THE HASHEMITE
KINGDOM OF
JORDAN

PD-AAQ-540

ISN 22326

JORDAN VALLEY AUTHORITY

JORDAN VALLEY IRRIGATION PROJECT

STAGE II

FEASIBILITY STUDY

VOLUME VI

PRELIMINARY DESIGN

APPENDIX J
STORAGE AND
POWER FACILITIES

APPENDIX K
IRRIGATION FACILITIES

APPENDIX L
COST ESTIMATES

JANUARY 1978

PREPARED BY
HARZA OVERSEAS
ENGINEERING COMPANY

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

REPORT OUTLINE

VOLUME I	MAIN REPORT
VOLUME II	APPENDIX A, HYDROLOGY ATTACHMENT 1, THE HYDROMETEOROLOGICAL NETWORK AND DATA APPENDIX B, ENVIRONMENTAL ASSESSMENT APPENDIX C, OPERATION STUDIES
VOLUME III	APPENDIX D, CONSTRUCTION MATERIALS APPENDIX E, GEOLOGY
VOLUME IV	APPENDIX F, SOILS APPENDIX G, AGRICULTURAL DEVELOPMENT ATTACHMENT 1, CROP YIELD STUDY ATTACHMENT 2, IRRIGATION APPLICATION EFFICIENCIES
VOLUME V	APPENDIX H, ECONOMIC ANALYSES APPENDIX I, FINANCIAL ANALYSES
VOLUME VI	**APPENDIX J, PRELIMINARY DESIGN OF STORAGE AND POWER FACILITIES** **APPENDIX K, PRELIMINARY DESIGN OF IRRIGATION FACILITIES** **APPENDIX L, COST ESTIMATES**
ANNEX D-1	FIELD LOGS OF TEST PITS, ADITS AND SHAFTS, AND LABORATORY TEST RESULTS
ANNEX E-1	DRILL HOLE LOGS, DRILL HOLE PERMEABILITY TEST RESULTS, AND PETROGRAPHIC ANALYSES
ANNEX K-1	IRRIGATION SYSTEM LAYOUTS

Appendix J

PRELIMINARY DESIGN OF STORAGE AND POWER FACILITIES

Table of Contents

	Page
Introduction	J-1
Maqarin Dam	J-1
Excavation Criteria	J-4
Talus	J-4
River Alluvium	J-6
Bituminous Marl Unit	J-7
Chalky Limestone Unit	J-7
Foundation Treatment	J-8
Grouting	J-9
General	J-9
Consolidation Grouting	J-9
Curtain Grouting - Bituminous Marl Unit	J-9
Curtain Grouting - Chalky Limestone Unit	J-10
Drainage	J-10
Embankment Design	J-11
Construction Materials	J-11
Impervious Materials	J-11
Embankment Shell Materials	J-12
Description of Structure	J-13
Alignment	J-13
Zoning	J-13
Crest Details	J-15
Construction Requirements	J-16
Impervious Clay - Zone 1	J-16
Impervious Talus - Zone 2	J-16
Filters - Zone 3F and 3C	J-17
Random Rockfill and Alluvium - Zone 4	J-17
Alluvium - Zone 5	J-17
Basalt Rockfill - Zone 6	J-18
Random Fill - Zone 7	J-18
Instrumentation	J-18
Stability Analyses	J-18
Design Parameters	J-19
Loading Conditions	J-19

Table of Contents (Cont'd)

	Page
Method of Analysis	J-19
Results	J-20
Quantity of Construction Materials	J-22
Design Phase Investigations and Testing	J-22
Foundation Area	J-22
Construction Materials	J-24
Testing	J-24
Spillway	J-25
General	J-25
Hydraulic Design	J-26
Foundation and Structural Design	J-27
Raising Maqarin Dam	J-29
Diversion During Construction	J-29
Low-level Outlet	J-32
Powerplant at Maqarin Dam	J-33
Water Conductor	J-33
Powerhouse	J-35
Transmission	J-36
Powerplant at King Talal Dam	J-36
Water Conductor	J-36
Powerhouse	J-37
Transmission	J-38
Diversion to East Ghor Main Canal	J-38
Diversion Dam	J-38
Uncontrolled Diversion to EGMC	J-40
Side-Wadi Diversion Structures	J-41
Wadi Yabis Diversion	J-42
Wadi Kufrinja Diversion	J-42
Wadi Rajib Diversion	J-43
Railroad Relocation	J-43
Initial Reservoir Filling	J-44

