203 9			2 7	11 2	49
3280	-230 5	-232 7	-203 9			2 2	8 6	63
3290	-231 5	-232 7	-204 0			1 2	4 1	41
3300	-231 5	-232 7	-204 0			1 2	4 1	21
3304	-231 0	-232 7	-204 1			1 7	6 2	134
3330	-231 5	-232 7	-204 2	3330	30	1 2	4 1	21
3334	-231 0	-232 7	-204 3			1 7	6 2	339
3400	-231 5	-232 7	-204 7	3400	22 1/2	1 2	4 1	443
3458	-230 0	-232 7	-205 0	3458	11 1/4	2 7	11 2	148
3475	-231 0	-232 7	-205 1	3506	5 5/8	1 7	6 2	294
3545	-232 0	-232 7	-205 5			0 7	2 2	147
3563	-229 5	-232 7	-205 6	3563	11 1/4	3 2	14 1	326
3603	-232 0	-232 7	-205 9			0 7	2 2	115
3655	-232 0	-232 7	-206 2			0 7	2 2	
Total fill vol=		22509	(m3)			Total trench vol=		27472

EXHIBIT 5 – 9

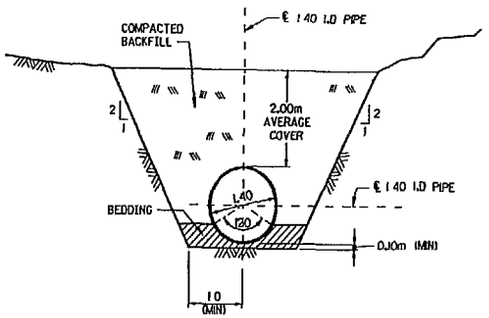


PLAN VIEW



A – A

TYPICAL PIPELINE BENDS WITH THRUST BLOCKS



TYPICAL PIPE AND TRENCH SECTION

SCALE 0 1 2 3 METERS

JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

TYPICAL PIPELINE
ALIGNMENT DETAILS

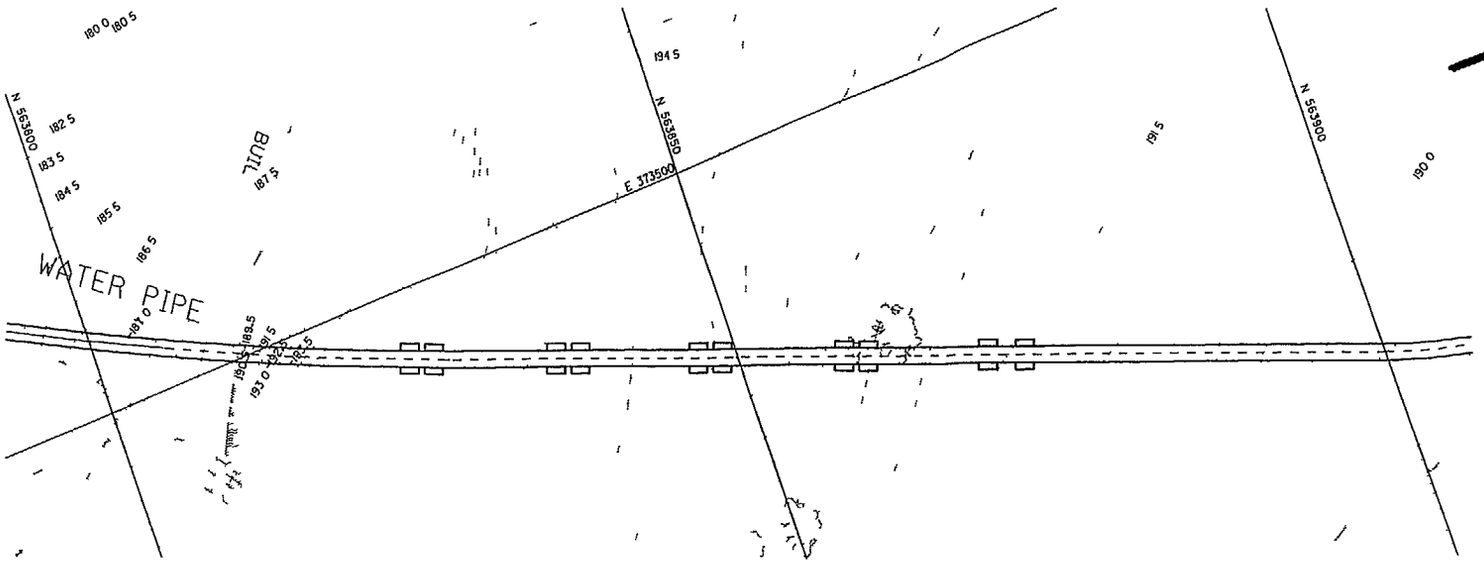
HARZA ENGINEERING COMPANY/CONSOLIDATED CONSULTANTS AMMAN-JORDAN APRIL 1996

FILE c:\dgn\5702g\pb nd dg

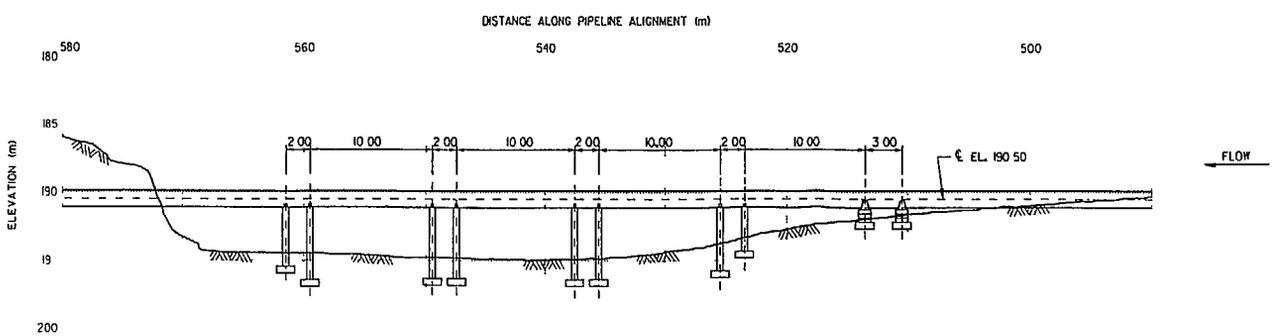
110

BEST AVAILABLE COPY

EXHIBIT 5 – 10



PLAN



PROFILE

SCALE 0 5 10 METERS

JORDAN WATER QUALITY IMPROVEMENT AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

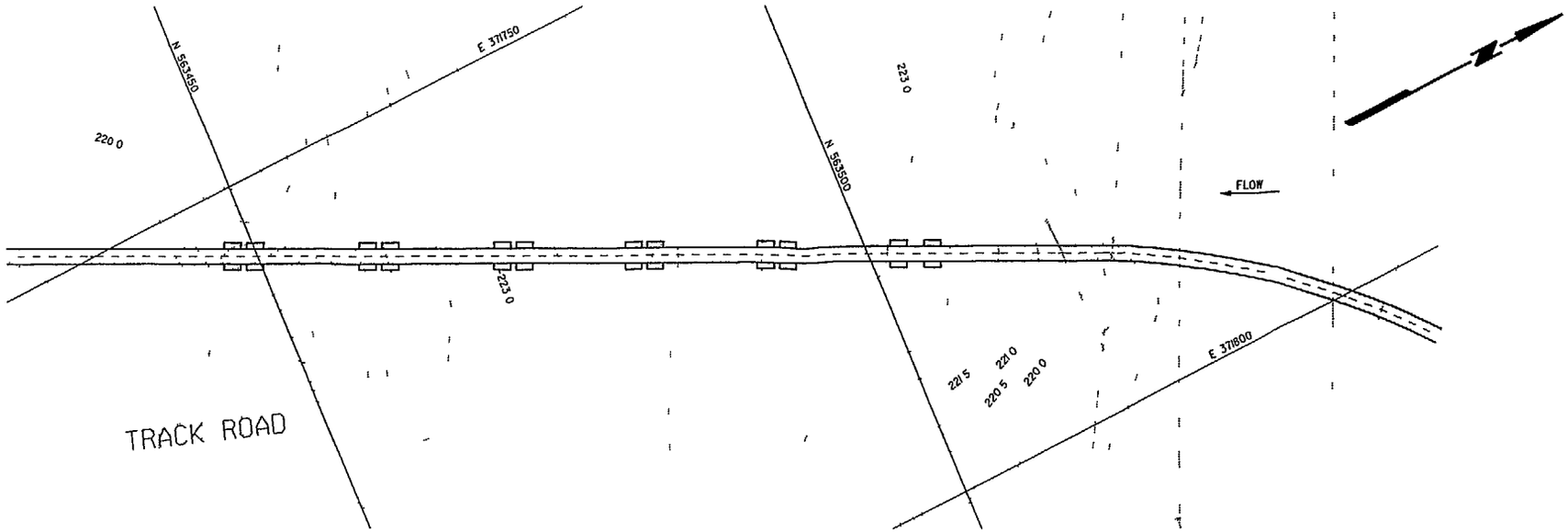
VIADUCT 1
PLAN AND PLAN

HARZA ENGINEERING COMPANY/CONSOLIDATED CONSULTANTS AMMAN-JORDAN APRIL 1996

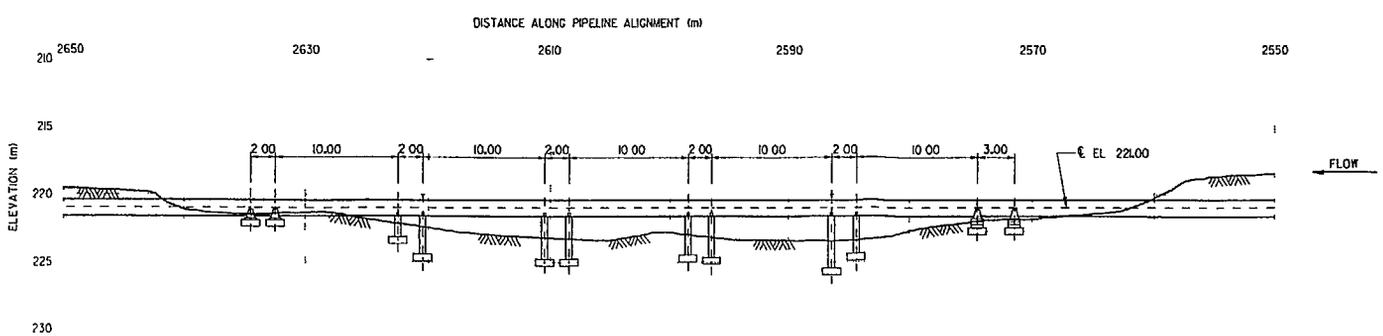
FILE: c:\dgn\5702g\ dgn

BEST AVAILABLE COPY

EXHIBIT 5 – 11



PLAN



PROFILE

SCALE 0 5 10 METERS

JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

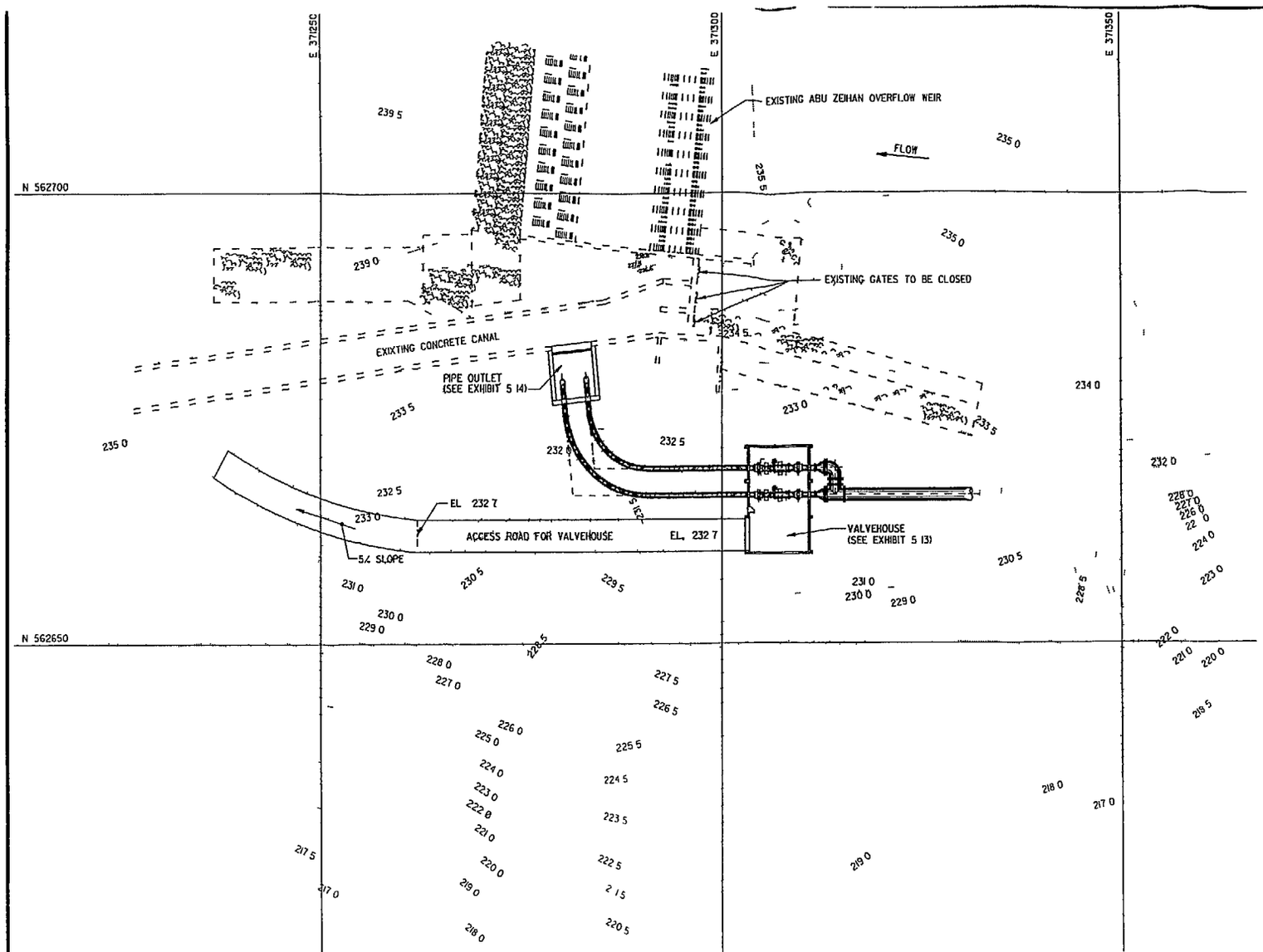
VIADUCT 2
PLAN AND PROFILE

HARZA ENGINEERING COMPANY/CONSOLIDATED CONSULTANTS AMMAN-JORDAN APRIL 1996

FILE: \dgn\5702g\ du 12 dg

BEST AVAILABLE COPY

EXHIBIT 5 – 12



SCALE 0 10 METERS

JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

VALVEHOUSE AND PIPE OUTLET
LOCATION PLAN

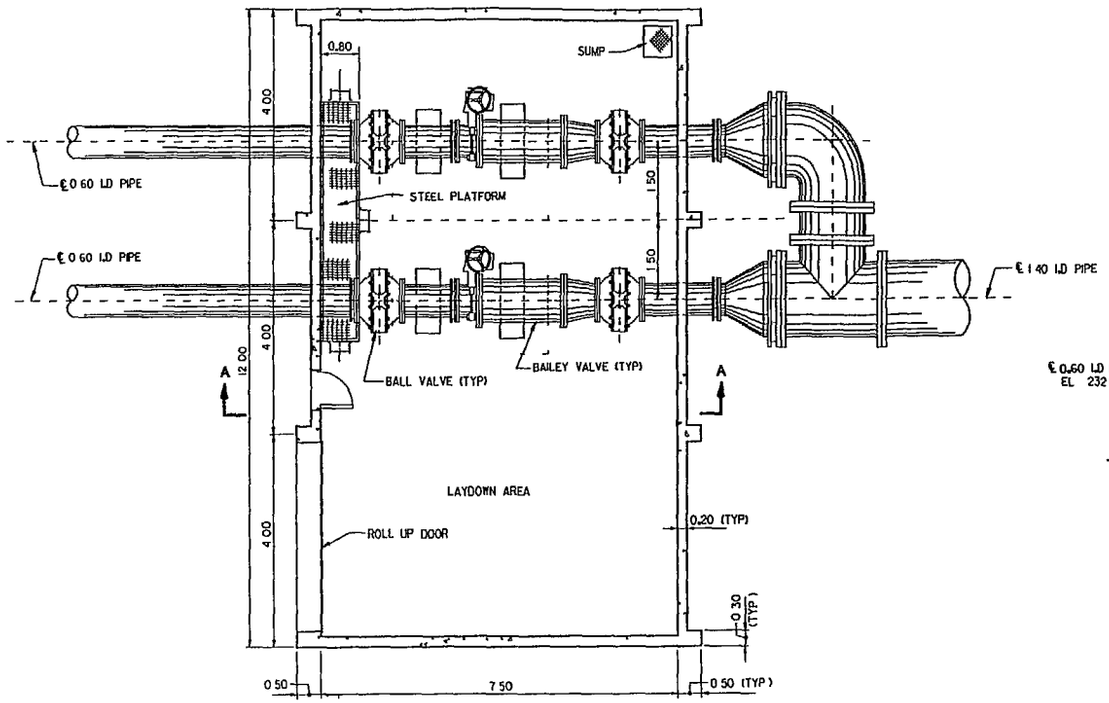
HARZA ENGINEERING COMPANY/CONSOLIDATED CONSULTANTS AMMAN-JORDAN APRIL 1996

FILE: c:\dg \5702g\pvhouse dgn
DATE: 8 Apr 9 1 0 0

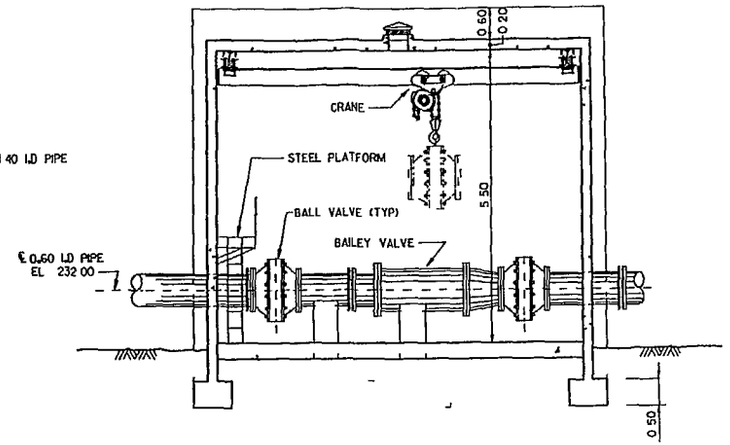
113

BEST AVAILABLE COPY

EXHIBIT 5 -13



PLAN



A - A

SCALE 0 1 2 3 METERS

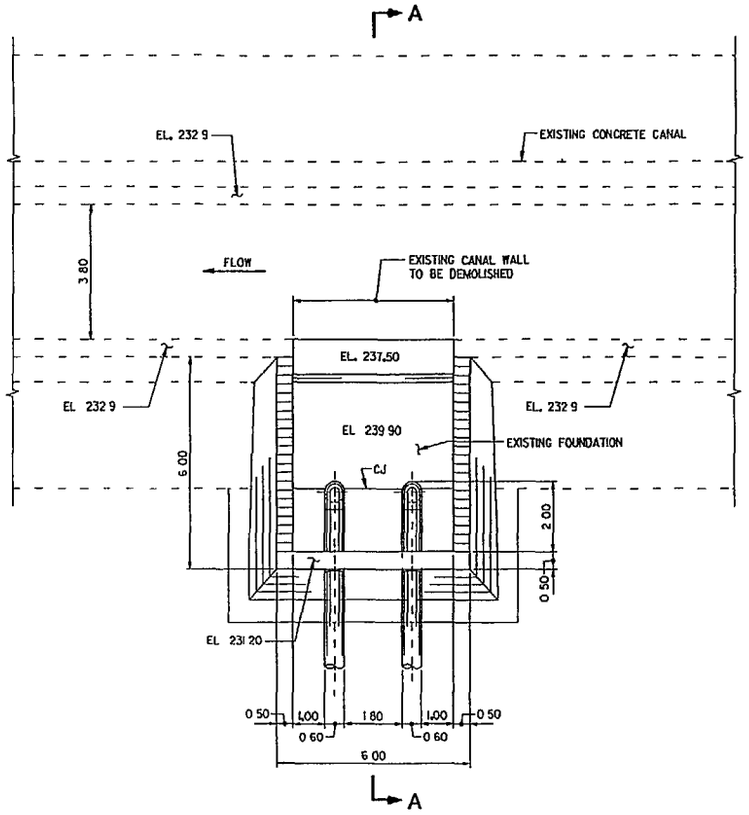
JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

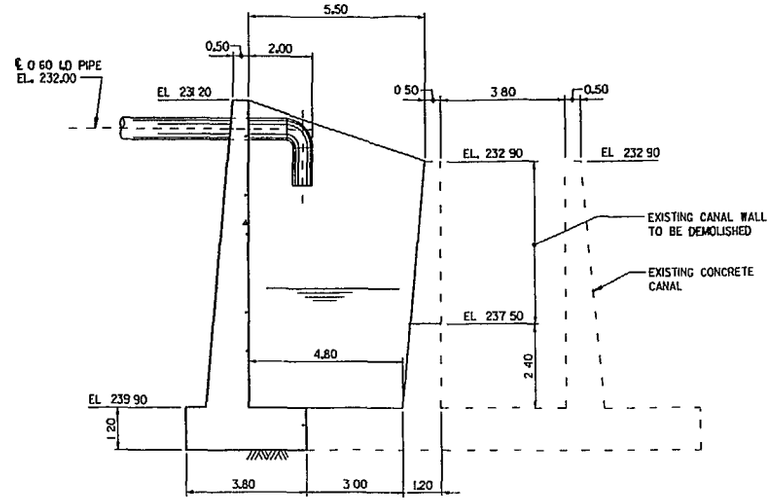
VALVE HOUSE
PLAN AND SECTION

HARZA ENGINEERING COMPANY/CONSOLIDATED CONSULTANTS AMMAN-JORDAN APRIL 1996

BEST AVAILABLE COPY



PLAN VIEW



SECTION A – A

SCALE 0 1 2 3 4 5 METER

JORDAN WATER QUALITY IMPROVEMENT
AND CONSERVATION PROJECT

ZARQA RIVER CONVEYANCE STUDY

PIPE OUTLET AT ABU ZEIGHAN CANAL
PLAN AND SECTION

HARZA ENGINEERING COMPANY/CONSOLIDATED CONSULTANTS AMMAN JORDAN APRIL 1996

FILE: c:\dg \STOZQ\ fl 1 dgn
0 8 Apr 96 1 08 0g

BEST AVAILABLE COPY

GEOTECHNICAL APPENDIX

		Page
		I
TABLE OF CONTENTS		II
	INTRODUCTION	1
	1 1 Purpose Of Study	1
	1 2 Scope Of Work	1
2 0	PROJECT DESCRIPTION	1
	SITE DESCRIPTION	2
	FIELD EXPLORATION AND LABORATORY TESTING	2
	4 1 Field Exploration	2
	4 1 1 Drilling	2
	4 1 2 Sampling	4
	4 1 3 Field Testing in Boreholes	4
	4 2 Laboratory Testing	4
5 0	SURFACE AND SUBSURFACE CONDITIONS	13
	5 1 Ground Materials	13
	5 2 Materials Physical & Mechanical Properties	13
	5 3 Materials Chemical Properties	22
	5 3 1 Sulphate Content In Ground Material	22
	5 3 2 Chloride Content In Ground Material	22
	5 3 Ground Water And Cavities	23
	CONCLUSIONS AND RECOMMENDATIONS	24
	6 1 Foundation Depth And Type	24
	6 2 Allowable Bearing Pressure	24
	6 3 Foundation Settlement	24
	6 4 Excavation Methods	24
	6 5 Excavation of Side Slopes	25
	6 6 Drainage	25
	6 7 Backfill Materials And Compaction Criteria	25
	6 8 Earth Pressure	25
	6 9 Foundation Excavation Inspection	25
	APPENDIX A Logs Of Borings	25

TABLE OF CONTENTS

		Page
LIST OF FIGURES		
Figure No 1	General Site Plan	3
Figure No 2	Grain Size Distribution	8
Figure No 3	Generalized Subsurface Profile AA'	14
Figure No 4	Generalized Subsurface Profile BB'	15
Figure No 5	Generalized Subsurface Profile CC'	16
Figure No 6	Generalized Subsurface Profile DD'	17
Figure No 7	Textural Classification Chart	19
Figure No 8	Casagrande Plasticity Chart	20
9	Modified Chart Of Expansiveness	21
LIST OF TABLES		
Table No 1	Laboratory Test Results	5
Table No 2	Chemical Test Results	12
3	Materials Types & Properties	18

1.0 INTRODUCTION

This report presents the results of the geotechnical investigation for the proposed site in Deir Alla

1.1 Purpose Of Study

The purpose of this study is to determine the surface and subsurface conditions at the project site and the physical and mechanical properties of the foundation ground in order to provide the structural engineer with sufficient information for the design of most suitable and safe foundations

1.2 Scope Of Works

The scope of work consists of the following

1. Collecting information and maps particular to the project site such as public services, site plan and land use maps
2. Making visits to the site to collect information about present land use surface topography, geological features and surface drainage
3. Drilling of eight boreholes and sampling of disturbed and undisturbed samples
4. Carrying out the necessary laboratory tests
5. Performing engineering analysis of field and laboratory findings
6. Developing conclusions and recommendations for foundation design and construction

2.0 PROJECT DESCRIPTION

The project consist of a pipe-line and its assosiated structures to carry part of the Zarqa river water (Talal Dam outlet water) to separate it saline base flow water

3 0 SITE DESCRIPTION

The surficial ground is covered with wadi deposits composed of sandy silty clay with gravel and cobbles of limestone and chert

No electrical or telephone poles, sewer or water pipes were observed within the site area However, electricity and water services are provided for the area

According to the geological maps for Deir Alla area and following our inspections, the general site area belongs to the Ajlun Group, Na'ur Formaion (A1/2) which is mainly formed of limestone marls, clays, marly clay, marly limestone and occasionally shales No faults or other special geologic features were observed at the site

A general site plan showing the location of the building and boreholes is presented in figure no 1

4 0 FIELD EXPLORATION AND LABORATORY TESTING

4 1 Field Exploration

4 1 1 Drilling

On Jan 20 and 21, 1996 eight boreholes were drilled at the site The boreholes are numbered 1 through 8 and they were drilled to a depth of 6 0 m each below the existing ground surface, respectively The locations of the boreholes are shown in figure no 1

The drilling was executed with Hands England-Drill Master 18 rotery rig, mounted on Mercedes LK 608, Truk, capacity = 120 m, using the rotary air flush drilling method The logs of the three boreholes are presented in Appendix A

UNIT COSTS ON SIMILAR PROJECTS

	UNIT	RATE JD
EARTHWORK		
Excavation for structures on general ground	CU M	1 1
Excavation in rock	CU.M	11 9
Compacted fill to make up levels and to form embankments	CU M	1 2
Surfacing of pumping stations and turnouts	SQ M	0 7
Trenching for single pipe including bedding and backfilling		
standard depth below formation level		
2 0 m deep for 600 mm dia	M	14 8
2 3 m deep for 900 mm dia	M	20 8
2 6 m deep for 1200 mm dia	M	41 1
Additional excavation over standard depth	CU M	5 2
Extra over normal for excavation in rock	CU M	11 9
CONCRETE WORK		
Concrete class "C"	CU M	71 4
Concrete class "C" sufate resistance	CU M	72 7
Concrete class "A"	CU M	143 3
Concrete class "A" sulfate resisting	CU M	146 0
20/20	CU M	48 1
25/20	CU M	50 5
30/20	CU M	54 8
35/20	CU M	62 2
40/20	CU M	64 0
REINFORCEMENT STEEL		
High tensile deformed	TON	527 6
DUCTILE IRON PIPES		
Class K8,600 mm	M	88
Class K8,700 mm	M	111
Class K9,800 mm	M	207
Class K9,900 mm	M	281
Class K7,900 mm	M	275
Class K7,1200 mm	M	380
DUCTILE IRON PIPE FITTINGS		
11-1/4 degree bend section all sockets		
600 mm	No	378
900 mm	No	1190
1200 mm	No	1950
22-1/2 degree bend all sockets		
600 mm	No	531
900 mm	No	1665
1200 mm	No	1950
45 degree bend all sockets		
600 mm	NO	974
900 mm	No	1665
1200 mm	No	2626
Tee section all sockets		
600 mm * 100 mm	No	565
600 mm * 150 mm	No	645

UNIT COSTS ON SIMILAR PROJECTS

	UNIT	RATE JD
600 mm * 200 mm	No	629
900 mm * 150 mm	No	1477
600 mm * 500 mm	No	1485
700 mm * 450 mm	No	1940
Tee section socket and flanged branch		
450 mm * 100 mm	No	780
500 mm * 100 mm	No	966
Invert level tee section & flanged branch		
450 mm * 100 mm	No	812
500 mm * 100 mm	No	1003
Reducer all sockets		
500 mm * 400 mm	No	269
500 mm * 450 mm	No	210
600 mm * 250 mm	No	647
700 mm * 400 mm	No	842
Isolation valve, diameter		
400 mm	No	4649
450 mm	No	5795
500 mm	No	7100
Air valve		
1C	No	757
2C	No	781
3C	No	781
Flexable coupling		
700 mm	No	483
800 mm	No	572
900 mm	No	655
1000 mm	No	756
GATE AND MECHANICAL WORKS		
Steel sliding gate		
762 mm * 610 mm	No	3516
914 mm * 762 mm	No	3648
1067 mm * 914 mm	No	3770
Heavy duty sluice gate		
762 mm * 610 mm	No	4947
914 mm * 762 mm	No	10119
1067 mm * 762 mm	No	12992
Chain link fencing,gate & concrete blocks	M	23
Gate for fencing, 5000 mm wide	No	530
Gate for fencing, 1200 mm wide	No	116
Heavy duty cast iron manhole cover,800mm *800mm	No	159
3-stage pump & motor, 100 HP	No	23150
3-stage pump & motor, 150 HP	No	29625
7-stage pump & motor, 200 Hp	No	52950
Slow closing air and vacuum valve,150mm	No	3071
WADI AND GULLY CROSSING		
Stone pitching in concrete	CU M	22 7

DAILY WAGES SCHEDULE

ITEM	UNIT	COST,JD	
FINE AGGREGATE	CU M	6 33	
COARSE AGGREGATE	CU M	6 33	
CEMENT AT SITE	TONS	47	
RFT AT SITE	TONS	325	
EQUIPMENT DEPRECIATION, 25 DAY/MONTH, 8 HOURS/DAY			
DUMP TRUCK	MONTH	4000	
CAT D9	MONTH	6000	
LOADER, 966E	MONTH	3000	
SCRAPER	MONTH	9000	
GRADER	MONTH	4000	
COMPACTOR	MONTH	6000	
WATER TANK		1500	
OPERATION AND MAINTENANCE COST ASSUME EQUAL TO DEPRECIATION COST			
EQUIPMENT HOURLY RATE			
EXCAVATOR	HOUR	50–75	200 HP-400 HP, EXCLUDING OPERATOR
LOADER	HOUR	28–71	260 HP -375 HP, EXCLUDING OPERATOR
TRACTOR INCLUDING DOZER	HOUR	30–58	
GRADER	HOUR	30	
ROLLERS & COMPACTOR	HOUR	20	
DUMPER, 35 TONS	HOUR	43	
WATER TANK, 20 CU M	HOUR	20	
LABOR RATES FOR CONSTRUCTION TRADES			
SKILLED			
H P OPERATOR	HOUR	4 78	
L P OPERATOR	HOUR	3 39	
H V DRIVER	HOUR	3 39	
L V DRIVER	HOUR	2 51	
HEAD MAN	HOUR	7 81	
MASON	HOUR	4 14	
CARPENTER	HOUR	4 14	
SKILLED LABOR	HOUR	4 14	
BLASTER	HOUR	4 14	
JR QUALITY SUPERVISOR	HOUR	2 88	
JR COST CONTROLLER	HOUR	2 88	
FOREMAN	HOUR	5 34	
ACCOUNTANT	HOUR	2 88	
LAB ASSISTANT	HOUR	2 88	
DRAFTSMAN	HOUR	2 51	
CAMP MANAGER	HOUR	3 10	
CLERK	HOUR	2 18	
SECRETARY	HOUR	2 51	
CASHIER	HOUR	2 88	
STORE KEEPER	HOUR	2 88	

DAILY WAGES SCHEDULE

ITEM	UNIT	COST,JD
STORE ACCOUNTANT	HOUR	2 88
DRESSER	HOUR	2 51
SECURITY OFFICER	HOUR	2 88
MECHANICS	HOUR	5 85
STEEL BENDER/FIXER	HOUR	4 14
BATCH PLANT SUPERVISOR	HOUR	3 98
AUTO ELECTRICIAN	HOUR	3 18
ELECTRICIAN	HOUR	4 14
SEMISKILLED		
LABOR	HOUR	3 39
DRILLER	HOUR	3.39
ELECTRICIAN	HOUR	4 14
UNSKILLED		
LABOR	HOUR	1 62
WATCHMAN	HOUR	1 61
OFFICE BOY	HOUR	1 69
CLEANER	HOUR	1 69

COST ESTIMATE

Item	Quantity	Unit	Unit Cost	Total Cost
Hwaret Wier			(JD)	(JD)
Concrete, wier	1,324	cu m	146	193,304
Concrete, dissipators	64	cu m	146	9,344
Concrete, retaining walls	596	cu m	146	87,016
Reinforcing Steel	119	tons	527 6	62,784
Rockfill	423	cu m	3	1,269
Gabion Mattress	149	cu m	1 5	224
Foundation Preparation	5,000	sq m	1	5,000
Clearing	10,000	sq m	1	10,000
Demolishing existing weir		LS		10,000
Cofferdam		LS		1,500
Excavation		LS		10,000
Subtotal Hwaret Weir				390,441
Hwaret Intake				
Excavation	365	cu m	3 8	1 387
Concrete	214	cu m	146	31,244
Reinforcing Steel	13	tons	527 6	6,859
Demolishing existing intake		LS		10,000
Sluice Gates (1 5m X 1 5m)	2	number	10000	20,000
Trashracks (1 5m X 1 5m)	1	number	3000	3,000
Subtotal Hwaret Intake				72,490
Desanding Basin				
Concrete	644	cu m	146	94,024
Reinforcing Steel	39	tons	527 6	20,576
Excavation	1,718	cu m	3 8	6,528
Foundation Preparation	3,750	sq m	1	3,750
Clearing	7,500	sq m	1	7 500
Demolishing existing canal		LS		5,000
Sluice Gates (1 5m X 1 5m)	5	number	10000	50,000
Subtotal Desanding Basin				187,379
Viaducts (2)				
Concrete	30	cu m	146	4,380
Reinforcing Steel	3	tons	527 6	1 583
Excavation	110	cu m	3 8	418
Subtotal Viaducts (2)				6 381
Valvehouse				
Excavation	210	cu m	3 8	798
Backfill (including Pipe)	135	cu m	2	270
Concrete Valvehouse	82	cu m	146	11,972
Concrete Valve foundation	12	cu m	146	1 752
Reinforcing Steel	6	tons	527 6	3,166
Subtotal Valvehouse				17,958

COST ESTIMATE

Item	Quantity	Unit	Unit Cost	Total Cost
Pipe to Outlet				
Excavation	18	cu m	3 8	68
Subtotal Pipe to Outlet				68
Valvehouse equipment	1	LS	619,595	619,595
(see attachment A)				
Outlet Basin				
Excavation	818	cu m	3 8	3,108
Backfill	512	cu m	2	1,024
Concrete, removal from channel wall	20	cu m	3	60
Concrete, for Outlet Basin	95	cu m	146	13,870
Reinforcing Steel	7	tons	527 6	3,693
Subtotal Outlet Basin				21,756
Road to Valvehouse				
Excavation	160	cu m	3.8	608
Fill	4	cu m	2	8
Subtotal Road to valvehouse				616
				616
Pipeline				
Pipe	3,655	m	580	2,119,900
Excavation	27,472	cu m	3 8	104,394
Backfill	22,509	cu m	4	90,036
Concrete (Encasement)	200	cu m	90	18,000
Field Alignment		LS		1,500
Field Installation		LS		5,000
Steel Pipe (Viaduct Crossing)	50	tons	2000	100,000
Bend (5-5/8 deg)	4	number	2600	10,400
Bend (11-1/4 deg)	11	number	2,600	28 600
bend (22-1/2 deg)	6	number	2,600	15,600
Bend (30 deg)	4	number	3,000	12,000
Bend (45 deg)	2	number	3 500	7,000
Concrete for Thrust Block	1 728	cu m	80	138 240
Demolishing Existing Canal		LS	10,000	10 000
Subtotal Pipeline				2 660,670
Subtotal Direct Cost				3 977 353
Contigencies (about 15%)				596 648
Total Direct Cost				4,574 000
Engineering Design				280,000
Construction Engineering &				457,000
Owner's Overhead (about 10%)				
TOTAL CONSTRUCTION COST				5,311,000

ELECTROCONDUCTIVITY (EC) MEASUREMENTS, MIXING RATIOS, AND ESTIMATED AVERAGE EC'S, WITH AND WITHOUT PROJECT

Date	JVA Monthly Averages				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)
	Zarqa River		King Abdullah Canal						
	KTD King Talal Dam (dS/m)	AZC Abu Zeighan Canal (dS/m)	KAC s south (Maadi) (dS/m)	KAC-n north (Sawalha) (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 16	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

ELECTROCONDUCTIVITY (EC) MEASUREMENTS, MIXING RATIOS, AND ESTIMATED AVERAGE EC'S, WITH AND WITHOUT PROJECT

	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
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
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

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

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

which implies

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

Estimated Cost and Irrigated Area for Various Crops

	Surrogate Species for EC Analysis	Economic Information				Estimated Areas		Irrigation Period	Base Year EC	Base Year Est Yield
		Costs (JD/du)	Returns (JD/du)	Margin (JD/du)	Base Cost Year	18 km Extension Project 1990 (du)	18 km Extension Project 1994 (du)			
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	338	405	jan-dec	1 20	98%
Others	Peach	103	302	199	1991	540	965	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		68	sep-apr	1 36	87%
Garlic	*Onion*	*115*	*123*	*8*	*1993*		68	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	6 460	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

Estimated Cost and Irrigated Area for Various Crops

	Surrogate Species for EC Analysis	Economic Information				Estimated Areas		Irrigation Period	Base Year EC	Base Year Est Yield
		Costs (JD/du)	Returns (JD/du)	Margin (JD/du)	Base Cost Year	18 km Extension Project 1990 (du)	18 km Extension Project 1994 (du)			
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 96	80%
Sweet Pepper (PH)	Pepper	375	692	317	1991	405	69	aug-dec	1 96	80%
Broad Bean	Broadbean	67	77	10	1991	2 116	1,566	sep-dec	1 90	88%
String Bean (PH)	Bean	309	410	102	1991	38	1	jan apr	0 81	97%
String Bean	Bean	172	315	143	1993	144	4	oct-dec	2 05	61%
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	64%
Turnip	Turnip	46	209	163	1991	16	-	sep-jan	1 65	86%
Carrot	Carrot	80	564	484	1991	27	73	sep-feb	1 46	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 65	100%
Others	*Tomato*	*113*	*234*	*121*	*1993*	509	1 029	sep-jan	2 06	85%
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	81%
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	60%
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*	16	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 26	92%
	AREA TOTAL					39 768	21 560			

Note

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

Analysis of Extimated 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	1 90	81%	662	1 78	84%	690	28 298	60 128	61 650
Lemon	1 90	81%	605	1 78	84%	631	25 853	13 968	14 249
Clementine	1 90	81%	449	1 76	84%	468	19 196	4 933	5 125
Mandarine	1 90	81%	552	1 78	84%	576	23 597	17 205	17 220
Grapefruit	1 90	83%	371	1 76	87%	386	15 401	482	501
Pummelor	1 90	83%	748	1 76	87%	779	31 055	2 699	2 934
Others	1 90	81%	244	1 78	84%	255	10 444	5 016	5 261
Bananas	1.90	70%	416	1 78	75%	444	25 646	11 380	15 380
Misc Trees									
Apple	1 96	73%	383	1 79	76%	410	26 767	853	853
Apple	1 96	73%	66	1 79	76%	71	4 833	148	148
Grape	1 96	86%	249	1 83	88%	255	5 597	2 579	2,561
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	2 068
Peach	1 96	73%	546	1 79	78%	584	38 100	2,789	2 795
Guava	1 90	81%	222	1 78	84%	230	7 617	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	27 161	42 491
						Sub-total 1991 data		71 821	83 688
						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	17 063	691
Squash	2 41	100%	275	2 40	100%	275			
Eggplant	2 32	78%	278	2 30	78%	279	0 874	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%	2 161	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%	236	1 604	189	62
Potato	2 47	76%	504	2 45	76%	506	1 900	1 184	387
Potato	2 19	80%	554	2 16	81%	557	3 787	446	148
						TABLE CONCLUDES ON FOLLOWING PAGE			

Analysis of Extimated 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	835	94
Sweet Pepper (PH)	2 32	73%	627	2 31	73%	629	2 299	931	159
Broad Bean	2 41	81%	71	2 40	81%	71	0 202	428	316
String Bean (PH)	1 86	67%	283	1 84	68%	286	2 729	98	3
String Bean	2 52	48%	246	2 50	49%	249	3 118	450	12
Lettuce	2 10	76%	155	2 08	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	840
Turnip	2 39	76%	185	2 38	78%	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	176	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%	368	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	66%	304	1 84	67%	313	8 942	145	15
String Bean	1 91	66%	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	897
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	1 647
						Sub-total 1993 data		6 687	1 147

benefit (JD) using 1991 data	152 936	109 604
benefit (JD) using 1993 data	235 291	157 515
unit benefit (JD/du) using 1991 data	3 846	5 084
unit benefit (JD/du) using 1993 data	5 917	7 306
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%

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

Analysis of Extimated 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	7 488	3 586	3 761
Bananas	1 20	96%	572	1 12	99%	591	18 526	8 221	11 096
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	8 670	3 994	3 997
Peach	1 30	94%	518	1 17	98%	539	20 786	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%	625	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%	2 828			
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	6 988	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	1 978
Potato	1 03	100%	688	0 97	100%	688			-
						TABLE CONCLUDES ON FOLLOWING PAGE			

Analysis of Extimated 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%	821	20 850	6 579	972
Sweet Pepper (PH)	1 96	80%	692	1 82	83%	718	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	867
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 26	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

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%

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

Analysis of Extimated 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	74 706	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	33 086	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%	284	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	22 763	7 645	9 225
Others	2 19	66%	217	1 73	80%	265	47 416	25,802	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 61	87%	51	1 53	92%	54	2 813	827	2 900
Garlic	1 44	85%	233	1 37	87%	237	4 466		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%	2 828	-		
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	34 428
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			