LIST OF TABLES

Table No.	Title	Page
J-1	Summary of Test Results, Foundation Area	J-5
J-2	Available Materials and Material Requirements	J-23

LIST OF EXHIBITS

Exhibit Number	Title
J-1	General Plan and Section
J-2	Grout Curtain and Drainage Curtain Profiles
J-3	Construction Materials Exploration
J-4	Embanment and Foundation Material Parameters
J-5	Slope Stability-Steady Seepage El. 200
J-6	Slope Stability-Rapid Drawdown El. 200
J-7	Slope Stability-End of Construction El. 200
J-8	Slope Stability-Steady Seepage El. 150
J-9	Slope Stability-Rapid Drawdown El. 150
J-10	Slope Stability-End of Construction El.150
J-11	Embankment Sections
J-12	Embankment Sections
J-13	Maqarin Dam Crest Elevation 158, Plan
J-14	Spillway Profile and Sections
J-15	Spillway Hydraulic Data
J-16	Diversion Tunnel and Outlet Works
J-17	Maqarin Powerplant
J-18	Maqarin Powerplant, One-Line Diagram
J-19	King Talal Powerplant - Plan and Sections
J-20	King Talal Powerplant, One-Line Diagram
J-21	Controlled Diversion Structure - Plan and Sections

LIST OF EXHIBITS (Cont'd)

Exhibit Number	
J-22	Uncontrolled Diversion Structure - Plan and Sections
J-23	Typical Side-Wadi Diversion - Plan and Sections
J-24	Railroad Relocation, Plan, and Profile

Appendix J

PRELIMINARY DESIGN OF STORAGE AND POWER FACILITES

Introduction

The recommended plan for Stage II development includes storage and power facilities at the Maqarin site, a low diversion structure to divert flow to the East Ghor Main Canal (EGMC), a powerplant at King Talal Dam, diversion facilities on three side wadis, a 14.5 km extension to the EGMC to serve the southern part of the Valley and a sprinkler irrigation system for 25,353 ha.

The preliminary designs of the storage, power, and diversion features are discussed in this Appendix. Additional information is available in Appendix D, Construction Materials and Appendix E, Geology. The preliminary designs for the irrigation system and the extension to the main canal are discussed in Appendix K, Preliminary Design of Irrigation Facilities.

Maqarin Dam

The storage facility at the Maqarin site was studied at two elevations for Stage II development to account for the possibility of different diversion conditions at the intake to the EGMC. A dam at El. 158 (reservoir El. 150) will be required if a diversion dam is included in the Project facilities. A plan and sections of this dam are shown on Exhibit J-1. A dam at El. 168 (reservoir elevation 160) will be required if uncontrolled diversion facilities are installed. The higher dam is required because the regulated discharge from the reservoir must be large enough to serve the project requirements with some water passing the intake.

The ultimate development (Stage III) of the project will include an embankment dam at the Maqarin site at elevation 200 to fully regulate streamflow at the site. Stage II development will include a raisable embankment dam at the Maqarin site with a crest elevation of 158. The ultimate development (El. 200) controls the embankment design for initial development.

The data presently available indicate that an inclined core rockfill structure would allow efficient use of the required excavation and available borrow materials to provide a stable embankment. The embankment includes an impervious core, filters, rockfill and river alluvium shells, and an upstream weighting berm.

Required excavation in the foundation area includes the removal of the talus under the embankment except where it underlies the upstream cofferdam and weighting berm. River alluvium, decomposed and highly weathered marly limestone will be removed under the embankment except where it underlies the upstream cofferdam and weighting berm.

Under the impervious zones, a core trench will be excavated to or below the top of fresh or slightly weathered rock.

A grout curtain and grouting gallery and adits will be constructed under the central portion of the impervious core. These features will extend under the spillway and into both abutments. Drainage adits and curtains are included in both abutments to intersect seepage passing through and around the grout curtains.

A sufficient quantity of satisfactory construction materials is available near the site. Limestone from required spillway excavation appears to be of marginal rockfill

quality and additional studies are required to optimize the use of this material for embankment construction.

Preliminary stability analyses of both the initial and ultimate embankments indicate that the Maqarin Dam is stable for conditions expected during the life of the project. The loading conditions analyzed were steady seepage, rapid drawdown, and construction, and included a seismic analyses for the steady seepage case.