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

	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%	760	1 36	92%	799	18 879	7,847	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	6,058	5,151
Spinach	1 53	97%	278	1 46	98%	280	2 307	346	87
Onion	1 43	85%	112	1 40	88%	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		96 578	53 914
						Sub-total 1993 data		100 896	55 131
Tomato	1 46	100%	298	1 38	100%	298		-	
Tomato (fun)	1 44	100%	383	1 37	100%	383			
Tomato	1 46	100%	309	1 38	100%	309			
Tomato (fun)	1 44	100%	1 419	1 37	100%	1,419	-		
Squash	1 48	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	6 418		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	3 846	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		6 124	2,068
						Sub-total 1993 data		3 662	1 331

benefit (JD) using 1991 data	328 601	319 224
benefit (JD) using 1993 data	439 763	459 244
unit benefit (JD/du) using 1991 data	8 288	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 6%	5 1%

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

Analysis of Extimated 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%	861	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	70 837	18,154	18 860
Mandarine	2 44	68%	464	1 91	81%	551	86 833	53 310	63 365
Grapefruit	2 44	70%	314	1 91	83%	370	56 673	1 772	1 843
Pummelor	2 44	70%	832	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	3 346	3 346
Apple	2 64	52%	47	2 00	72%	65	18 176	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%	187	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	88%	50	6 276	1 846	6 470
Garlic	2 43	81%	188	1 81	76%	208	40 102		2 724
Garlic	2 43	81%	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	55 818	113 461	4 588
Tomato	2 49	88%	291	1 85	98%	323	31 380	265 482	10 735
Tomato (PH)	2 49	88%	2 494	1 85	98%	2 763	268 771	548 328	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	51 679
Eggplant (PH)	2 45	78%	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	20 651
Cucumber (PH)	2 49	85%	1 984	1 85	97%	2 277	293 098	452 500	48 452
Potato	2 37	77%	243	1 88	86%	271	28 619	17 838	5,825
Potato	2 47	75%	220	1 80	88%	255	35 239	4 153	1 357
Potato	2 37	77%	516	1 88	86%	578	60 801	37 887	12 376
Potato	2 47	75%	519	1 80	88%	602	83 200	9,805	3 203
						TABLE CONCLUDES ON FOLLOWING PAGE			

Analysis of Extimated 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	26 882	23 481
Hot Pepper (PH)	2 38	72%	536	1 88	82%	611	74 867	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	5 612	11 872	8 785
String Bean (PH)	2 45	50%	212	1 73	71%	298	86 216	3 108	86
String Bean	2 46	50%	255	2 05	62%	315	59 952	6 644	240
Lettuce	2 49	69%	140	1 85	81%	165	25 391	54 084	45 981
Spinach	2 46	87%	247	2 05	91%	261	13 407	2 014	503
Onion	2 47	60%	79	1 81	76%	100	20 840	507	4 068
Onion	2 47	60%	391	1 81	76%	493	102 208	2 512	20 143
Turnip	2 35	76%	186	1 83	83%	203	17 082	311	-
Carrot	2 50	82%	415	1 86	75%	507	91 976	2 512	6 748
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		1 496,650	589 694
						Sub-total 1993 data		2,198,865	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 64	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	9,350
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	13 383	13,089	2 218
						Sub-total 1991 data		113 418	19,669
						Sub total 1993 data		104,835	13 446

benefit (JD) using 1991 data	1 924 133	987 881
benefit (JD) using 1993 data	2,744 807	1 211 431
unit benefit (JD/du) using 1991 data	48 384	45 619
unit benefit (JD/du) using 1993 data	69 016	56 186
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 6%

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

Analysis of Extimated 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	5,188
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	67 196	1 652	13,243
Turnip	2 04	81%	196	1 65	66%	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		1 338 639	467 280
Tomato	1 97	96%	288	1 22	100%	298	11 924	11 145	764
Tomato (tun)	1 87	97%	374	1 21	100%	383	9 630	1,124	77
Tomato	1 97	96%	297	1 22	100%	309	12 355	11 546	792
Tomato (tun)	1 87	97%	1,363	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%	289	96 085	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 28	96%	89	1 43	100%	93	3 631	11 616	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	18 446	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	8 881

			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	618 007
unit benefit (JD/du) using 1991 data	35 423	40 134	20 058	22 346
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 6%	12 0%	4 9%	6 6%
percentage increase in returns 1993 data	8 2%	12 7%	4 7%	7 1%

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

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

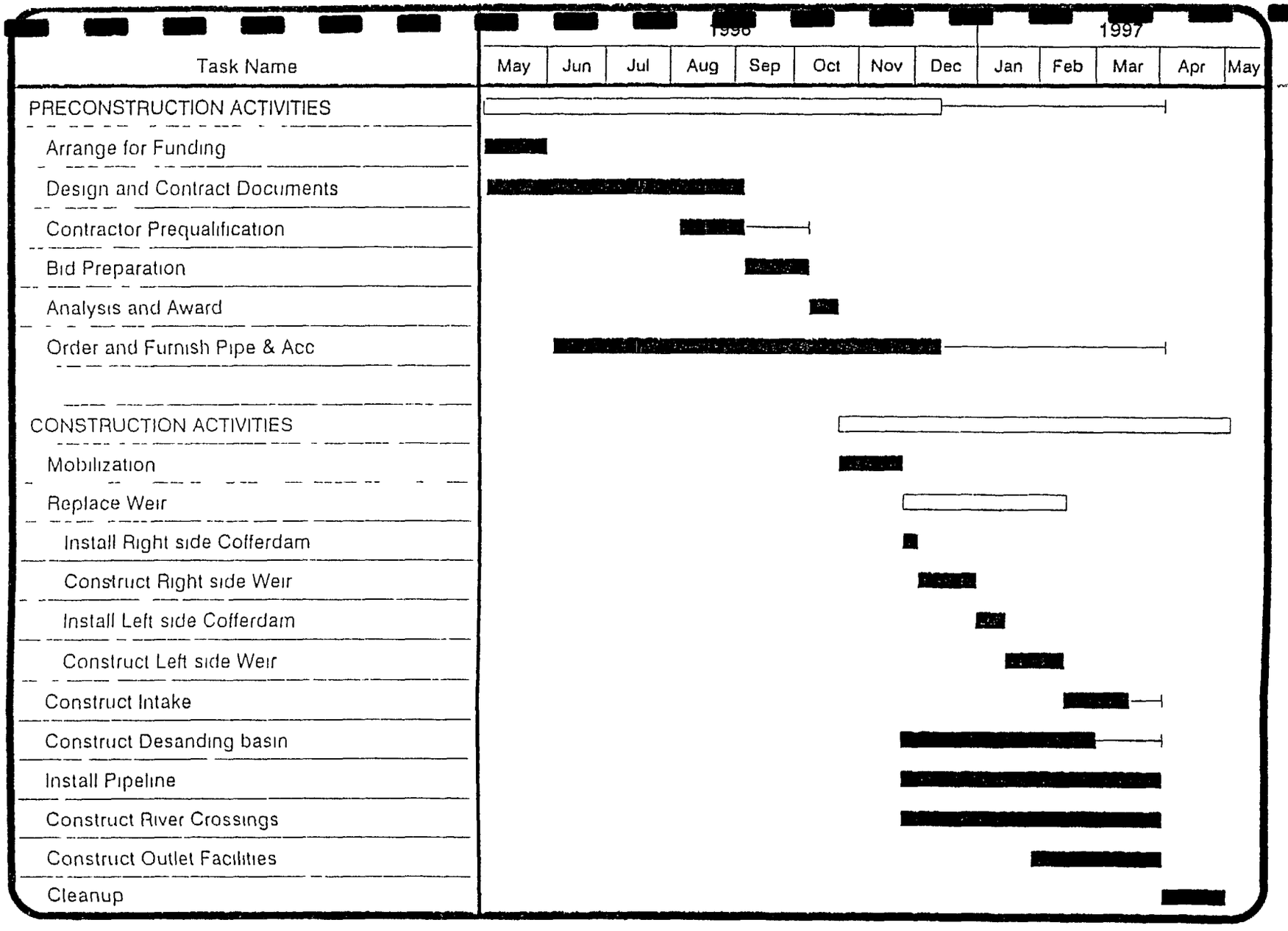
	1994 1995 Season								
	Without Project			With Project					
	EC (dS/m)	Est % Yield	Estimated Returns (JD/du)	Estimated EC (dS/m)	Est % Yield	Estimated Returns (JD/du)	Project Benefit (JD/du)	Gross Benefit (1990 Cropping)	Gross Benefit (1994 Cropping)
FRUIT TREES									
Citrus									
Citrus	2 08	77%	627	1 44	92%	752	124 857	265 294	272,016
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	82,228
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%	61	21 849	696	696
Grape	2 08	84%	244	1 40	94%	273	26 591	13,173	13,182
Grape	2 08	84%	526	1 40	94%	588	61 669	28,421	28 443
Peach	2 20	66%	361	1 43	90%	494	132 667	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	187,481
						Sub-total 1991 data		332,692	389,298
						Sub-total 1993 data		468 328	584,045
FIELD CROPS									
Wheat	1 87	100%	17	1 21	100%	17		-	-
Maize	2 30	79%	46	1 41	95%	55	9 316	2,741	9 607
Garlic	2 00	71%	196	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	26 065	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	10 318
Tomato	2 00	96%	290	1 39	100%	304	13 489	114 116	4,614
Squash	2 19	100%	275	1 81	100%	275			
Eggplant	2 15	81%	288	1 73	89%	315	26 255	67 677	39,974
Eggplant (PH)	1 91	86%	2 355	1 40	95%	2 606	251 024	519 918	307,095
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	22 564	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			

FINANCIAL ANALYSIS
ZARQA RIVER CONVEYANCE STUDY

			JDx1,000
Equalizing Revenues (1995 JDx1,000)	455	Reference Year Cost	5 311
Construction Cost (1995 JDx1,000)	5 311	Escalated Cost	5 744
O & M Cost (1995 JDx1,000)	55	Equity Financing	0
Inflation Rate	3 0%	Debt Financing	5,744
Debt Financing	100%	Interest During Const	185
Debt Cost of Money	6 0%	O & M Account	58
Discount Rate	6 0%	Debt Service Reserve Acc	0
Interest on Debt	6 0%	Interest on Invested Fund	0
Debt Repayment period	20 Years	Financing Fee	185
Financing Fee	3 0%	Total Debt Investment	6,173

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
zing Revenues	0	482	497	512	527	543	559	576	593	611	629	648	668	688	708	729	751	774	797	821	846
Costs	0	58	60	62	64	66	68	70	72	74	76	78	81	83	86	88	91	94	96	99	102
Capital Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ce	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
iation	0	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
Operating Expenses	0	173	175	177	179	181	183	185	187	189	191	193	196	198	201	203	206	209	211	214	217
erating Income	0	309	322	335	348	362	377	391	406	422	438	455	472	490	508	526	546	565	586	607	628
Charges	0	370	360	350	338	326	314	300	286	271	255	238	220	201	180	159	136	112	86	59	30
Before Taxes	0	-61	39	15	10	36	63	91	121	151	184	217	252	289	327	368	410	454	499	548	598
Taxes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
come	0	-61	39	15	10	36	63	91	121	151	184	217	252	289	327	368	410	454	499	548	598
al Repayment	0	168	178	189	200	212	225	238	252	267	284	301	319	338	358	379	402	426	452	479	508
low	0	114	102	88	75	-61	-47	32	17	1	15	32	49	66	84	103	122	142	163	184	205
Value of Cash Flow	0	102	85	70	56	-43	31	20	10	1	8	16	23	29	35	41	45	50	54	57	60
ative Present Value sh Flow	0	102	187	257	313	356	387	-407	-417	-418	-410	394	371	342	307	-266	221	-171	-118	-60	0

Exhibit 7 8



Zarqa River Conveyance Study

Jordan Water Quality Improvement and Conservation Project

IMPLEMENTATION SCHEDULE

Exhibit 8 1

Exhibit 9 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 Project Hwaret Pipeline	16.3 (Vegetables)	1 1 (vegetables) 0 - 0 6 (citrus)	37	2 1 bridge, 1 buried	6
Proposed Project with Mitigation	0	Same as Proposed Project	Same as Proposed Project	Same as Proposed Project	Same as Proposed Project
Hwaret Canal-Pipeline	Same as Proposed Project	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

Exhibit 9 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. Hwaret 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 Project
Hwaret Canal-Pipeline	Same as No-Action Alternative	Same as Proposed Project	Same as Proposed Project
Thahab Pipeline	No Flow[2] (0-20 L/s)	Same as Proposed Project	Same as Proposed Project

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 The Hwaret Weir

Exhibit 9 3

Effects of Alternatives on Water Quality of Zarqa River at Sites Downstream of the 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 Project Hwaret 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 Project 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 Project
Hwaret Canal-Pipeline	Same as Proposed Project	Same as Proposed Project	Same as Proposed Project	Same as Proposed Project
Thahab Pipeline	No Flow	Same as Proposed Project	Same as Proposed Project	Same as Proposed Project

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 (University of Jordan, 1994, 1995)

[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

Exhibit 9 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 Project Hwaret 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 Hwaret.** Same as No-Action **Hwaret to Abu Zeighan** Open Water birds - Good, Thick Cover Water birds - Fair, Songbirds - Good Shorebirds - Poor, Small Raptors - Fair Large Raptors - Poor
Proposed Project 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 Hwaret** Same as No-Action **Hwaret to Abu Zeighan** Open Water birds - Good, Thick Cover Water birds - Good Songbirds - Excellent, Shorebirds - Fair, Small Raptors - Fair Large Raptors - Poor
the Hwaret Canal-Pipeline	Same as Proposed Project	Same as Proposed Project	Same as Proposed Project
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

Exhibit 9 5

Effects on Human Uses of the Zarqa River and in the Areas Irrigated from the KAC-s

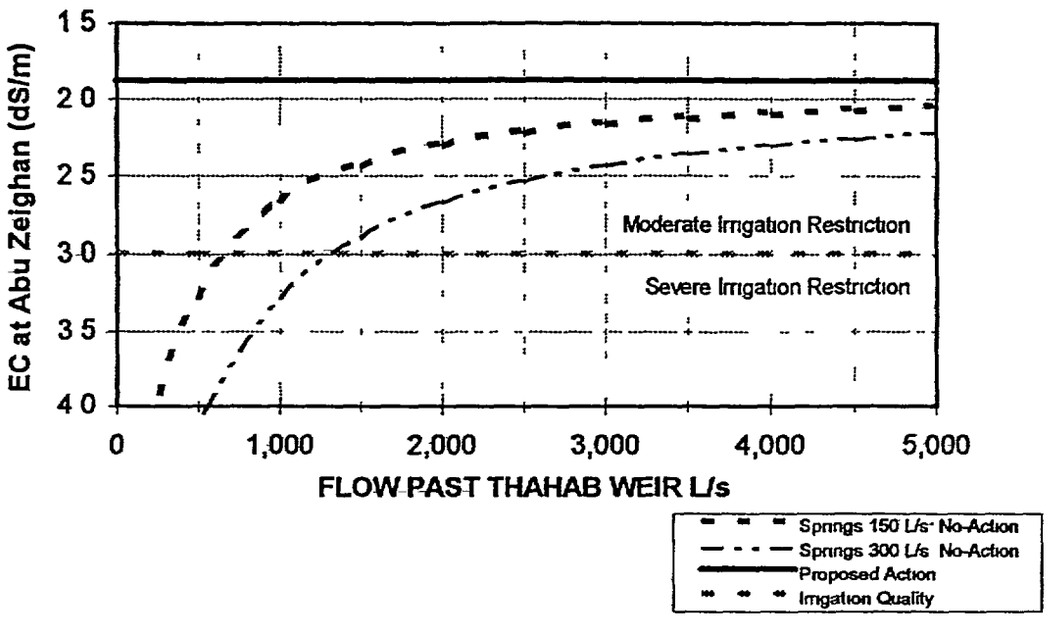
Alternative	Thahab to Hwaret (5 2 river km)	Hwaret to Abu Zeighan (4 7 river km)	Below Abu Zeighan (17 river km)	Irrigated Areas (42,000+ du)
No-Action	**Irrigation**· Moderate Restriction - one user **Pastoralists** "Very Satisfactory" (Occasional No Flow) **Bathing**· None **Washing** Limited	**Irrigation** 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 Project Hwaret 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 Project 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 Project
Hwaret Canal-Pipeline	Same as No-Action	Same as Proposed Project	Same as Proposed Project	Same as Proposed Project
Thahab Pipeline	**Irrigation** No Flow - one user **Pastoralists** "Very Satisfactory" (Frequent No Flow) **Bathing** None **Washing** Limited use	Same as Proposed Project	Same as Proposed Project	Same as Proposed Project

Exhibit 9 6

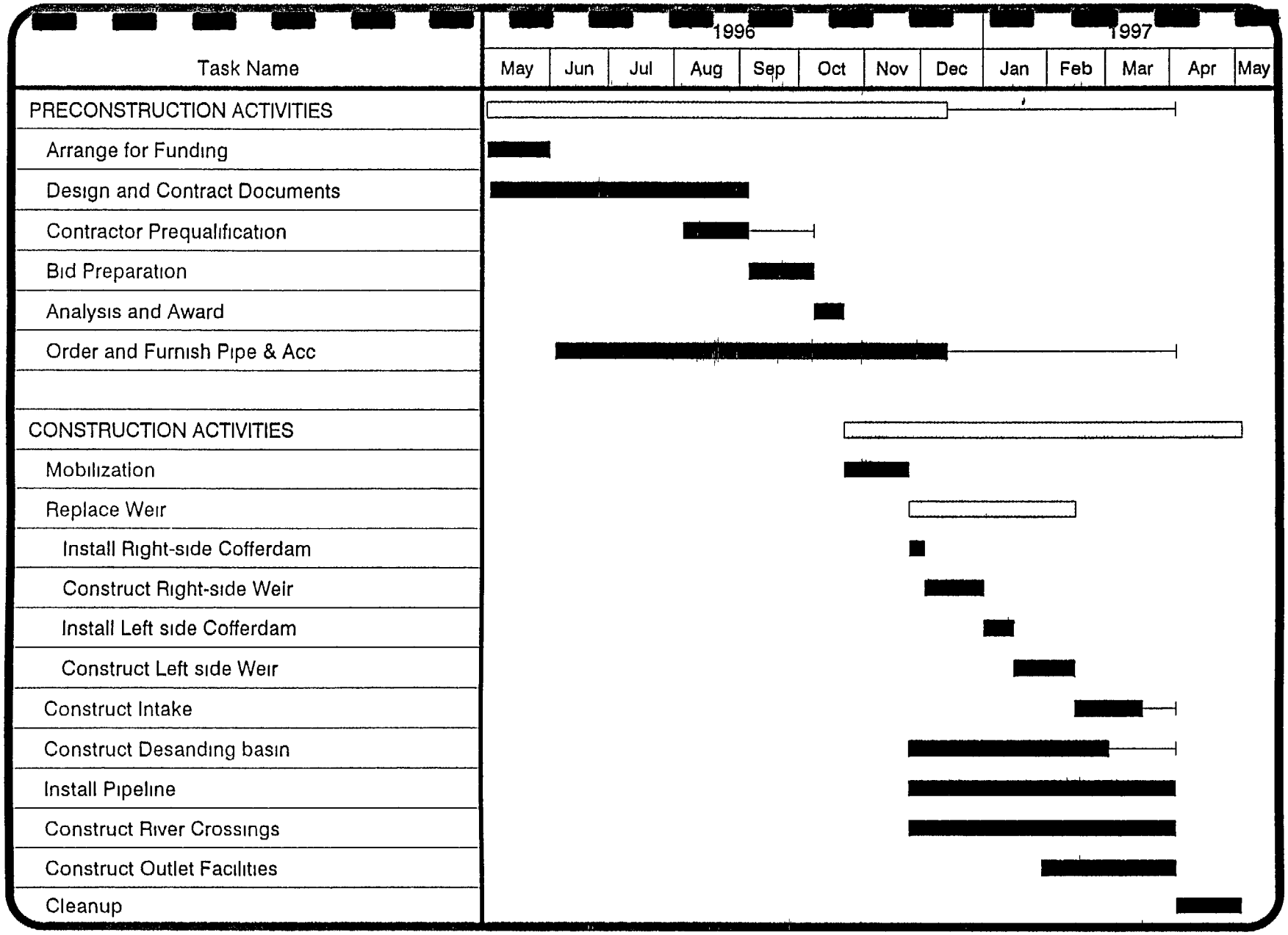
Average EC's (dS/m) in the KAC-s for Various Growing Periods
"Without" represents the average of observed monthly average values, "With" represents the predicted value that would have occurred had the project been in operation

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

Exhibit 9 7



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)



Zarqa River Conveyance Study

Jordan Water Quality Improvement and Conservation Project

IMPLEMENTATION SCHEDULE

Exhibit 10 1

GEOTECHNICAL APPENDIX

		Page
		I
TABLE OF CONTENTS		II
	INTRODUCTION	1
	1 1 Purpose Of Study	1
	1 2 Scope Of Work	1
2 0	PROJECT DESCRIPTION	1
	SITE DESCRIPTION	2
	FIELD EXPLORATION AND LABORATORY TESTING	2
	4 1 Field Exploration	2
	4 1 1 Drilling	2
	4 1 2 Sampling	4
	4 1 3 Field Testing in Boreholes	4
	4 2 Laboratory Testing	4
5 0	SURFACE AND SUBSURFACE CONDITIONS	13
	5 1 Ground Materials	13
	5 2 Materials Physical & Mechanical Properties	13
	5 3 Materials Chemical Properties	22
	5 3 1 Sulphate Content In Ground Material	22
	5 3 2 Chloride Content In Ground Material	22
	5 3 Ground Water And Cavities	23
	CONCLUSIONS AND RECOMMENDATIONS	24
	6 1 Foundation Depth And Type	24
	6 2 Allowable Bearing Pressure	24
	6 3 Foundation Settlement	24
	6 4 Excavation Methods	24
	6 5 Excavation of Side Slopes	25
	6 6 Drainage	25
	6 7 Backfill Materials And Compaction Criteria	25
	6 8 Earth Pressure	25
	6 9 Foundation Excavation Inspection	25
	APPENDIX A Logs Of Borings	25

52

TABLE OF CONTENTS

Page

LIST OF FIGURES

Figure No 1	General Site Plan	3
Figure No 2	Grain Size Distribution	8
Figure No 3	Generalized Subsurface Profile AA'	14
Figure No 4	Generalized Subsurface Profile BB'	15
Figure No 5	Generalized Subsurface Profile CC'	16
Figure No 6	Generalized Subsurface Profile DD'	17
Figure No 7	Textural Classification Chart	19
Figure No 8	Casagrande Plasticity Chart	20
9	Modified Chart Of Expansiveness	21

LIST OF TABLES

Table No 1	Laboratory Test Results	5
Table No 2	Chemical Test Results	12
3	Materials Types & Properties	18

1.0 INTRODUCTION

This report presents the results of the geotechnical investigation for the proposed site in Deir Alla

1.1 Purpose Of Study

The purpose of this study is to determine the surface and subsurface conditions at the project site and the physical and mechanical properties of the foundation ground in order to provide the structural engineer with sufficient information for the design of most suitable and safe foundations

1.2 Scope Of Works

The scope of work consists of the following

1. Collecting information and maps particular to the project site such as public services, site plan and land use maps
2. Making visits to the site to collect information about present land use surface topography, geological features and surface drainage
3. Drilling of eight boreholes and sampling of disturbed and undisturbed samples
4. Carrying out the necessary laboratory tests
5. Performing engineering analysis of field and laboratory findings
6. Developing conclusions and recommendations for foundation design and construction

2.0 PROJECT DESCRIPTION

The project consist of a pipe-line and its assosiated structures to carry part of the Zarqa river water (Talal Dam outlet water) to separate it saline base flow water

3 0 SITE DESCRIPTION

The surficial ground is covered with wadi deposits composed of sandy silty clay with gravel and cobbles of limestone and chert

No electrical or telephone poles, sewer or water pipes were observed within the site area However electricity and water services are provided for the area

According to the geological maps for Deir Alla area and following our inspections, the general site area belongs to the Ajlun Group, Na'ur Formaion (A1/2) which is mainly formed of limestone marls, clays, marly clay, marly limestone and occasionally shales No faults or other special geologic features were observed at the site

A general site plan showing the location of the building and boreholes is presented in figure no 1

4 0 FIELD EXPLORATION AND LABORATORY TESTING

4 1 Field Exploration

4 1 1 Drilling

On Jan 20 and 21, 1996 eight boreholes were drilled at the site The boreholes are numbered 1 through 8 and they were drilled to a depth of 6 0 m each below the existing ground surface, respectively The locations of the boreholes are shown in figure no 1

The drilling was executed with Hands England-Drill Master 18 rotery rig, mounted on Mercedes LK 608, Truk, capacity = 120 m, using the rotary air flush drilling method The logs of the three boreholes are presented in Appendix A

15

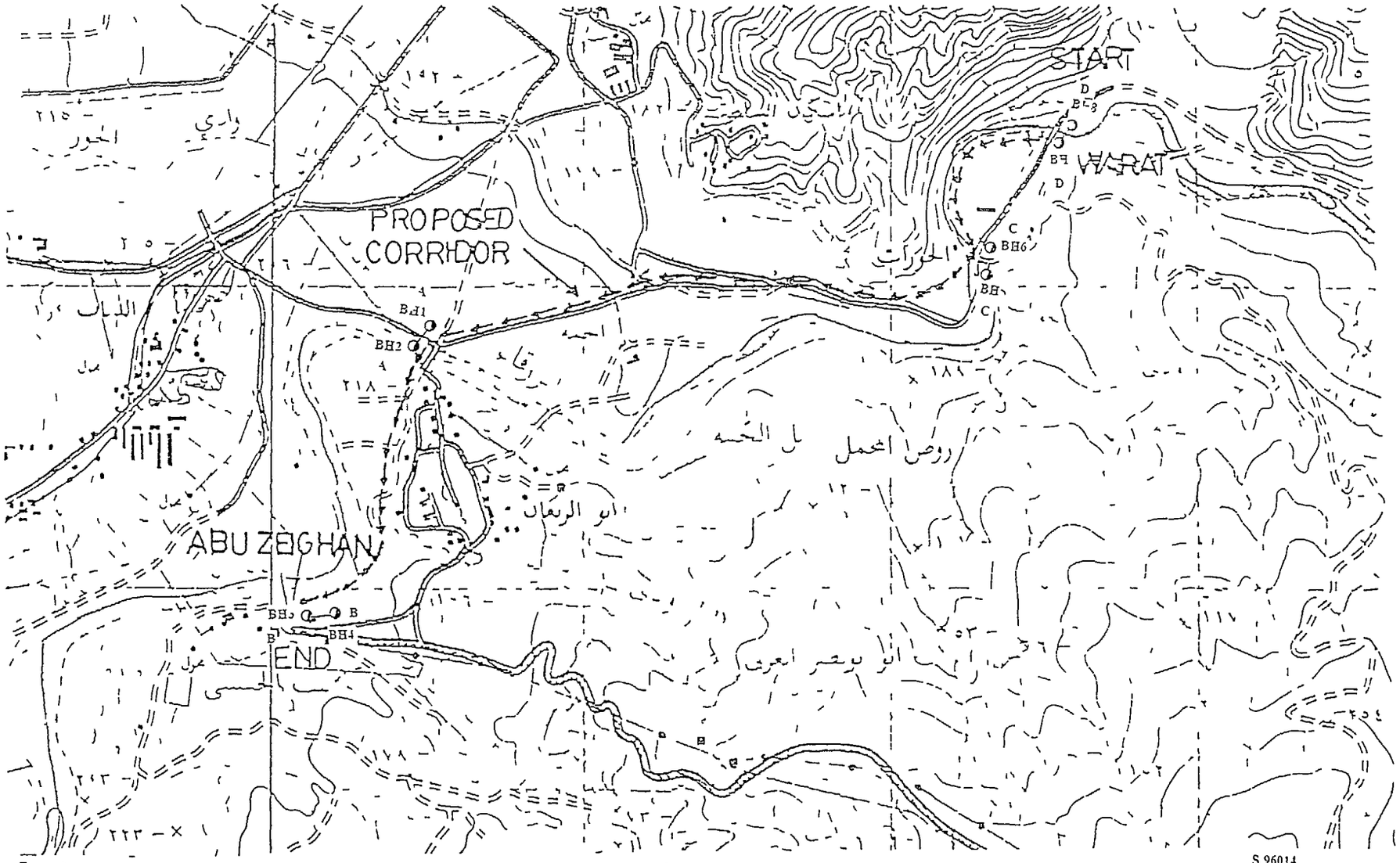


Figure No 1

General Site Plan
Scale 1 1250

S 96014

BEST AVAILABLE COPY

4 1 2 Sampling

Because of the hard and mixed nature of the materials encountered in all the boreholes, only disturbed and split spoon samples were obtained using down the hole hammer The samples recovered were examined described and classified by our geotechnical engineers, placed in proper sequence in wooden boxes and taken to our laboratories for testing The moist samples were placed in waterproof plastic bags before placing in wooden boxes

4 1 3 Field Testing

Standard Penetration Tests (S P T) were performed at various depths in most boreholes to obtain approximate relative densities of the ground materials The tests were performed in accordance with

4 2 Laboratory Testing

In order to determine the physical and mechanical properties of the ground materials laboratory tests were performed on selected samples from the boreholes The following tests were performed according to American Society For Testing And Materials (ASTM) Standards

1 ASTM D 2216-80 "Laboratory Determination Of Water (Moisture) Content Of Soil Rock And Soil Aggregate Mixtures"

2 ASTM D 4318-93, "Test for Liquid Limit Plastic Limit and Plasticity Index of Soil"

3 ASTM D 422-63 (1990) "Particles Size Analysis Of Soils"

4 ASTM C 136-93 ' Method For Sieve Analysis Of Fine and Coars Aggregate"

5 B S 1377 Part 3 1990 Test 5 ' Determination Of The Sulphate Content Of Soil And Ground Water Gravimetric method for acid extracts in which hydrochloric acid was used

6 B S 1377 Part 3 1990, Test 7 3 Determination Of Acid-Sobuble Chloride Content" Nitric acid was used

7 B S 1377 Part 3 1990 Test 9 Determination Of The pH Value

8 ASTM D 4373-84 (1990) Standard Test Method for Calcum Carbonate of Soils '

The results of the tests 1 through 4 are summarized in Table No 1 Grain size distribution charts are plotted on figure no 2 Chemical test results (Tests from 5 thruogh 8) are presented in Table No 2

TABLE No 1

LABORATORY TEST RESULT

S95014

BN	D (m)	Bd (g/cm^3	M/C (%)	ATTERBERG LIMITS			PARTICLE SIZE DISTRIBUTION				UNCONFIN TEST		TRIAXIAL TEST	
				LL (%)	PL (%)	PI (%)	GRVL (%)	SAND (%)	SILT (%)	CLAY (%)	qu (Kg/cm2)	F SL (%)	C (Kg/cm2)	ϕ (°)
1	0 5		14 2											
	1 5		15 6	22 6	17 3	5 3	2 2	61 5	31 5	4 8				
	2 5		10 6											
	3 5		13 6											
	4 5		6 3											
	5 5		4 3											
2	0 5		14 5											
	1 5		15 5											
	2 5		4 9											
	3 5		4 2											
	4 5		8 6											
	5 5		11 0											
3	0 5		13 9											
	1 5		11 9											
	2 5		3 9	22 6	6 8	15 8		79 0	18 3	2 7				
	3 5		10 9											
	4 5		0 3											
	5 5		2 8											
4	0 5		10 0											

BN Boring Number
D Depth
Bd Bulk Density
qu Compressive Strength
LL Liquid Limit
PL Plastic Limit
PI Plasticity Index
C Cohesion
ϕ Friction Angle
M/C Moisture Content
F SL Failure Strain

158

TABLE No 1

LABORATORY TEST RESULT

S95014

BN	D (m)	Bd (g/cm^3	M/C (%)	ATTERBERG LIMITS			PARTICLE SIZE DISTRIBUTION				UNCONFIN TEST		TRIAXIAL TEST	
				LL (%)	PL (%)	PI (%)	GRVL (%)	SAND (%)	SILT (%)	CLAY (%)	qu (Kg/cm2)	F St (%)	C (Kg/cm2)	φ (°)
4	1 5		10 0											
	2 5		9 1	38 7	18 6	20 1	0 8	17 9	52 6	28 7				
	3 5		6 2											
	4 5		14 0											
	5 5		8 1											
5	0 5		10 2											
	1 5		13 6	20 0	13 5	6 5	46 3	33 9	17 8	2 1				
	2 5		9 2											
	3 5		4 9											
	4 5		5 2											
	5 5		4 6											
6	0 5		6 8											
	1 5		2 3											
	2 5													
	3 5													
	4 5													
	5 5		5 2											
7	0 5		12 5											
	1 5		12 3											

BN Boring Number
D Depth
Bd Bulk Density
qu Compressive Strength
LL Liquid Limit
PL Plastic Limit
PI Plasticity Index
C Cohesion
φ Friction Angle
M/C Moisture Content
F st Failure Strain

TABLE No 1

LABORATORY TEST RESULT

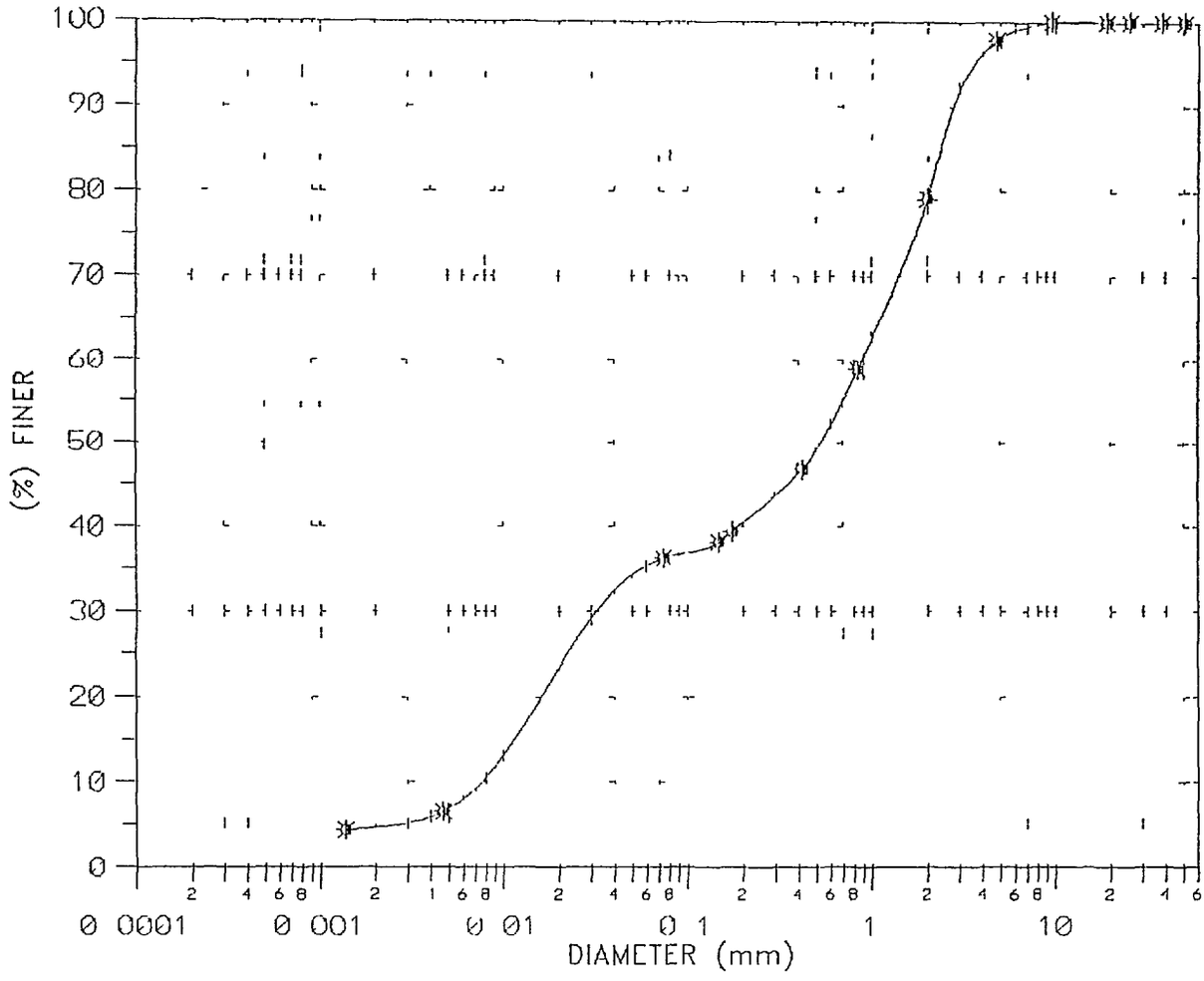
S95014

BN	D (m)	Bd (g/cm^3	M/C (%)	ATTERBERG LIMITS			PARTICLE SIZE DISTRIBUTION				UNCONFIN TEST		TRIAXIAL TEST	
				LL (%)	PL (%)	PI (%)	GRVL (%)	SAND (%)	SILT (%)	CLAY (%)	qu (Kg/cm2)	F St (%)	C (Kg/cm2)	ϕ (°)
7	2 5		14 2											
	3 5		4 3											
	4 5		7 1											
	5 5		4 6											
8	0 5		8 6											
	1 5		6 8											
	2 5		6 2											
	3 5		5 3											
	4 5		8 2											
	5 5		4 9											

BN Boring Number
D Depth
Bd Bulk Density
qu Compressive Strength
LL Liquid Limit
PL Plastic Limit
PI Plasticity Index
C Cohesion
ϕ Friction Angle
M/C Moisture Content
F St Failure Strain

160

Grain Size Analysis

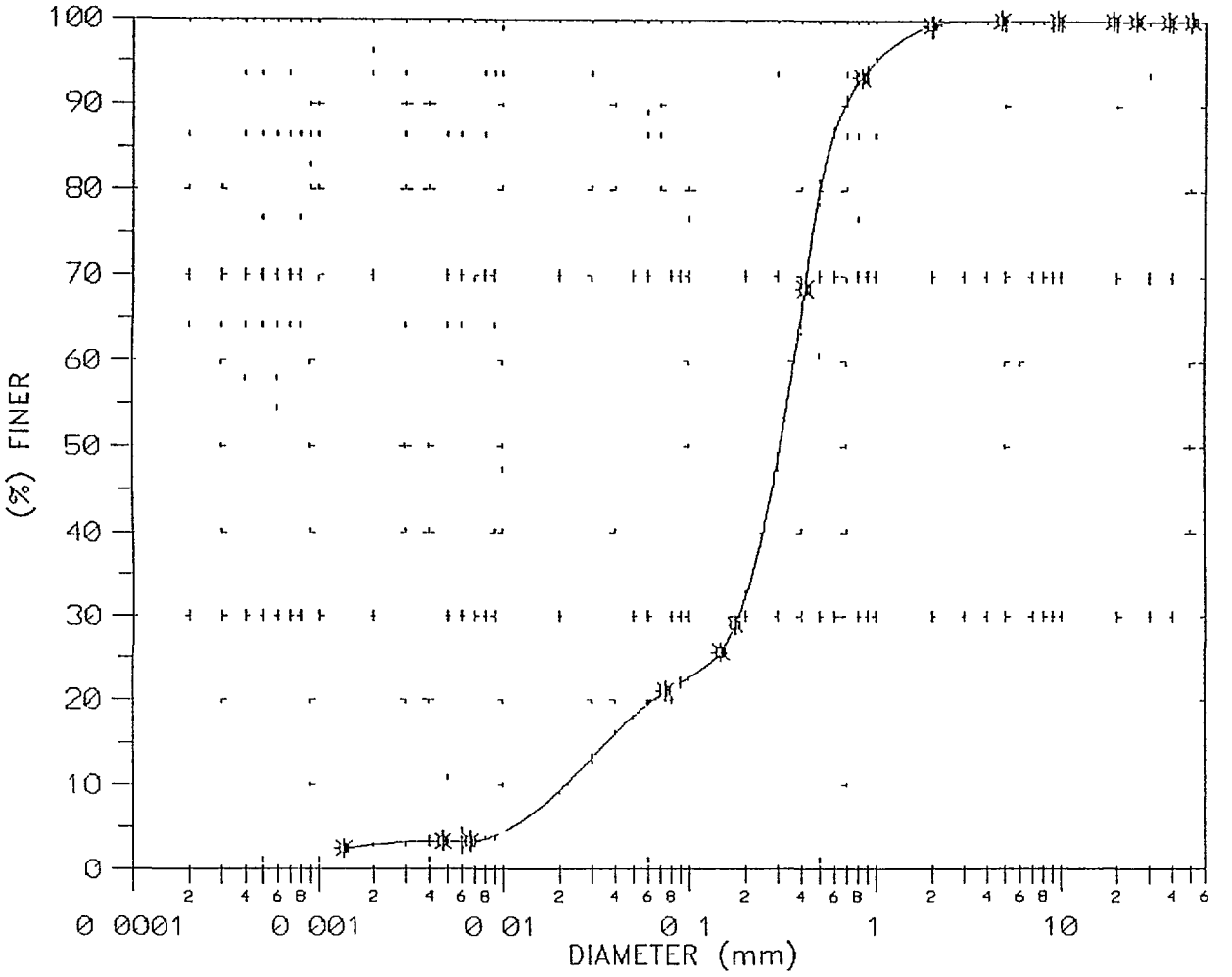


SYM	BN	SAMPLE No	DEPTH (m)	GRVL (%)	SAND (%)	SILT (%)	CLAY (%)	CLASSIFICATION
✳	1	351	1 5	2 20	61 51	31 52	1 77	Sandy Silt