Additional investigations will be required for detailed design of the proposed structures. These investigations will provide information to select the best axis, and to optimize the embankment design with respect to cost, ease of construction and stability.

The Maqarin Damsite is located on the Yarmouk River in a gorge approximately 250 m deep. The sides of the gorge are relatively steep, approximately 1.5HÑ1V, and generally are covered with talus. The bottom of the gorge is less than 100 m wide at the damsite but widens both upstream and downstream from the site. This widening of the valley generally restricts the locations of potential dam axes to a reach of less than 0.5 km along the river.

The lower portion of the embankment will be founded on the Bituminous Marl Unit (marly limestone), while the upper portion will rest on the Chalky Limestone Unit (chalky limestone). The bedrock is covered with alluvial materials in the valley bottom and talus on the abutment slopes.

A detailed description of the site geology is included in Appendix E, Geology. A geologic cross-section of the gorge is shown on Exhibit J-2.

A lens in the Bituminous Marl Unit which may have been altered to clay was encountered under the impervious core

3

section of the proposed dam. This lens varies in thickness from 20 to 40 meters with the shallowest part of the lens approximately 30 meters below the base of the impervious core. Preliminary stability analyses indicate that this lens does not adversely affect the stability of the dam. Additional investigation and evaluation of this altered zone and other features such as small clay zones and a sand-filled cavity will be required during the final design phase.

Excavation Criteria

Talus. Both abutments of the site are blanketed with clayey talus. The thickness of this talus ranges widely but is up to 15 meters deep on the left abutment and up to 25 meters deep on the right abutment. The material consists primarily of angular basalt and limestone gravel and cobbles with the voids filled with a medium plastic marly clay. Scattered blocks and boulders of basalt are also present.

Large scale gradation and density tests were performed on this material from Shafts 2 and 5 and Adit 2, (see Table J-1). Tests indicate that the talus is medium dense and would have good shear strength when consolidated under the load of the dam. The talus, however, is poorly graded with 50 to 75 percent gravel and cobble sizes. A void approximately 5 m^3 in volume was found in Shaft 5. The talus would be relatively impervious when saturated by the reservoir and consolidated by the embankment load. The preliminary design concept requires removal of the talus under the embankment section except under the upstream weighting berm for the following reasons:

a) The shear strength of the talus is less than the shear strength of the proposed shell materials.