Figure No 2a

S 95014

Grain Size Analysis

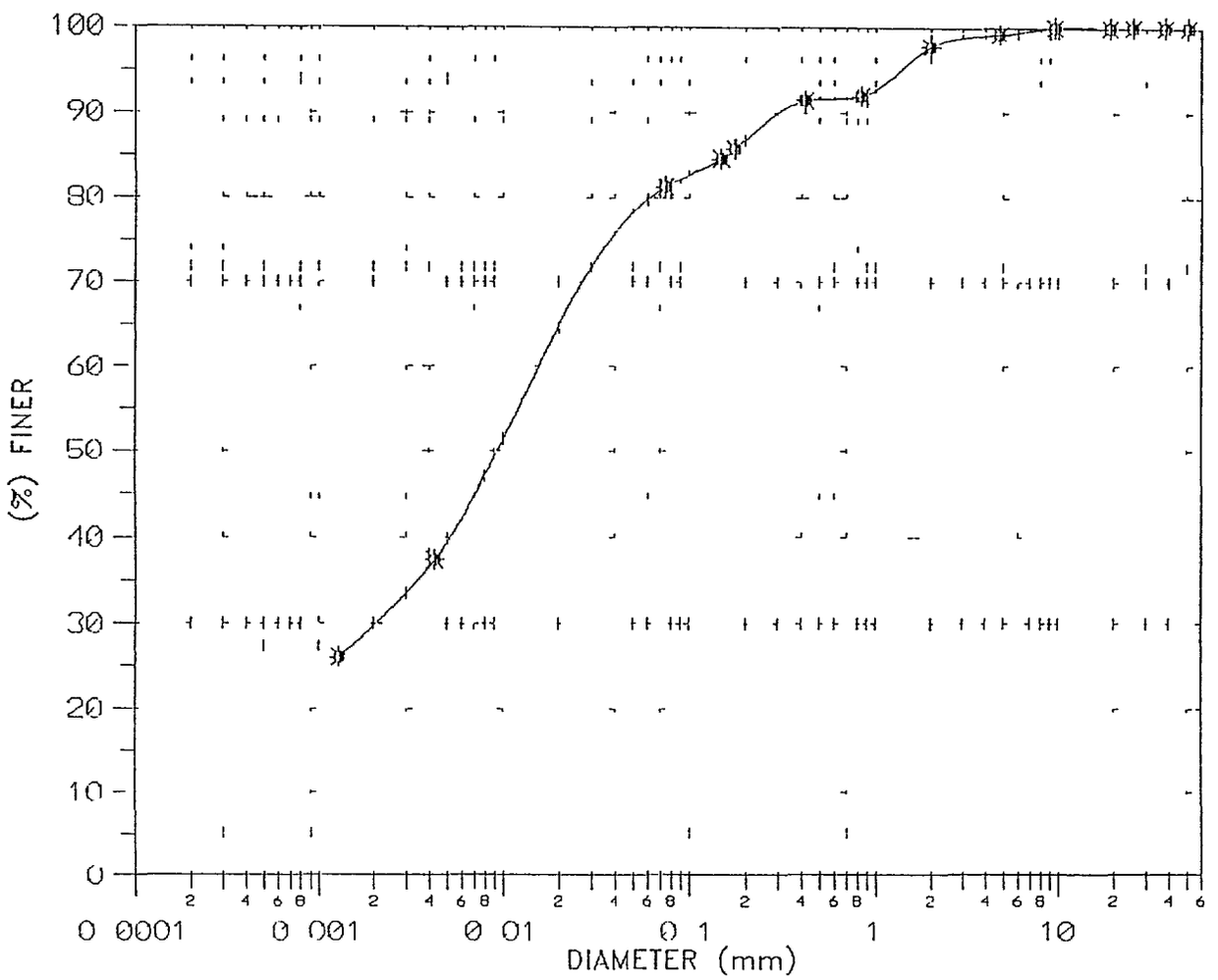


SYM	BN	SAMPLE No	DEPTH (m)	GRVL (%)	SAND (%)	SILT (%)	CLAY (%)	CLASSIFICATION
✳	3	369	2 5	0 00	79 00	18 33	2 68	Slightly Clayey Sand

Figure No 2b

S 95014

Grain Size Analysis

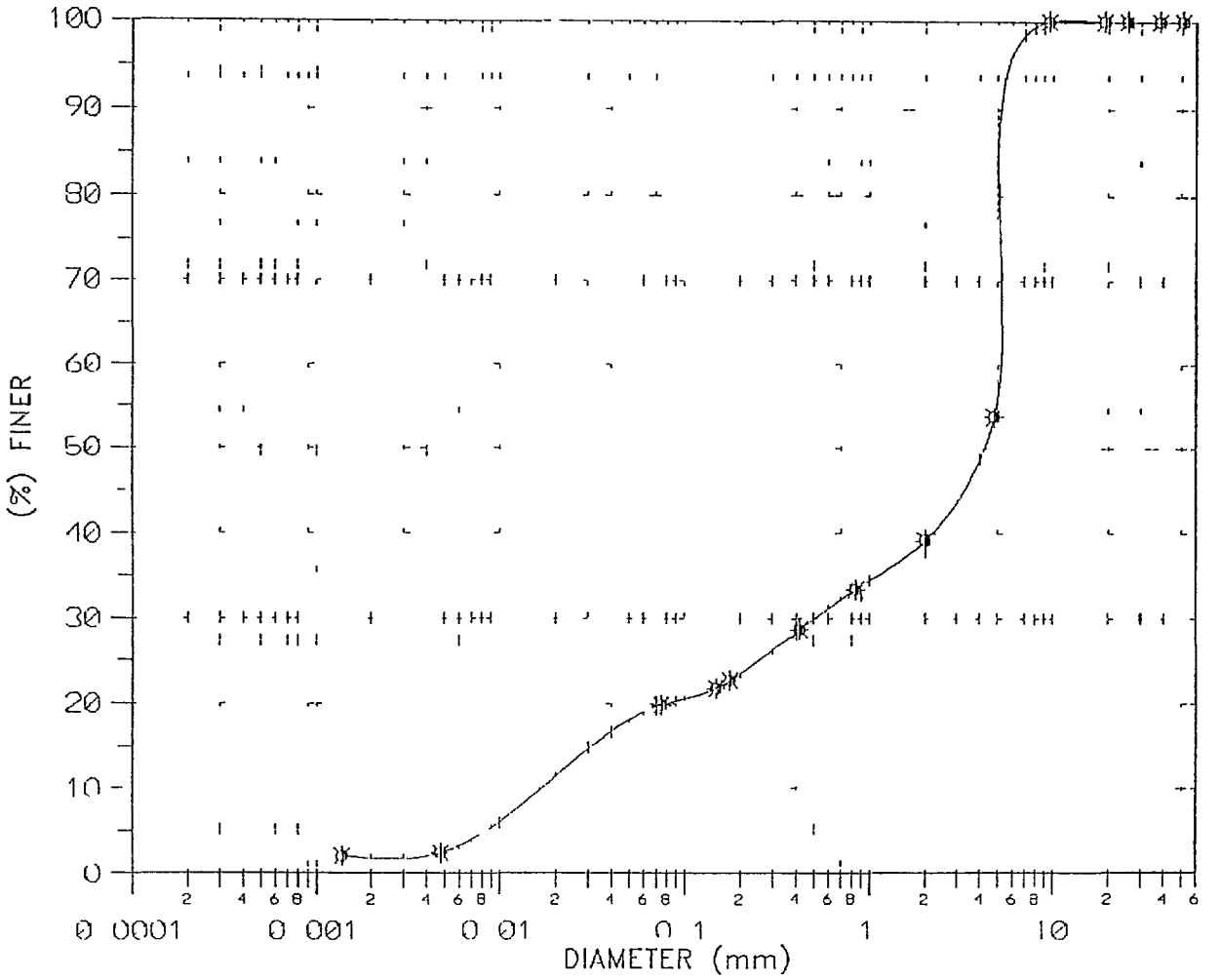


SYM	BN	SAMPLE No	DEPTH (m)	GRVL (%)	SAND (%)	SILT (%)	CLAY (%)	CLASSIFICATION
⊕	4	377	2 5	0 84	17 87	52 58	28 71	Silty Clay with Sand

Figure No 2c

S 95014

Grain Size Analysis



SYM	BH	SAMPLE No	DEPTH (m)	GRVL (%)	SAND (%)	SILT (%)	CLAY (%)	CLASSIFICATION
✳	5	382	1 5	46 26	33 80	17 79	2 06	Sandy Silt

Figure No 2d

S 95014

164

TABLE No 2

Chemical Test Results

BN	Depth (m)	SO3 %	CaCo3 %	PH	CL %
4	3 5	0 10	19 21	8 60	0 09
5	1 5	0 02	53 23	9 10	0 02
8	1 5	0 04	14 32	8 80	0 04

BN Boring Number
PH Acidity
CL Chloride
SO3 Sulphate Oxide
GYPS Gypsum
CaCo3 Calcium Carbonate

165

6 0 CONCLUSIONS AND RECOMMENDATIONS

According to field and laboratory investigations, subsurface conditions, engineering analysis and practical experience, it can be concluded that the proposed project building can be satisfactorily supported by the ground at the site, provided that the following recommendations are followed

6 1 Foundation Depth And Type

It is recommended that foundations be laid on the wadi deposits composed of sandy silty clay with gravel and cobbles of limestone and chert

The foundation depth may vary according to the architectural requirements but should not be less than 1 5 m below the finished level of ground surrounding the structures

This foundation ground is suitable to support the structures loads on individual footings with tie beams Strip footings may also be used if required

6 2 Allowable Bearing Pressure

No undisturbed samples could be obtained at the site for strength testing because of the hard, mixed and intercalated nature of the materials encountered However the allowable bearing pressure was estimated based on the results obtained from SPT and according to our previous experience with similar materials Accordingly an allowable bearing pressure value of 2 3 kg/cm^2 is recommended for the whole site area

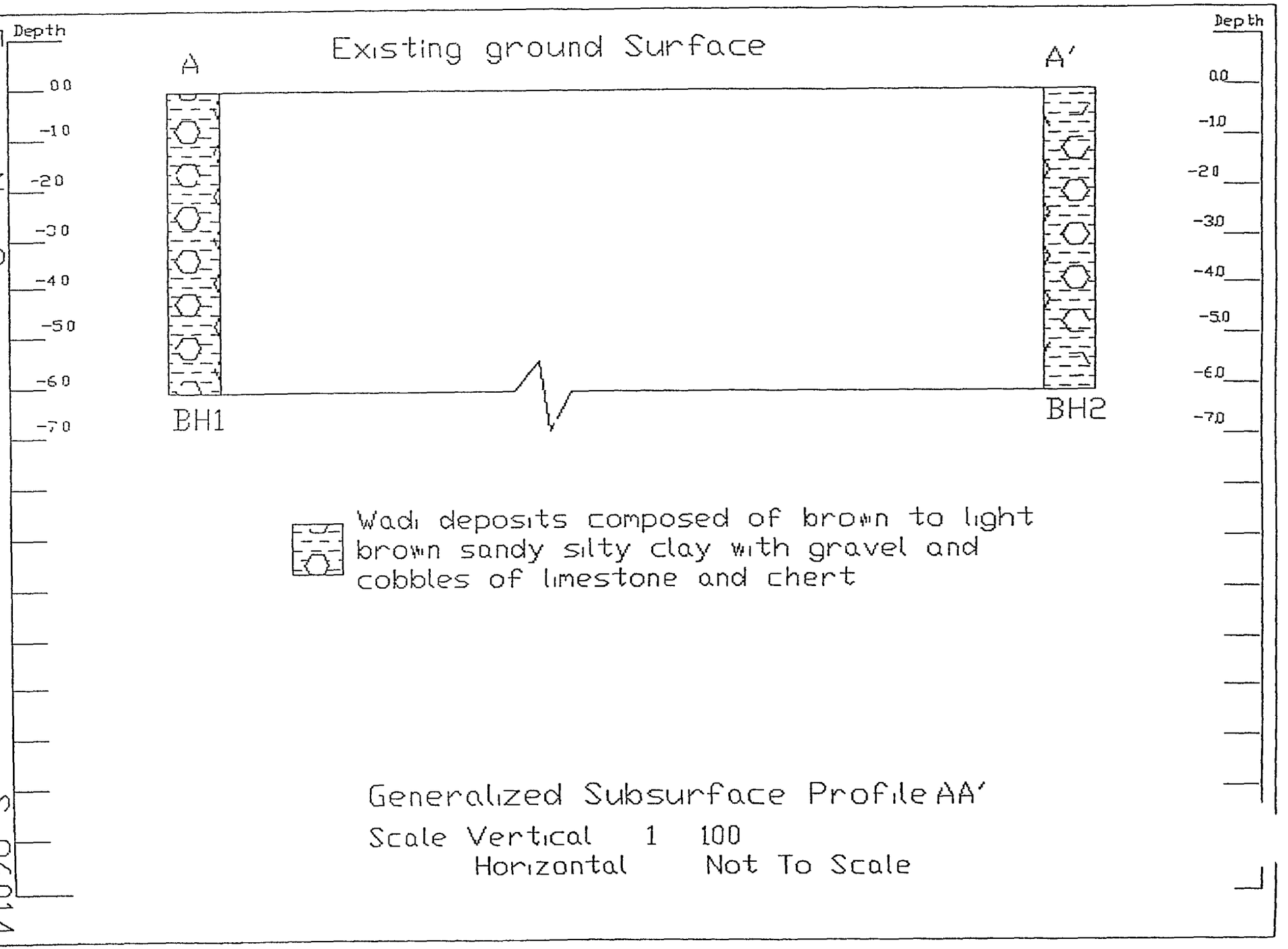
6 3 Foundation Settlement

Short term settlments wich correspond to the estimated net allowable bearing pressure, will be distortion settlement due to the mixed and hetrogenity of the wadi depsits However it is expected that most of settlement will take place during construction and should be accounted for accordingly No applicable long term (consolidation) settlements of the foundations are anticipated since the subsurface soils are composed mainly of granular materials Therefore only short term settlements has been considered due to the granular nature of the subsurface materials encountered This settlement is expected to be small uniform and within tolerable limits

6 4 Excavation Methods

It is expected that the excavation will be through the wadi deposits materials Therefore pneumatic and mechanical equipment such as jack hammers and rock breakers will be required in addition to conventional excavation equipment such as loaders and bulldozers