Table J-1

SUMMARY OF TEST RESULTS
FOUNDATION AREA

Hole* No.	Sample No.	Depth (M)	Grain Size +#4 %	Grain Size -#4+#200 %	Grain Size -#200 %	Atterberg Limits L.L. %	Atterberg Limits P.L. %	Atterberg Limits P.I. %	Insitu Dry Density tons/m³	Natural Water Content %	Specific Gravity	Standard Compaction Dry Unit Weight tons/m³	Standard Compaction Optimum Moisture Content %	Insitu Permeability K20 cm/sec	Triaxial Shear C' kg/cm²	Triaxial Shear Ø' deg.	Soil Classification USCS	REMARKS
FD1	1	0.3-1.0	6	23	71	34.9	20.0	14.9	-	-	2.74	-	-	-	-	-	CL	Right Abutment Talus
	2	1.0-4.0	82	11	7	32.1	19.5	12.6	-	-	2.80	-	-	-	-	-	CL	" " "
	3	4.0-6.0	68	10	22	31.4	19.1	12.3	-	-	2.80	-	-	-	-	-	CL	" " "
FD2	1	0.3-3.5	61	19	20	-	-	-	1.37	8.3	2.71	-	-	-	-	-	-	" " "
FD3	1	0.3-6.0	77	8	15	31.5	19.0	12.5	-	-	2.75	1.67	19.4	-	-	-	CL	" " "
	2	0.3-6.0	65	16	19	30.4	15.6	14.8	-	-	2.76	-	-	-	-	-	CL	" " "
FD4	1	0.4-1.0	2	21	77	43.8	31.7	12.1	-	-	2.65	-	-	-	-	-	ML	Bottom of Right Abutment
	2	1.0-3.0	84	9	7	-	-	-	1.48	9.9	2.72	-	-	7.3×10^{-4}	-	-	-	Talus
	3	5.3-5.8	0	13	87	33.7	16.2	17.5	-	-	2.70	-	-	-	-	-	CL	" " "
FD5	1	0.3-4.2	72	13	15	-	-	-	1.59	9.5	2.74	-	-	3.3×10^{-4}	-	-	-	" " "
	2	0.3-4.2	51	20	29	30.1	16.8	13.3	-	-	2.74	-	-	-	-	-	-	" " "
FD6	1	0.7-1.2	63	12	25	43.2	26.0	17.2	-	-	2.66	-	-	-	-	-	CL	" " "
	2	1.2-2.5	2	20	78	34.3	17.3	17.0	1.49	18.7	2.73	-	-	9.0×10^{-5}	0.1	35.0	CL	" " "
	3	2.5-3.0	61	17	22	31.2	16.8	14.4	-	-	2.74	-	-	-	-	-	CL	" " "
FD7	1	0.2-3.5	69	6	25	-	-	-	-	-	2.70	-	-	-	-	-	-	" " "
	2	3.5-5.5	83	4	13	-	-	-	1.36	11.1	2.78	-	-	-	-	-	-	" " "
FD8	1	0.0-1.0	58	14	28	35.2	20.1	15.1	-	-	2.72	-	-	-	-	-	CL	" " "
	2	1.0-3.5	0	14	86	36.3	18.6	17.7	1.46	19.0	2.75	-	-	-	-	-	CL	" " "
FD9	1	0.4-2.0	70	17	19	-	-	-	1.36	8.5	2.71	-	-	1.1×10^{-2}	-	-	-	Left Abutment Talus
	2	2.0-6.0	85	8	7	-	-	-	-	-	2.70	-	-	-	-	-	-	" " "
FD10	1	0.5-6.0	0	11	89	-	-	-	-	-	2.72	-	-	-	-	-	-	" " "
	2	0.5-6.0	0	11	89	-	-	-	1.48	11.6	2.72	-	-	2.5×10^{-7}	-	-	-	" " "
Shaft 2	1**	0.3-2.0	56	17	27	36.9	19.7	16.2	-	5.9	2.71	-	-	-	-	-	GC	Right Abutment Talus
	2	2.0-4.0	-	-	-	58.0	34.8	23.2	-	-	2.86	-	-	-	-	-	GC	" " "
	3	10.0-10.3	73	13	14	-	-	-	-	-	-	-	-	-	-	-	GC	" " "
Shaft 5	1	2.0-3.0	73	11	16	36.9	26.3	10.6	1.93	2.4	2.81	1.74	15.4	-	-	-	GC	" " "
Adit 2	1	portal	48	18	34	34.6	20.3	14.3	1.73	6.3	2.67	1.68	18.4	-	-	-	GC	" " "

* FD series test pits completed in 1965. All others completed in 1976.
** Clay dispersion tests indicate this material is nondispersive.

Leaving the talus in place would require flatter embankment slopes.

b) The variable thickness of the talus would produce differential settlements in the embankment saturated by the reservoir, possibly resulting in undesirable stress conditions in the embankment.

c) In some areas, the talus covers decomposed marly limestone which has a lower shear strength than the talus.

d) The talus material lacks a significant amount of coarse and medium-sand size particles and would not be self-healing for concentrated leakage.

e) The talus is heterogeneous in density. A cavity was found in Shaft 5 and other cavities or voids may be present. These cavities could collapse and cause potential foundation piping problems.

f) The talus, being relatively impervious, would not adequately relieve foundation seepage under the downstream shell, thus increasing foundation uplift and decreasing stability.

g) Removal of the talus will expose geologic defects that might exist in the foundation, (faults, shear zones, etc.), which can be treated if necessary.

River Alluvium. The river alluvium is a heterogeneous mixture of gravel, cobbles and boulders with lenses of silty and sandy clays and silts. This material will be removed under the core and the upstream and downstream shells of the embankment to expose the foundation rock and allow treatment of geologic defects, if necessary, and will involve excavations up to 15m deep. The alluvial material will be left in place under the upstream cofferdam and weighting berm to facilitate

construction and reduce diversion tunnel costs.

Bituminous Marl Unit. Beds of the Bituminous Marl Unit, when decomposed and highly weathered marl have relatively low shear strength and density. These highly weathered beds will be removed under the dam section except where it underlies the upstream cofferdam.