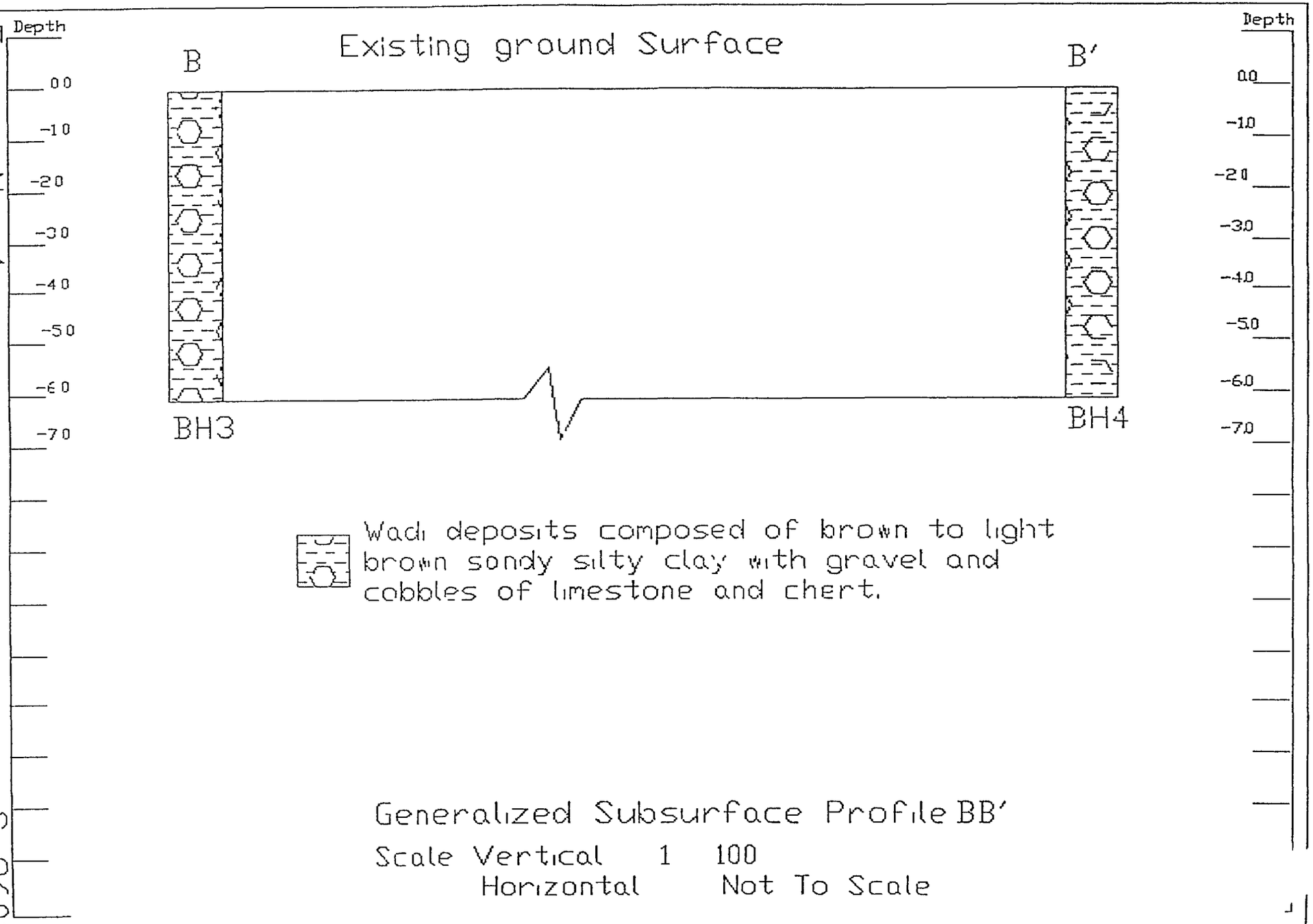
Figure No. 3



S 96014

167

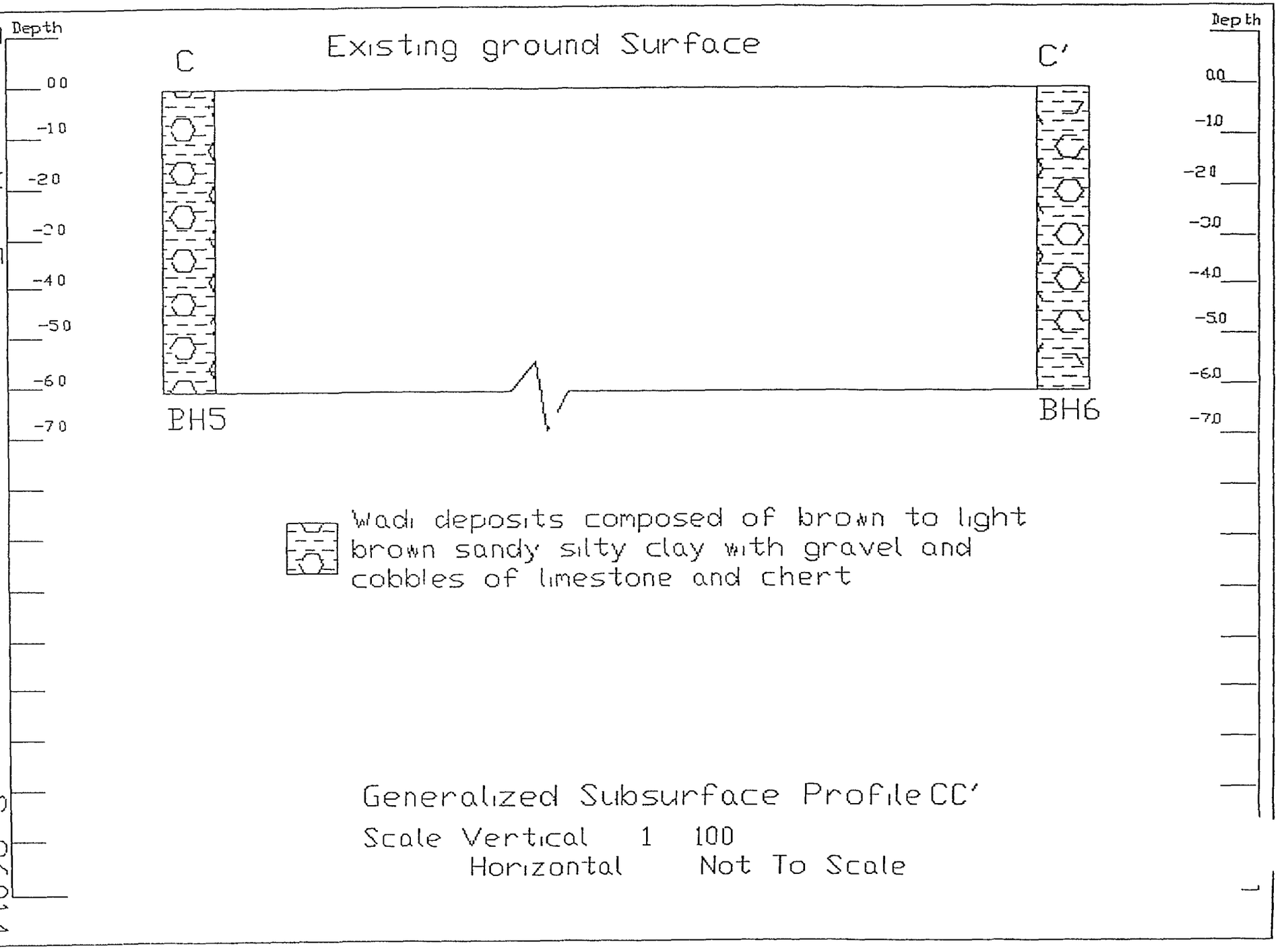
Figure No. 4



S 96014

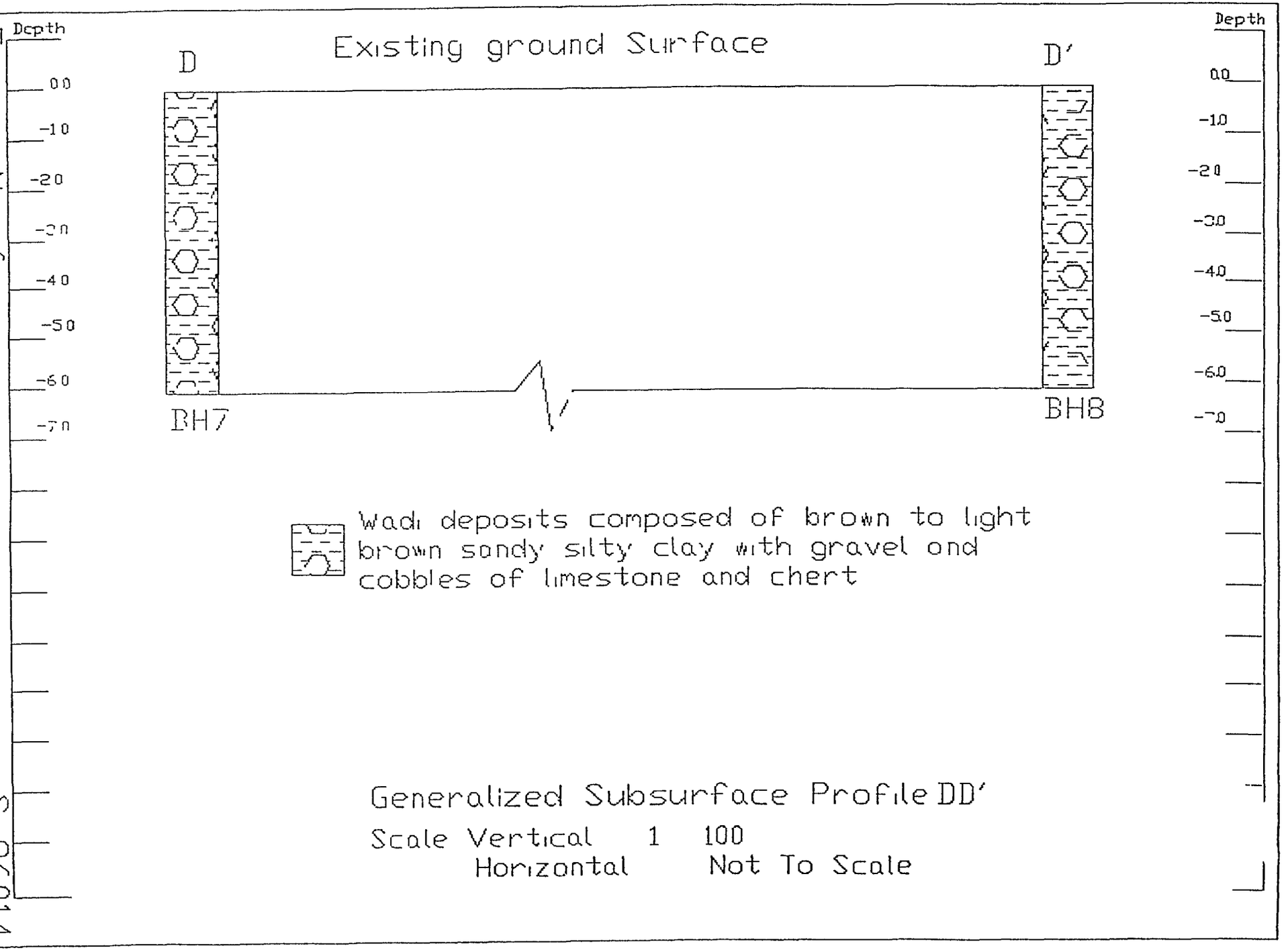
168

Figure No. 5



S 960014

Figure No. 6



S 96014

Table No 3

Material Types and Properties

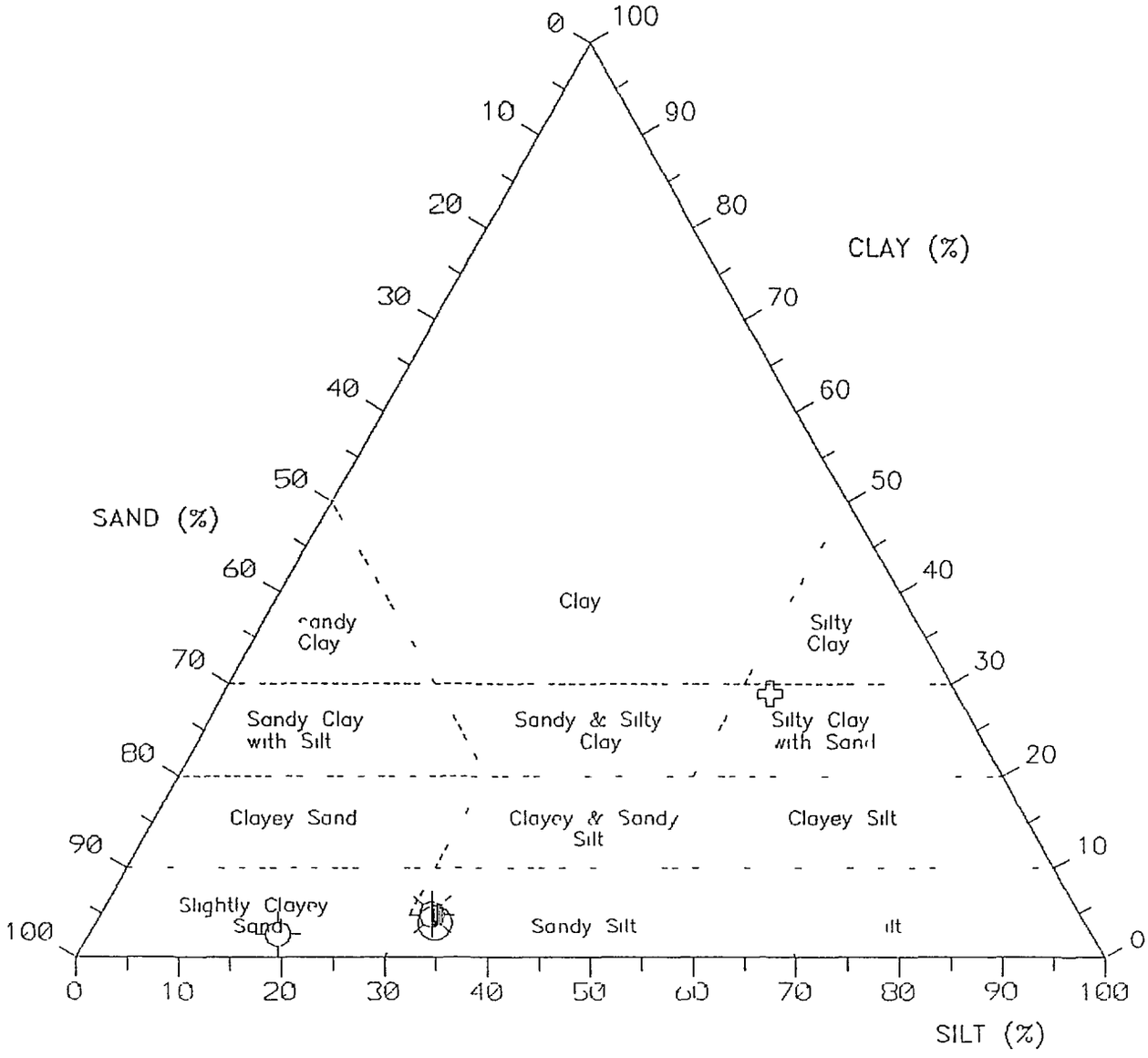
Approximate Depth (m)	Geologic Description	Summary of Test Results	Material Classification
From 0.0 to 6.0 m bottom of all boreholes	Wadi deposits composed of brown to light brown sandy silty clay with gravel and cobbles of limestone and chert	M/C 0.3-15.6% Gr 0.0-46.3% S 17.9-79.0% M 17.8-52.6% C 2.7-28.7% LL 20.0-38.7% PL 6.8-18.6% PI 5.3-20.1% N 13 - 50 / 2 fcm	Tc Sandy silt to slightly clayey sand to silty clay with sand P Low to Medium PE Low to Medium R D Medium to very dense

M/C Moisture Content
Gr Gravel
S Sand
M Silt
C Clay
D Rock Quality Description
LL Liquid Limit
PI Plasticity Index
PL Plastic Limit
TC Textural Classification (For fraction passing sieve no 10)
PI Potential for Expansiveness
P Plasticity (For fraction passing sieve no 40)

' See Legend to Boring Logs, Appendix A

171

TEXTURAL CLASSIFICATION CHART

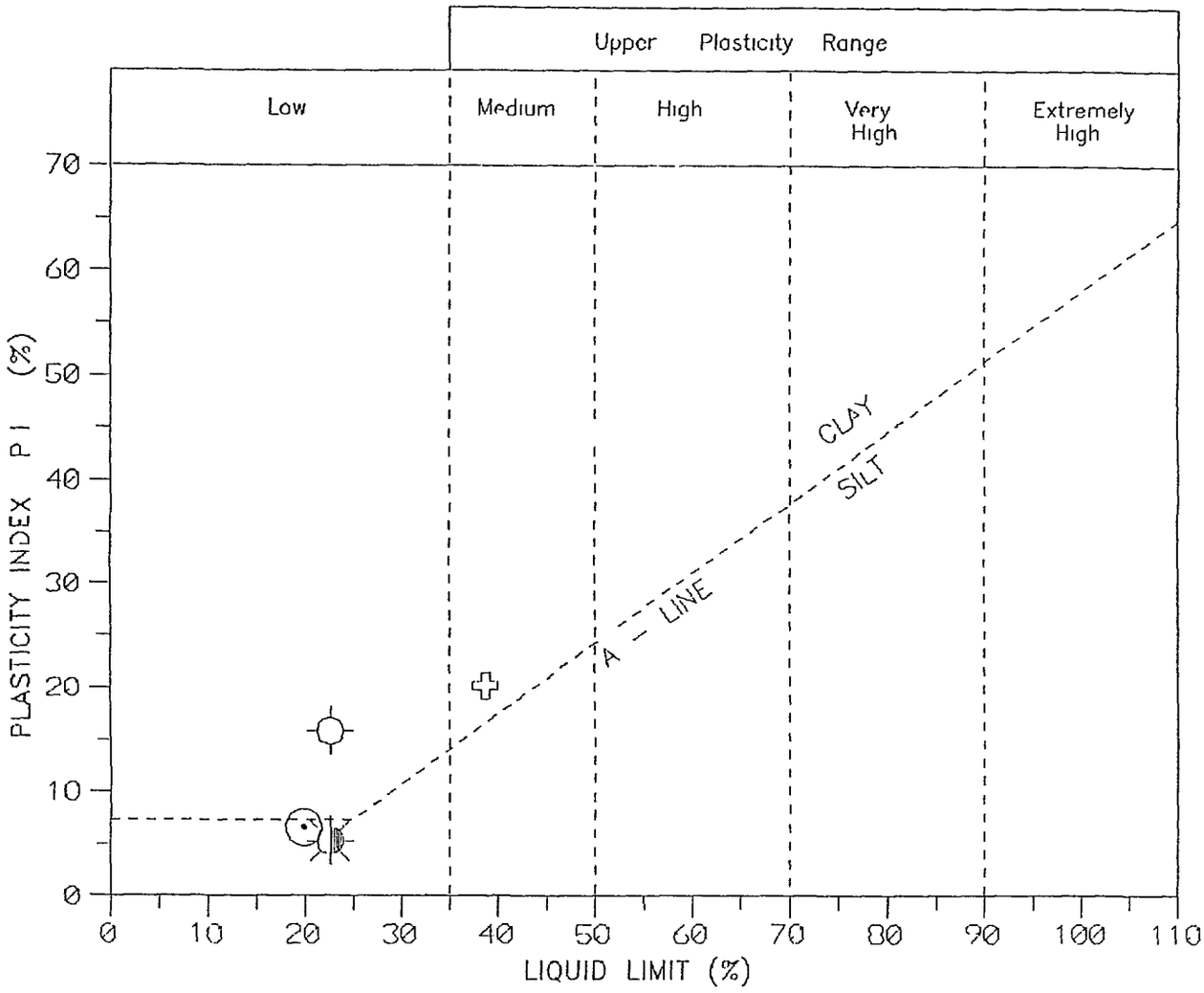


SYM	BN	SAMPLE NO	DEPTH (m)	SAND (%)	SILT (%)	CLAY (%)	CLASSIFICATION
	1	351	1 5	62 89	32 23	4 88	Sandy Silt
	3	369	2 5	79 00	18 33	2 68	Slightly Clayey Sand
	4	377	2 5	18 02	53 03	28 95	Silty Clay with Sand
	5	382	1 5	63 06	33 10	3 83	Sandy Silt

Figure No 7 S 95014

172

CASAGRANDE PLASTICITY CHART
(A - LINE)

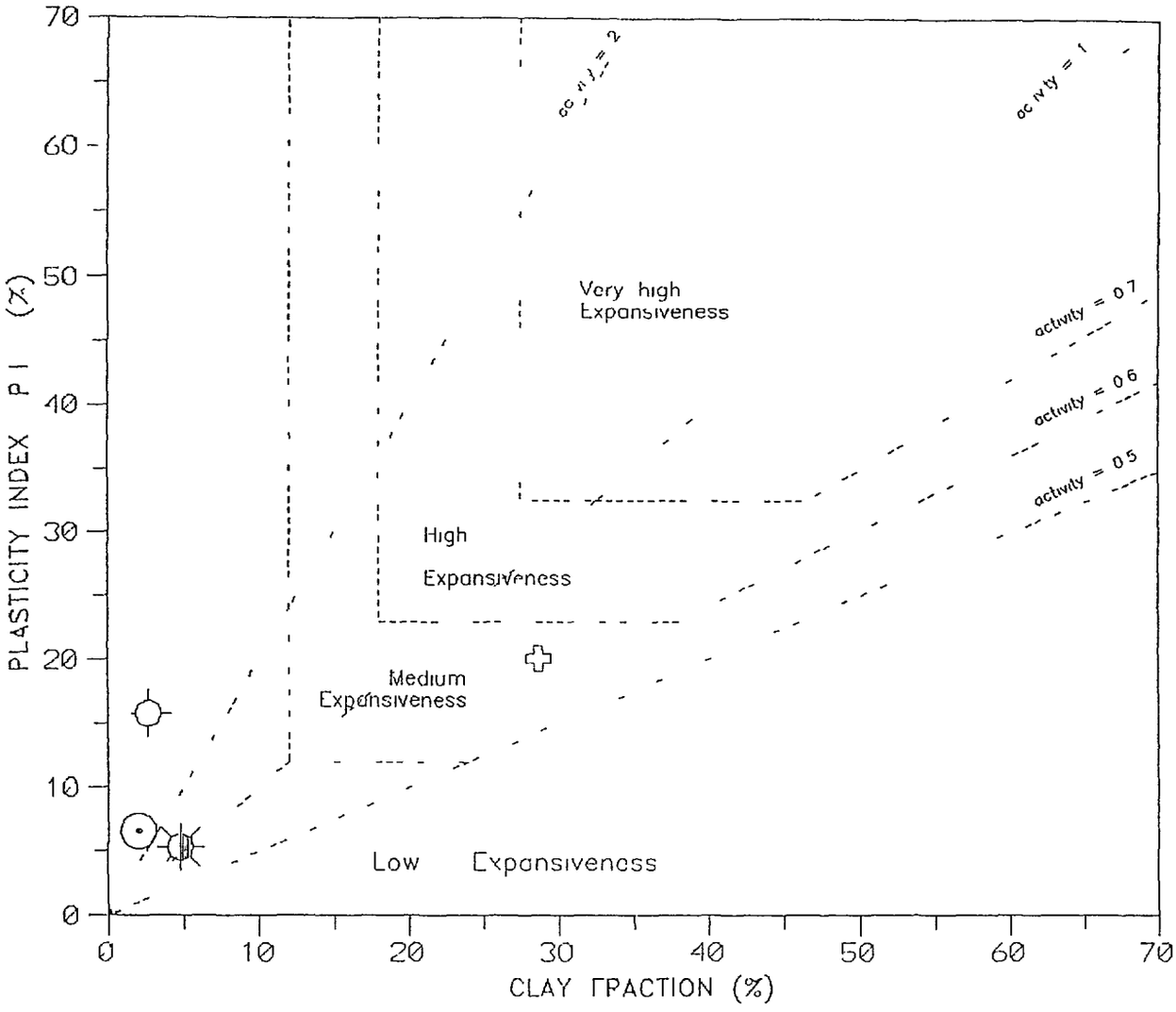


SYM	BN	SAMPLE No	DEPTH (m)	LL (%)	PL (%)	PI (%)	CLASSIFICATION	PLASTICITY
	1	351	1 5	22 60	17 30	5 30	Sandy silt	Low
	3	369	2 5	22 60	6 80	15 80	Slightly clayey sand	Low
	1	377	2 5	38 70	18 60	20 10	Silty clay with sand	Medium
	5	382	1 5	20 00	13 50	6 50	Sandy silt	Low

Figure No 8

S 95014

MODIFIED CHART OF EXPANSIVENESS
(WILLIAMS AND DONALDSON 1980)



SYM	BN	SAMPLE No	DEPTH (m)	CLAY (%)	PI (%)	CLASSIFICATION	POTENTIAL OF EXPANSIVENESS
	1	351	1 5	4 77	5 30	Sandy silt	Low
	3	369	2 5	2 68	15 80	Slightly clayey sand	Low
	1	377	2 5	28 71	20 10	Silty clay with sand	Medium
	5	382	1 5	2 06	6 50	Sandy silt	Low

Figure No 9 S 95014

5 3 Materials Chemical Properties

5 3 1 Sulphate Content

Sulphate content expressed as sulphur trioxide (SO_3) for soil and water samples tested from boreholes and are shown in Table no 2

Sulphate attack to concrete is well documented phenomena and is caused by the presence of high Sulphate content either by the ingress of the Sulphate of the surrounding environment, such as foundations soils or by the presence of Sulphate in the concrete ingredients, such as the sand or aggregate or both The attack results in a considerable internal expansion which may lead to cracking and disintegration of the concrete

The British Standards BS 5328 Part 1 1990 "Guide to Specifying Concrete" have stated requirements for concrete exposed to Sulphate attack, depending in the concentration of the Sulphate in the surrounding soil or in water This requirements state the type of cement to be used, the minimum cement content, and maximum free water to cement ratio Additionally, the British Building Research Establishment (BRE), in UK have published digest 250, "Concrete in Sulphate bearing soils and ground waters" 1981 introducing slight alternatives to the requirements

Due to the Sulphate content present in the foundations soil, this site is classified within class (1) as categorized in both BS 5328 Part 1 and BRE digest 250 "Guide to Specifying Concrete"

No sepcial requirements concerning the cement type and contact and water ratio are specified in both BS and BRE specifications

5 3 2 Chloride Content in Ground Materials

The chloride content for the tested soil samples are also presented in Tables no 2

Chlorides do not react expansively with Portland cement as do sulphates Their effect when present in concrete is to increase the risk of corrosion of embedded metals of which the greatest volume used is steel reinforcement They can be tolerated in plain concrete although when present in large amount some surface dampness may result but widespread and serious damage has been caused by the use of chloride-contaminated aggregates in reinforced concrete

175

The corrosion products occupy more than twice the volume of steel, and their formation can be accompanied by pressures as great as 32 N/mm^2, resulting in cracking of the concrete, frequently followed by sapling of the cover In severe cases of corrosion there may be a reduction in section of the reinforcing bars, leading to a loss of tensile strength of the concrete

Additionally, it is advisable that concrete cover for the steel reinforcement be increased in the structures to protect the steel from the ingress of the chlorides present in the surrounding environment Surface protection and sealing of the concrete and steel should also be considered

Since corrosion can be initiated at lower chloride level in Sulphate resisting Portland cement concrete than in ordinary Portland cement, the use of Sulphate resisting Portland cement blended with a pozzolanic materials can reduce the risk of damage being caused by Sulphate contaminated aggregates If chlorides are also present the use of Sulphate-resisting cement may increase the risk of corrosion of reinforcing steel

The chloride ion content in the concrete expressed by weight of cement content should be less than the limit specified in B S 5328 of 0 4% for ordinary Portland cement and of 0 2% for Sulphate resisting cement

5 4 Ground Water And Cavities

No free ground water or cavities were encountered in any of the boreholes to the depths drilled

Partial los of air circulation (without drop of drilling tools) was observed from 2 5 to 5 0m in borehole No 6 which indicate that air voids may exist

176

6.0 CONCLUSIONS AND RECOMMENDATIONS

According to field and laboratory investigations subsurface conditions, engineering analysis and practical experience it can be concluded that the proposed project building can be satisfactorily supported by the ground at the site, provided that the following recommendations are followed

6.1 Foundation Depth And Type

It is recommended that foundations be laid on the wadi deposits composed of sandy silty clay with gravel and cobbles of limestone and chert

The foundation depth may vary according to the architectural requirements but should not be less than 1.5 m below the finished level of ground surrounding the structures

This foundation ground is suitable to support the structures loads on individual footings with tie beams. Strip footings may also be used if required

6.2 Allowable Bearing Pressure

No undisturbed samples could be obtained at the site for strength testing because of the hard mixed and intercalated nature of the materials encountered. However, the allowable bearing pressure was estimated based on the results obtained from SPT and according to our previous experience with similar materials. Accordingly an allowable bearing pressure value of 2.3 kg/cm^2 is recommended for the whole site area

6.3 Foundation Settlement

Short term settlments wich correspond to the estimated net allowable bearing pressure will be distortion settlement due to the mixed and hetrogenity of the wadi depsits. However it is expected that most of settlement will take place during construction and should be accounted for accordingly. No applicable long term (consolidation) settlements of the foundations are anticipated since the subsurface soils are composed mainly of granular materials. Therefore only short term settlements has been considered due to the granular nature of the subsurface materials encountered. This settlement is expected to be small, uniform and within tolerable limits

6.4 Excavation Methods

It is expected that the excavation will be through the wadi deposits materials. Therefore pneumatic and mechanical equipment such as jack hammers and rock breakers will be required in addition to conventional excavation equipment such as loaders and bulldozers

6 5 Excavation Side Slopes

To minimize the instability problems the temporary excavation sides should be cut at a face inclination not steeper than one horizontal to two vertical (1H 2V)

If these side slopes can not be achieved for insufficient lateral distance or for any other reason, temporary lateral support (shoring) system will be necessary

6 6 Drainage

It is recommended to protect the foundation ground and excavation from surface water both during and after construction by providing proper drainage and protection system

6 7 Backfill Material And Compaction Criteria

The wadi materials generally are generally considered suitable for backfilling purposes However the final decision shall be taken during construction