In the area beneath the impervious zones 1 and 2 of the dam, all weathered and gypsum bearing marly limestone will be removed. It is estimated that the depth of excavation from the top of weathered rock will be approximately 15 meters on both abutments and 5 meters in the valley bottom. Local, deeply weathered areas may require more excavation. The slide block at the base of the left abutment, (See Exhibit J-2), will be removed and the area shaped to prevent undesirable stress concentrations in the impervious zones.

Following these criteria, the impervious zones of the dam will be founded on fresh marly limestone and the shells will be founded on hard weathered marl.

Chalky Limestone Unit. The exploration indicates that beds of the Chalky Limestone Unit generally are highly fractured and weathered to depths up to and perhaps exceeding 25 meters. Exposed portions of the limestone are often found to be case-hardened. The weathered material is generally soft and friable.

The core trench, which will be the entire width of the impervious zones, will be excavated through the highly fractured and friable chalky limestone to slightly weathered chalky limestone. The average excavation depth is estimated to be approximately 20 meters from the top of weathered rock.

The shells of the dam will be founded on hard weathered limestone located approximately 5.0 m below the existing ground surface.

Foundation Treatment

The foundation surface under the shells of the dam consists of hard weathered chalky or marly limestone or marl. This surface will be cleaned to ensure that the rockfill makes good contact with the intact rock of the foundation and that careful inspection and evaluation of the bedrock can be made. Decomposed shear zones or fault zones in the downstream area will be protected by filter material if required.

The foundation surface under the impervious zones of the dam (bottom of the core trench) will consist of hard, fresh to slightly weathered limestone and fresh marly limestone. The core trench will be shaped to remove any over hangs or significant sharp breaks in slope. Deeply weathered shear zones or faults will be excavated to a depth equal to 1.5 to 3.0 times their width and backfilled with dental concrete or mortar. After completion of curtain grouting, the foundation will be cleaned with air and airwater jets to remove all loose materials. This cleaned surface will be moistened and a 1 cm ± layer of slush grout will be broomed onto the surface just prior to placement of the impervious core material. The first lift of impervious material will be placed while the slush grout is still plastic. The purpose of the slush grout is to seal any surface cracks at the fill-foundation contact and prevent erosion of the core material by high velocity seepage at the contact.

Grouting

General. A grout curtain and grouting gallery will be constructed under the center of the impervious core. Grouting galleries at both abutments will be provided at El. 30, 90 and 158 for the initial development and at El. 198 for the ultimate development. The gallery at El. 30 will be continuous under the dam. A single-row grout curtain will be required in the Bituminous Marl Unit and a multi-row grout curtain will be required in the Chalky Limestone Unit. A multi-row grout curtain also may be required in portions of the Bituminous Marl Unit. The grout curtain will extend to the depth required for the initial development. During raising the dam for the ultimate development, the grout curtain and galleries will be extended to the required depth. The grouting and drainage curtain profiles are shown on Exhibit J-2.

Consolidation Grouting. Consolidation grouting will be performed in the core trench, where required, to depths of approximately six meters, prior to curtain grouting. The Bituminous Marl Unit will not generally require consolidation grouting except for local areas of sheared or highly jointed rock. Consolidation grouting will be more extensive in the Chalky Limestone Unit since the drill holes indicate that this material is generally more fractured and open than the marly limestone. The objectives of the consolidation grouting areÑ 1) to seal the upper portion of the core foundation thus reducing seepage gradients in this areañ and 2) to confine the grout from the curtain grouting, allowing higher pressures to be used.

Curtain Grouting - Bituminous Marl Unit. The water pressure tests performed in exploratory holes and an evaluation

of the grouting test performed by Energoprojekt indicate that, in general, the Bituminous Marl Unit is relatively tight and that only a single-row curtain may be required in this geologic unit. However, there is evidence of solution effects in the unit and several exploration holes showed high water takes. The curtain will be designed and constructed to ensure that the solution effects, as they occur along the alignment of the grout curtain, are adequately treated. The grout-curtain depth in the bottom of the valley is estimated to be 150 meters for the ultimate development. The grout holes will be inclined approximately normal to the abutment slope to intersect more efficiently the near vertical joint systems and to reduce the total amount of drilling required. Based on the Energoprojekt grout test results and pressure test data 60 kg per square meter of grout curtain was used in the cost estimate as the average grout take for the Bituminous Marl Unit.