The materials to be used for backfilling purposes under bottom slab and behind underground walls shall be a soil or soil-rock mixture which is free from organic matter or other deleterious substances It shall not contain rocks or lumps over 15 cm in greatest dimension and not more than 15 percent larger than 7 cm The plasticity index for the backfill material shall not be more than 15 percent It shall be spread in lifts not exceeding 25 cm in uncompacted thickness, moisture conditioned to its optimum moisture content and compacted to a dry density not less than 95 percent of the maximum dry density is obtained by standard proctor compaction test (ASTM D 698)

6 9 Earth Pressure

The underground walls if any drained and backfilled as recommended above shall be designed for an equivalent fluid pressure of 0 7 gm/cm^3 (700 kg/m^3)

6 10 Foundation Excavation Inspection

The recommendations given in this report are based on the assumption that the subsurface materials and conditions do not deviate appreciably from those disclosed in the borings

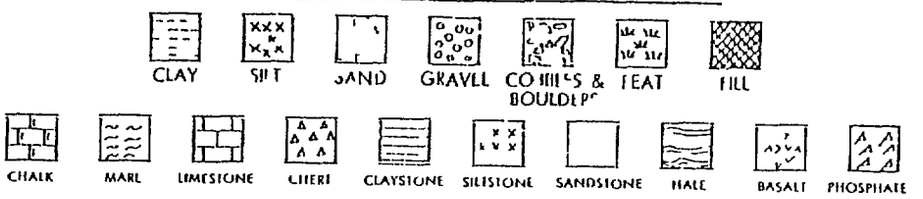
Our office should be notified in writing immediately after foundation excavation and before foundation construction to inspect the excavations and confirm that the required ground is reached and all the undesirable and loose materials are removed

APPENDIX A

LOGS OF BORINGS

LEGEND TO BORING LOGS

SYMBOLS FOR COMMON SOIL AND ROCK TYPES



SAMPLER TYPE

	HAMMER	CORE BARREL	AUGER	SHELBY TUBE	DRIVE CYLENDER (Manual)	DRIVE BARREL	DRIVE SPLIT SPOON (S P T)
Sample Disturbance	Disturbed	Relatively Undisturbed	Disturbed	Undisturbed	Relatively Undisturbed	Relatively Undisturbed	Disturbed

S P T (Blows/30 cm) The number of blows in the Standard Penetration test required to drive a five centimeter diameter split tube sampler a distance of thirty centimeters using sixty five kilograms weight falling seventy six centimeters

Fine Grained Soils

S P T (Blows/30 cm)	Consistency	Field Identification	Unconfined Compressive Strength (kgf/cm²)
0 2	Very soft	Easily penetrated several cms with fist	<0 25
2 4	Soft	Easily penetrated several cms with thumb	0 25–0 5
4 8	firm	Penetrated several cms by thumb with moderate effort	0 5–1 0
8 15	Stiff	Readily indented by thumb but penetrated only with great effort	1 0–2 0
15 30	Very Stiff	Readily intented by thumb nail	2 0–4 0
≥ 30	Hard	Indented with difficulty by thumb nail	> 4 0

Coarse Grained Soils

S P T (Blows/30 cm)	Description	Field Identification	Relative Density (%)
0 4	Very loose	Easily indented with finger thumb or fist	0–20
4 10	loose	loss easily indented with fist but easily shoveled	20–40
10 30	Medium dense	Shoveled with difficulty	40–60
30 50	Dense	Requires pick to loosen for shoveling by hand	60–80
> 50	Very dense	Requires blasting or heavy equipment to loosen	80–100

Recovery The percentage of length of core recovered in each run to the total length of the core run

R Q D The Rock Quality Designation is the percentage of the sum of lengths of intact core pieces ten centimeters or longer to the total length of the core run

Point Load Strength and Unconfined Compressive Strength

In the point load test a rock core is loaded between two steel cones and failure occurs by tensile splitting A point load strenght index I_s is calculated as the ratio of the applied load P at rupture to the square of the distance H between the loading points: $I = P/H$

A correlation that is commonly used between the point load index and the unconfined compressive strength qu of a cylender with a length to diameter ratio of 2 to 1 is $qu = 24\ I_{s(50)}$

where $I_{s(50)}$ is the point load strength corrected to a diameter of 50 mm (Brock and Franklin 1972)

Rock Quality

Rock Quality Designation RQD (%)	Rock Quality Description
0–25	Very Poor
25–50	Poor
50–70	Fair
70–90	Good
90–100	Excellent

Rock Strength

Description	Point Load strength (for 50 mm diameter sample) $I_{s(50)}$ (kg/cm²)	Unconfined Compressive strength (kg/cm²)
Very Weak	<0 5	<12 5
Weak	0 5–2	12 5–50
Moderately Weak	2 –5	50–125
Moderately Strong	5 –20	125–500
strong	20–40	500–1000
Very strong	> 40	> 1000

LOGS OF BORING

PROJECT	Zarqa River Conveyance Study	**BORING NO**	1
LOCATION	Zarqa river (S96014)	**ELEVATION**	-
DRILLING DATE	20/1/1996	**GROUND WATER DEPTH**	N E
DRILLING METHOD	ROTARY AIR FLUSH	**TOTAL BORING DEPTH**	6 0 m

Depth (m)	T	REC (%)	RQD (%)	S P T (N)	BOI	DESCRIPTION	qu (kg/cm^2)	Dd (gm/cm^3)
-						Wadi deposits composed of brown to light brown sandy silty clay with gravel and cobbles of limestone and chert		-
-1								-
-					34			-
-2								-
-								-
-3					50 / 27cm			
-								-
4								-
-					47			
-5								-
-								-
-6								
-						End Of Boring		
-7								-
-								
-8								-
-								-
-9								-
-								-
-10								-
							1	1

1	S T	Sampler Type	4	SPT	Standard Penetration Test
2	REC	Core Recovery	5	qu	Unconfined Comp Str
3	RQD	Rock Quality Designation	6	Dd	Dry Density
7	N L	Not Encountered			

LOGS OF BORING

PROJECT	Zarqa River Conveyance Study	BORING NO	2
LOCATION	Zarqa river (S96014)	ELEVATION	-
DRILLING DATE	21/1/1996	GROUND WATER DEPTH	N E
DRILLING METHOD	ROTARY AIR FLUSH	TOTAL BORING DEPTH	6 0 m

Depth (m)	1	REC (%)	RQD (%)	S P T (N)	BOI	DESCRIPTION	qu (kg/cm^2)	Dd (gm/cm^3)
-						With deposits composed of brown to light brown sandy silty clay with gravel and cobbles of limestone and chert		-
-1								-
-				50 / 24cm		*From 0 to 1 0 m mixed of silty clay materials		-
-2								-
-								-
-3				33				-
-								-
4								-
-				46				-
-5								-
-								-
-6								
-						End Of Boring		-
-7								-
-								
-8								-
-								-
-9								-
-								
-10								-
							1	1

1	S T	Sampler Type	1	SPT	Standard Penetration Test
2	REC	Core Recovery	5	qu	Unconfined Comp Str
3	RQD	Rock Quality Designation	6	Dd	Dry Density
7	N L	Not Encountered			

LOGS OF BORING

PROJECT	Zarqa River Conveyance Study	BORING NO	3
LOCATION	Zarqa river (S96014)	ELEVATION	-
DRILLING DATE	21/1/1996	GROUND WATER DEPTH	N E
DRILLING METHOD	ROTARY AIR FLUSH	TOTAL BORING DEPTH	6 0 m

Depth (m)	T	REC (%)	RQD (%)	S P T (N)	BOI	DESCRIPTION	qu (kg/cm^2)	Dd (gm/cm^3)
-						Wadi deposits composed of brown to light brown sandy silty clay with gravel and cobbles of limestone and chert		-
-1								-
-				26		*From 2 0 to 3 0 m and 3 0 to 6 0 m with light brown slightly clayey sand		-
-2								-
-				50 / 28cm				-
-3								-
-				43				-
4								-
-								-
-5				13				-
-								-
-6		-	-	49			- -	-
-								
-7						End Of Boring		-
-								-
-8								-
-								-
-9								-
-								
-10								-
							1	1

1	S T	Sampler Type	4	SPT	Standard Penetration Test
2	RLC	Core Recovery	5	qu	Unconfined Comp Str
3	RQD	Rock Quality Designation	6	Dd	Dry Density
7	N L	Not Encountered			

LOGS OF BORING

PROJECT	Zarqa River Conveyance Study	**BORING NO**	4
LOCATION	Zarqa river (S96014)	**ELEVATION**	-
DRILLING DATE	21/1/1996	**GROUND WATER DEPTH**	N E
DRILLING METHOD	ROTARY AIR FLUSH	**TOTAL BORING DEPTH**	6 0 m

Depth (m)	T	REC (%)	RQD (%)	S P T (N)	BOI	DESCRIPTION	qu (kg/cm^2)	Dd (gm/cm^3)
-						Wadi deposits composed of brown to light brown sandy silty clay with gravel and cobbles of limestone and chert		-
-1								-
				38				
-								-
-2								-
				45				
-								-
-3								-
-								-
				44				
4								-
-								-
-5								-
				44				
-								-
-6								
-								-
-7						End Of Boring		-
-								
-8								-
-								
-9								-
-								
-10								-
							1	1

1	S T	Sampler Type	4	SPT	Standard Penetration Test
2	REC	Core Recovery	5	qu	Unconfined Comp Str
3	RQD	Rock Quality Designation	6	Dd	Dry Density
7	N E	Not Encountered			

LOGS OF BORING

PROJECT	Zarqa River Conveyance Study	BORING NO	5
LOCATION	Zarqa river (S96014)	ELEVATION	-
DRILLING DATE	20/1/1996	GROUND WATER DEPTH	N E
DRILLING METHOD	ROTARY AIR FLUSH	TOTAL BORING DEPTH	6 0 m

Depth (m)	T	REC (%)	RQD (%)	S P T (N)	BOI	DESCRIPTION	qu (kg/cm^2)	Dd (gm/cm^3)
-						Wadi deposits composed of brown to light brown sandy silty clay with gravel and cobbles of limestone and chert		-
-1								-
-				47				-
-2								-
-								-
-3				56 / 29cm				-
-								-
4								-
-				50				-
-5								-
-								-
-6				--		--	- --	
-								-
-7						End Of Boring		-
-								-
-8								-
-								-
-9								-
-								-
-10								-
							1	1

1	S T	Sampler Type	4	SPT	Standard Penetration Test
2	REC	Core Recovery	5	qu	Unconfined Comp Str
3	RQD	Rock Quality Designation	6	Dd	Dry Density
7	N E	Not Encountered			

LOGS OF BORING

PROJECT Zarqa River Conveyance Study **BORING NO** 6

LOCATION Zarqa river (S96014) **ELEVATION** -

DRILLING DATE 21/1/1996 **GROUND WATER DEPTH** N E

DRILLING METHOD ROTARY AIR FLUSH **TOTAL BORING DEPTH** 6 0 m

Depth (m)	I	REC (%)	RQD (%)	S P T (N)	BOI	DESCRIPTION	qu (kg/cm^2)	Dd (gm/cm^3)
-						Wadi deposits composed of brown to light brown sandy silty clay with gravel and cobbles of limestone and chert		-
-1								-
-				29		*From 2 0 to 5 0 m partial loss of air		-
-2								-
-								-
-3				22				-
-								-
4								-
-				33				-
-5								-
-				46				-
-6								
-								-
-7						End Of Boring		-
-								-
-8								-
-								-
-9								-
-								
-10								
							1	1

1	S T	Sampler Type	4	SPT	Standard Penetration Test
2	RFC	Core Recovery	5	qu	Unconfined Comp Str
3	RQD	Rock Quality Designation	6	Dd	Dry Density
7	N L	Not Encountered			

LOGS OF BORING

PROJECT	Zarqa River Conveyance Study	BORING NO	7
LOCATION	Zarqa river (S96014)	ELEVATION	-
DRILLING DATE	20/1/1996	GROUND WATER DEPTH	N E
DRILLING METHOD	ROTARY AIR FLUSH	TOTAL BORING DEPTH	6 0 m

Depth (m)	T	REC (%)	RQD (%)	S T T (N)	BOI	DESCRIPTION	qu (kg/cm^2)	Dd (gm/cm^3)
-						Wadi deposits composed of brown to light brown sandy silty clay with gravel and cobbles of limestone and chert		-
-1				39				-
-								-
-2								-
-				46				-
-3								-
-								-
4				31				-
-								-
-5								-
-				40				-
-6								-
-						End Of Boring		-
-7								-
-								
-8								-
-								
-9								-
-								
-10								-
							1	1

1	S T	Sampler Type	4	SPT	Standard Penetration Test
2	REC	Core Recovery	5	qu	Unconfined Comp Str
3	RQD	Rock Quality Designation	6	Dd	Dry Density
7	N E	Not Encountered			

LOGS OF BORING

PROJECT	Zarqa River Conveyance Study	BORING NO	8
LOCATION	Zarqa river (S96014)	ELEVATION	-
DRILLING DATE	21/1/1996	GROUND WATER DEPTH	N F
DRILLING METHOD	ROTARY AIR FLUSH	TOTAL BORING DEPTH	6 0 m

Depth (m)	1	REC (%)	RQD (%)	S P T (N)	BOI	DESCRIPTION	qu (kg/cm^2)	Dd (gm/cm^3)
-						Wadi deposits composed of brown to light brown sandy silty clay with gravel and cobbles of limestone and chert		-
-1								--
-				48				-
-2								--
-				44				-
-3								--
-								-
4				41				-
-								-
-5								--
-				45				-
-6		-						--
-						End Of Boring		-
-7								--
-								-
-8								--
-								-
-9								--
-								-
-10								--
							1	1

1	S T	Sampler Type	4	SPT	Standard Penetration Test
2	REC	Core Recovery	5	qu	Unconfined Comp Str
3	RQD	Rock Quality Designation	6	Dd	Dry Density
7	N E	Not Encountered			

APPENDIX

ENVIRONMENTAL ASSESSMENT

ZARQA RIVER WATER CONSERVATION AND QUALITY IMPROVEMENT

HWARAT TO ABU ZEIGHAN CONVEYOR PROJECT

ENVIRONMENTAL ASSESSMENT

MARCH 1996

189

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

190

ZARQA RIVER WATER CONSERVATION AND QUALITY IMPROVEMENT

HWARAT TO ABU ZEIGHAN CONVEYOR PROJECT

ENVIRONMENTAL ASSESSMENT

TABLE OF CONTENTS

1 SUMMARY 1

2 INTRODUCTION 4
- 2 1 OBJECTIVES 5
- 2 2 PROJECT SETTING 5
- 2 3 BACKGROUND 6

3 PROJECT PURPOSE 9

4 ALTERNATIVES INCLUDING THE PROPOSED ACTION 10
- 4 1 PROPOSED ACTION 10
- 4 2 NO-ACTION ALTERNATIVE 13
- 4 3 FEASIBLE ALTERNATIVES TO THE PROPOSED ACTION 13
  - 4 3 1 Canal-Pipeline Combination 13
  - 4 3 2 Pipeline from Thahab Weir to Abu Zeighan Canal 14
- 4 4 COMPARISON OF ALTERNATIVES 16
  - 4 4 1 Construction and Operation Effects on Land Use 16
  - 4 4 2 Operation Effects on Streamflow 17
  - 4 4 3 Operation Effects on Water Quality 19
  - 4 4 4 Operation Effects on Aquatic Life, Vegetation and Migratory and Resident Bird Habitat 21
  - 4 4 5 Operation Effects on Human Uses of Water in the Zarqa River and Irrigated Areas 22
- 4 5 ALTERNATIVES ELIMINATED FROM CONSIDERATION 26
  - 4 5 1 Construction of a Pipeline from KTD to Abu Zeighan Canal 26
  - 4 5 2 Improving the River Bed 26
  - 4 5 3 Use of a Deep Cutoff Wall 26
  - 4 5 4 Preventing Saline Spring and Seep Water from Entering the Channel 27
  - 4 5 5 Power Generation Alternative 27
  - 4 5 6 Off-take from Zarqa Carrier II 27

191

5 AFFECTED ENVIRONMENT 28
5 1 ENVIRONMENTAL SETTING 28
5 1 1 Zarqa Basin 28
5 1 2 Climate and Precipitation 29
5 1 3 Surface Water Hydrology 29
5 1 4 Groundwater 32

5 2 WATER QUALITY 33
5 4 1 Wildlife Habitat 37
5 4 2 Birds 39
5 4 3 Mammals, Reptiles and Amphibians 39
5 5 HUMAN ENVIRONMENT 40
5 5 1 Cultural Resources - Antiquities 40
5 5 2 Agricultural Activities 41
5 5 3 Population 44
5 5 4 Public Health 45

6 ENVIRONMENTAL CONSEQUENCES 46
6 1 CONSTRUCTION EFFECTS 46
6 1 1 Proposed Action - IRR3a 46
6 1 2 Canal-Pipeline Combination - IRR3b 48
6 1 3 Pipeline from Thahab Weir to Abu Zeighan Canal - IRR1 48
6 2 EFFECTS ON STREAMFLOW AND WATER QUALITY 51
6 2 1 No-Action Alternative 51
6 2 2 Diversion at Hwarat Weir 53
6 2 3 Diversion at Thahab Weir 59
6 3 GROUNDWATER 60
6 4 WILDLIFE AND AQUATIC RESOURCES 61
6 4 1 Diversion at Hwaret Weir 61
6 4 2 Diversion at Thahab Weir 62
6 4 3 Habitat Downstream of Abu Zeighan Weir 62
6 4 4 Habitat 63
6 5 SUITABILITY OF WATER FOR AGRICULTURE AND OTHER USES 63
6 5 1 Cultivated Areas 63
6 5 2 Pastoral Uses 63
6 5 3 Other Uses 64
6 6 MAINTAINING PRODUCTIVITY OF AFFECTED LANDS 65
6 7 CROP PRODUCTION - PRIMARY BENEFITS OF THE PROJECT 65
6 8 ANTIQUITIES 71
6 9 HUMAN POPULATION 72
6 9 1 Employment 72
6 9 2 Human Health 72

192

7 RECOMMENDED MITIGATION MEASURES 73
7 1 CONSTRUCTION IMPACTS 73
7 1 1 Disruption of Cultivated Areas 73
7 1 2 Dwellings 74
7 1 3 Stream Channel Construction 74
7 1 4 Antiquities 74
7 2 DIVERSION OF KTD WATER FROM THE RIVER CHANNEL 75

8 MONITORING 76

9 LIST OF PREPARERS 77

193

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

194

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

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

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

196

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

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

197

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)

198

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

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

[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

200

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

201

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

202

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

204

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

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

205

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 II 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	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

210

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

211

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

212

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

---

[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

213

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

214

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

215

With the minimum 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

217

(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

218

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

221

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

222

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

---

[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

224

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

225

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
- *Pistacia atlantica*
- *Anabasis syriaca*
- *Capparis decidua*
- *Retama raetama*
- *Hammada* spp
- *Artemisia herba-alba*
- *Noea muronata*
- *Ferula communis*
- *Crocus* spp
- *Asphodelus microcarpus*
- *Gypsophila arabica*
- *Ureginia maritimia*
- *Astragalus spinosa*

228

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 callipinus*
- *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
- *Nerium 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

229

"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

[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

231

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

---

[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

234

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)

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]

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

235

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

236

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

---

[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

---

[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 <u>not</u> 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

240

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

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

241

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

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

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

245

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

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

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

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

248

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

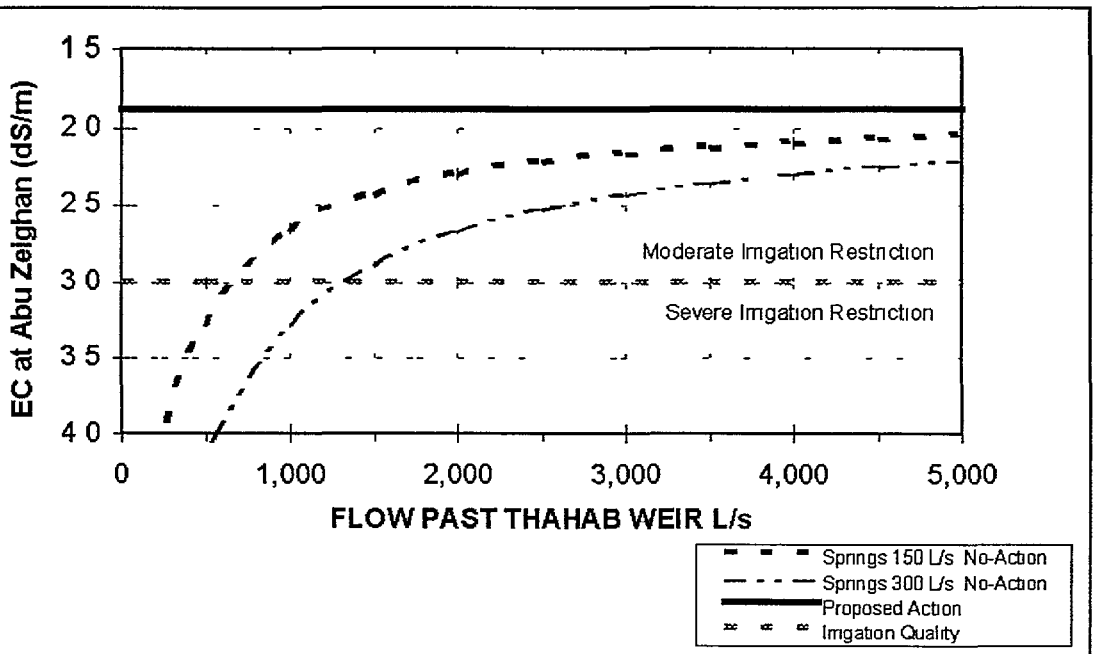


Figure 6-1 Predicted salinity in Abu Zeighan Canal relative to flow at Thahab Weir For saline spring flows of 150 L/s and 300 L/s under No-Action Alternative (Saline Springs EC = 8 0 dS/m, KTD EC = 1 88 dS/m)

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

250

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

---

[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

[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

253

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

254

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

256

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

257

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 Zarqa 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

---

[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

[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

---

[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

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

Not later than the Final Design Phase of the project and prior to <u>any</u> 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

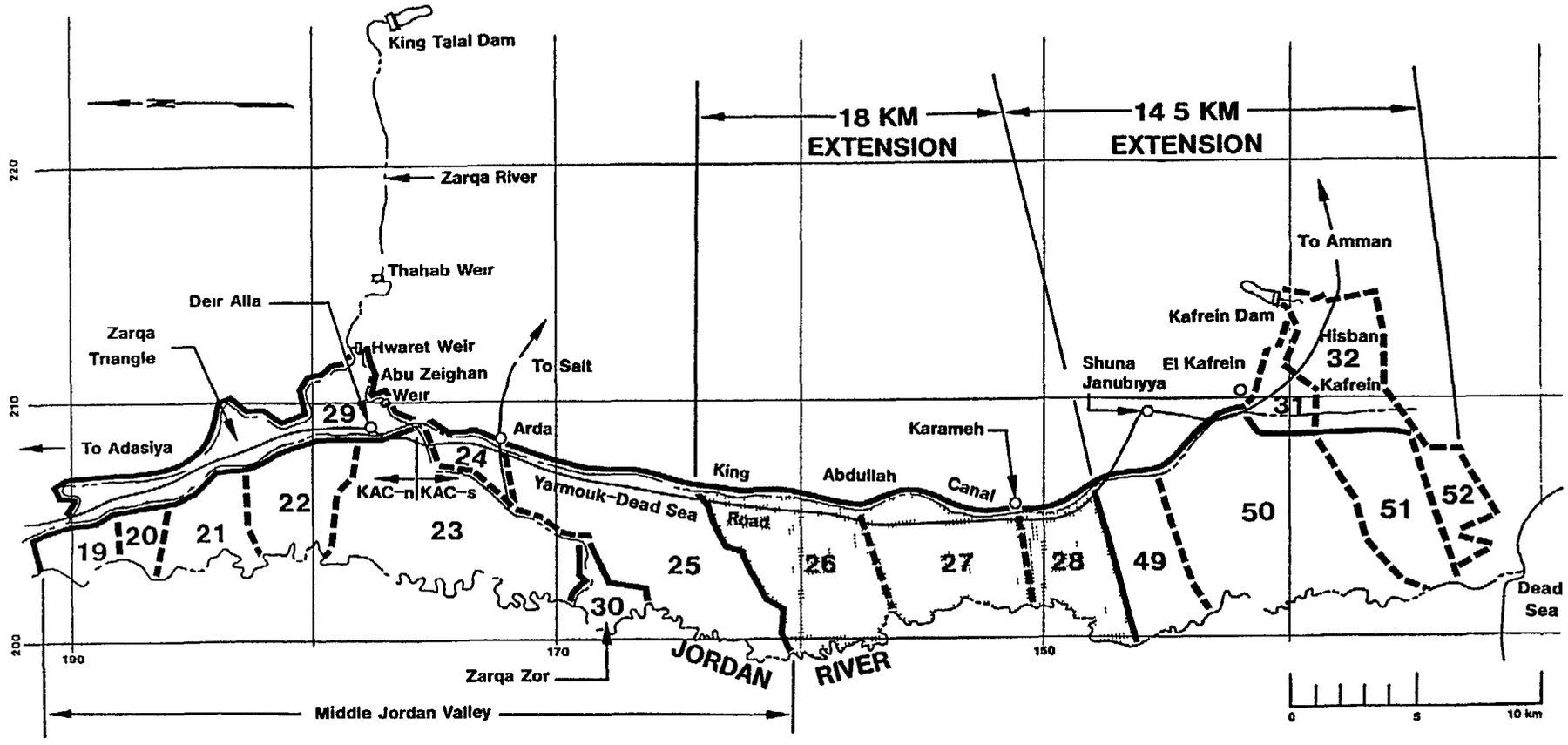
7 2 DIVERSION OF KTD WATER FROM THE RIVER CHANNEL

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

HARZA ENGINEERING COMPANY CHICAGO

Figure 4-1

OVERALL PROJECT AREA

271

BEST AVAILABLE COPY

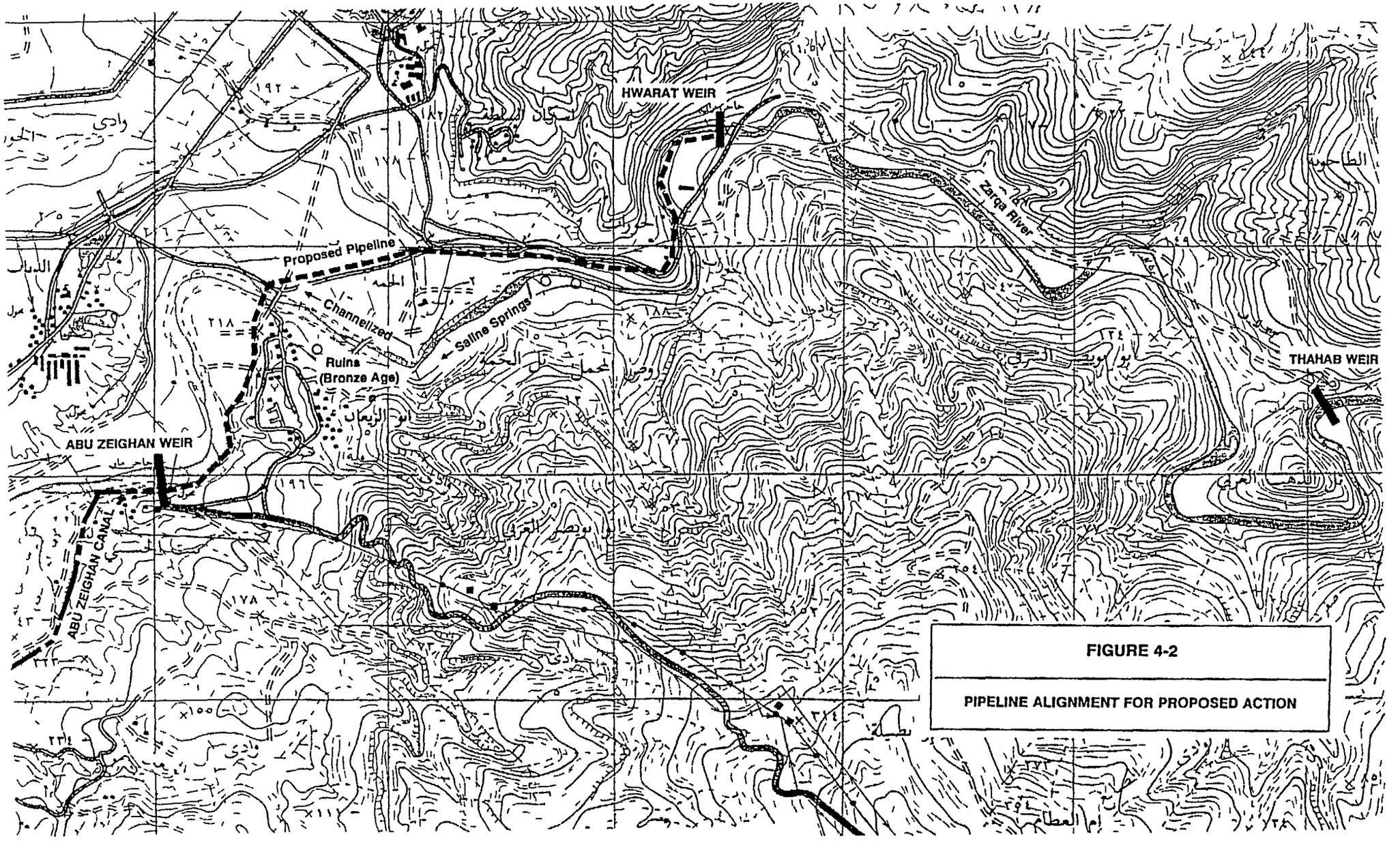


FIGURE 4-2

PIPELINE ALIGNMENT FOR PROPOSED ACTION

BEST AVAILABLE COPY

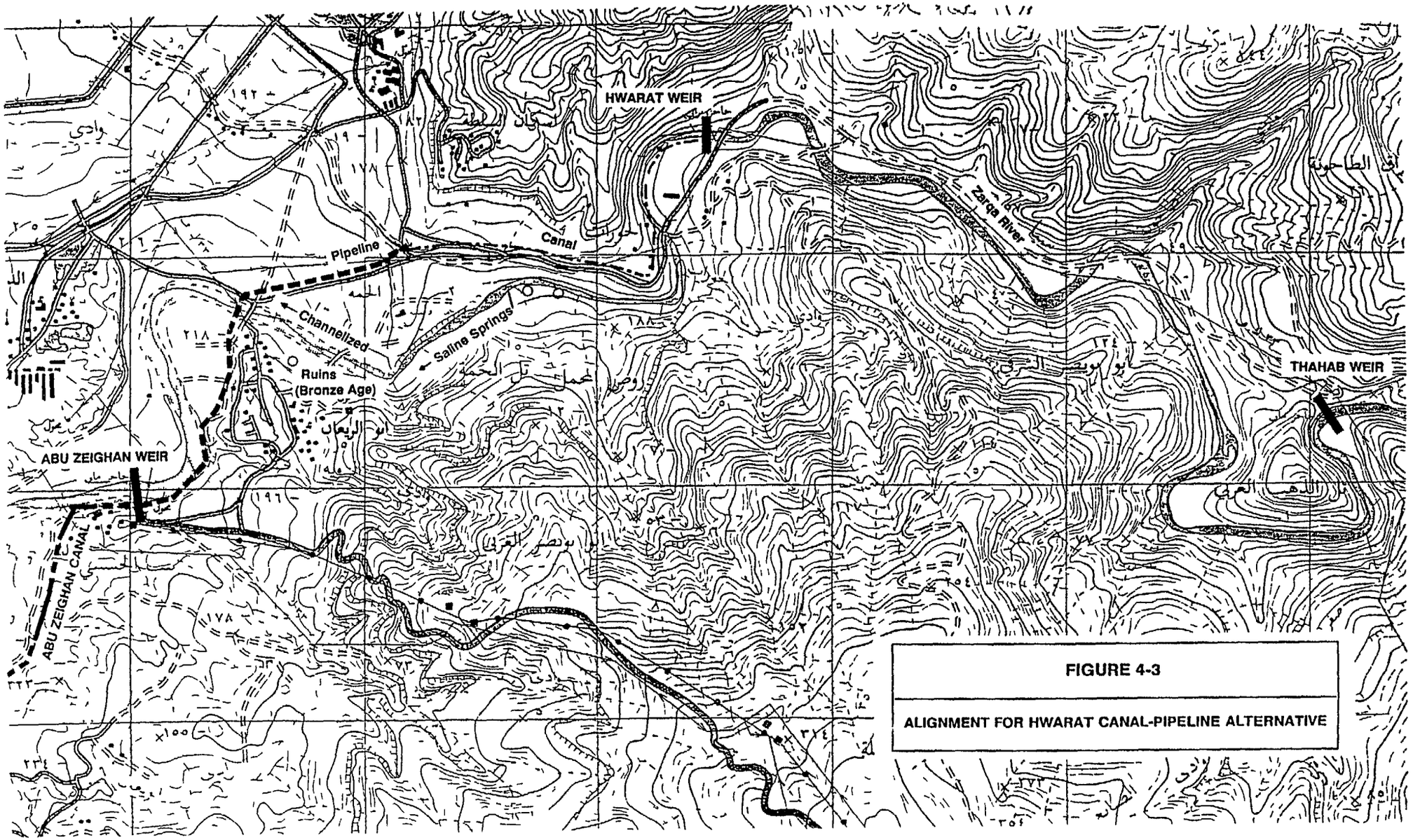


FIGURE 4-3

ALIGNMENT FOR HWARAT CANAL-PIPELINE ALTERNATIVE

BEST AVAILABLE COPY

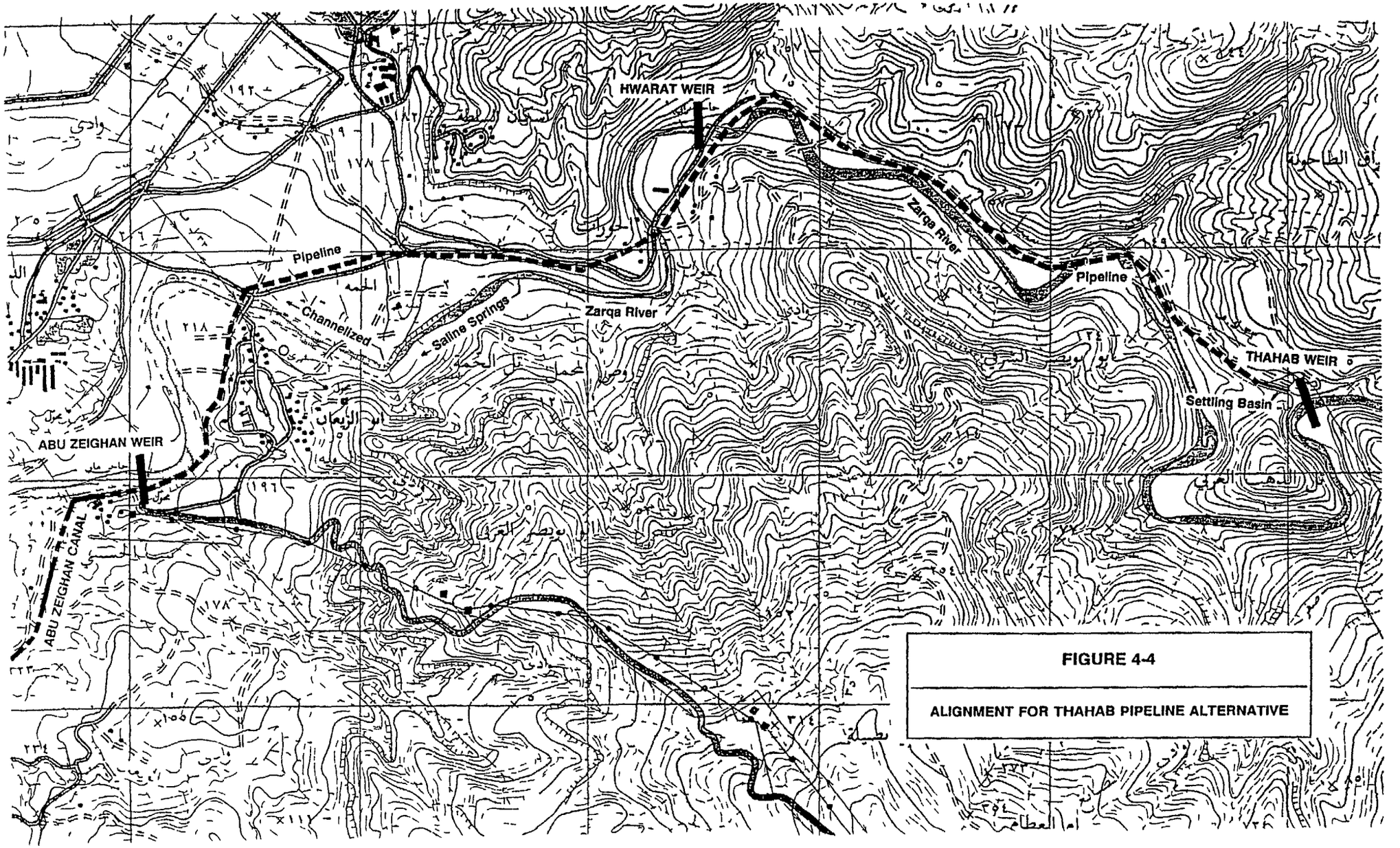


FIGURE 4-4

ALIGNMENT FOR THAHAB PIPELINE ALTERNATIVE

274

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 soltarius*	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 viridis

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	Ptyodactylus hasselquistii
Elegant Lizard	Ophisops elegans

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
Melanoides tuberculata
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
Crocothemis arabica
Zygonyx torrida

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

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

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

		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
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	98%
Others	Peach	103	302	199	1991	540	965	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	-	68	sep-apr	1 36	87%
Garlic	*Onion*	*115*	*123*	*8*	*1993*	-	68	sep-apr	2 18	67%
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*	8 460	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	2 578	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

	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				
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 96	80%
Sweet Pepper (PH)	Pepper	375	692	317	1991	405	69	aug-dec	1 96	80%
Broad Bean	Broadbean	67	77	10	1991	2 116	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	61%
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	64%
Turnip	Turnip	46	209	163	1991	18	-	sep-jan	1 65	86%
Carrot	Carrot	80	564	484	1991	27	73	sep-feb	1 46	84%
Carrot	*Carrot*	*55*	*194*	*139*	*1993*	27	73	sep-feb	2 16	69%
Others	Tomato	85	182	97	1991	509	1 029	sep-jan	1 65	100%
Others	*Tomato*	*113*	*234*	*121*	*1993*	509	1 029	sep-jan	2 06	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	60%
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*	16	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 26	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	1 90	81%	662	1 76	84%	690	28.298	60 126	61 650
Lemon	1 90	81%	605	1 76	84%	631	25 853	13 968	14 249
Clementine	1 90	81%	449	1 76	84%	468	19 196	4 933	5 125
Mandarine	1 90	81%	552	1 76	84%	576	23 597	17 205	17 220
Grapefruit	1 90	83%	371	1 76	87%	386	15 401	482	501
Pummelor	1 90	83%	748	1 76	87%	779	31 055	2 699	2 934
Others	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	15 360
Misc. Trees									
Apple	1 96	73%	383	1 79	78%	410	26 767	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	2 068
Peach	1 96	73%	546	1 79	78%	584	38 100	2 789	2 795
Guava	1 90	81%	222	1 78	84%	230	7 617	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	27 161	42 491
						Sub total 1991 data		71 821	83 688
						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%	2 161	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%	236	1 604	189	62
Potato	2 47	76%	504	2 45	76%	506	1 900	1 184	387
Potato	2 19	80%	554	2 16	81%	557	3 787	446	146

TABLE CONCLUDES ON FOLLOWING PAGE

285

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	81%	71	2 40	81%	71	0.202	426	316
String Bean (PH)	1 86	67%	283	1 84	68%	286	2 729	98	3
String Bean	2 52	48%	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	176	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	66%	304	1 84	67%	313	8 942	145	15
String Bean	1 91	66%	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	1 647
						Sub-total 1993 data		6 687	1 147

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

benefit (JD) using 1991 data	152 936	109 604
benefit (JD) using 1993 data	235 291	157 515
unit benefit (JD/du) using 1991 data	3 846	5 084
unit benefit (JD/du) using 1993 data	5 917	7 306
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%

286

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	16 870	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	3 586	3 761
Bananas	1.20	96%	572	1 12	99%	591	18 526	8 221	11 096
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	8 670	3 994	3 997
Peach	1 30	94%	518	1 17	98%	539	20 786	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%	625	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	6 986	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%	296	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	1 978
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	867
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%

288

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	22 763	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	4 466		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	6 058	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	6 418		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		6 124	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%

290

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	63 365
Grapefruit	2 44	70%	314	1 91	83%	370	56 673	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	3 346	3 346
Apple	2 64	52%	47	2 00	72%	65	18 176	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%	187	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	61%	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	55 818	113 461	4 588
Tomato	2 49	88%	291	1 85	98%	323	31 380	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	51 679
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	20 651
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	86%	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	86%	576	60 801	37 887	12 376
Potato	2 47	75%	519	1 80	88%	602	83 200	9 805	3 203

TABLE CONCLUDES ON FOLLOWING PAGE

251

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	26 882	23 481
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	5 612	11 872	8 785
String Bean (PH)	2 45	50%	212	1 73	71%	298	86.216	3 108	86
String Bean	2 46	50%	255	2 05	62%	315	59 952	8 644	240
Lettuce	2 49	69%	140	1 85	81%	165	25 391	54 084	45 981
Spinach	2 46	87%	247	2 05	91%	261	13 407	2 014	503
Onion	2 47	60%	79	1 81	76%	100	20 640	507	4 068
Onion	2 47	60%	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	6 748
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		1 496 650	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 64	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	13 383	13 089	2 218
						Sub total 1991 data		113 418	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	987 881
benefit (JD) using 1993 data	2 744 607	1 211 431
unit benefit (JD/du) using 1991 data	48 384	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%

292

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)
FRUIT TREES									
Citrus									
Citrus	2 08	77%	627	1 44	92%	752	124 857	265 294	272 016
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	82 228
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	187 481
						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%	196	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	26 065	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	13 489	114 116	4 614
Squash	2 19	100%	275	1 81	100%	275			-
Eggplant	2 15	81%	288	1 73	89%	315	26 255	67 677	39 974
Eggplant (PH)	1 91	86%	2 355	1 40	95%	2 606	251 024	519 918	307 095
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

293

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	5 188
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	67 196	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		1 338 639	487 280
Tomato	1 97	96%	286	1 22	100%	298	11 924	11 145	764
Tomato (tun)	1 87	97%	374	1.21	100%	383	9 630	1 124	77
Tomato	1 97	96%	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%	289	96 085	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%	6 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 الاثار العامة

عمان

Ref

Date

الرقم ٨ ٢٢ / ١/١/٨

التاريخ ١٢/ ١٩٩٦/٣/

الموافق ١٤١٦/١٠/

عطوفة امين عام سلطة وادي الاردن

ارجو التلطف بالعلم بأنه تم اجراء الكشف اللازم على المسار المقترح لخط المياه الناقل المسمى خط الرقاء 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 الريحان غربا .

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

وتفضلوا بقبول فائق الاحترام

مدير عام دائرة الآثار

د. عاري شنه

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 .

295

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