Curtain Grouting - Chalky Limestone Unit. The results of the exploratory drilling and water pressure testing indicate that the joints in Chalky Limestones unit are open and pervious for their full depth. A multi-row grout curtain will be required in this material. This curtain will tie into the curtain in the Bituminous Marl Unit and extend deeply into the abutment beyond the end of the dam. A grout take of 150 kg per square meter of grout curtain was used for the cost estimate.

Drainage

Drainage curtains are included in both abutments to intersect seepage passing through and around the grout curtains. These curtains will be constructed by excavating drainage adits at El. 30, and 90 for the initial development

and at El. 150 for the ultimate development. Drain holes will be drilled to connect the adits as well as downward from the lower adits.

The drainage curtains combined with the inherent draining ability of the rockfill shells will prevent the buildup of undesirable water pressure under the downstream portion of the embankment and improve the stability of the abutments and spillway.

Core trench excavation, grout curtain, and drainage adits are shown on Exhibit J-2.

Embankment Design

The investigations and studies have shown that sufficient quantities of satisfactory construction materials are available near the site to construct a high rockfill embankment.

The data presently available indicate that an inclined-core, rockfill-shell structure would allow efficient use of the required excavation materials and provide a stable embankment. Additional exploration may indicate better foundation conditions slightly downstream from the present impervious core-foundation contact.

Construction Materials

A detailed description of the construction materials investigations and an evaluation of the results of these investigations is given in Appendix D, Construction Materials. The location of potential material sources is shown on Exhibit J-3. A brief summary of this evaluation follows.

Impervious Material. Impervious materials available at the site include alluvial and residual clays and clayey talus. Borrow Areas B, B1, R1 and R2 contain primarily clays of medium to high plasticity. These borrow areas are large enough to work economically and are relatively close to the dam.

Clayey talus materials are also available from the required dam and spillway excavation.

Embankment Shell Materials. Materials available near the site, which are suitable for construction of the embankment shells, include basalt, chalky limestone, and river alluvium materials.

The river alluvium materials will vary from free-draining rockfill quality to nearly impervious. The river alluvium may require washing to remove excessive quantities of fines. The alluvium will be available from required excavation and from Borrow Areas U and D.

Basalt is available from the required spillway excavation and from a potential quarry in the basalt flows on the Syrian side of the river. The basalt from the Syrian side of the river appears to be a promising source of concrete aggregate and good quality rockfill. There are indications that the basalt from the required spillway excavation also could be a suitable source of good quality rockfill. If this source is confirmed during the design phase testing program, it may be used as the primary source.

The chalky limestone is exposed on both sides of the valley in thinly to massively-bedded units. Laboratory testing of samples obtained from the massive limestone cliffs on the right side of the river downstream from the dam site indicate that this material would produce marginal quality rockfill and would not provide a sufficient quantity to be considered as the primary source of rockfill. However, it may be used as random rockfill, (Zone 4). The less resistant limestone above and below the massive material would produce poor quality rockfill. The required spillway excavation will produce a large quantity of marginal to poor

quality lime-stone. Additional studies, including extensive field testing, are required during the design phase to optimize the use of limestone as rockfill.

The basalt, with its superior quality and vast quantity is considered to be the primary source of rockfill for feasibility study purposes.

Filter materials can be produced from basalt in conjunction with concrete aggregate production. The coarse filter might be produced from processing the river alluvium.

Description of Structure

Alignment. The valley bottom is less than 100 meters wide for a reach of about 0.5 km along the river. The foundation investigations have revealed a gravel-filled pothole in the bedrock which extends approximately to elevation -30 meters in the upstream portion of the reach. The impervious core was located downstream of this known feature. It is recognized that potholes and other undesirable features may exist in the foundation area of the core. Future investigations will determine the scope of the required foundation treatment and may lead to the choice of a better alignment. The use of an inclined core cross-section places the axis approximately 100 meters downstream from the location shown in previous reports.

Zoning. The zoning of the embankment is based on the properties of the materials available from required excavation and borrow along with consideration of cost and ease of construction. The selected section is shown on Exhibit J-4.

The medium to highly plastic clays which are available for core material, although highly impervious, are not ideal for a vertical core embankment 130 m to 180 m high. They have relatively low shear strength and will consolidate more

under embankment and reservoir loading than the adjacent shells. This might cause arching and a reduction in vertical stresses in the core. In an extreme case, these stresses could be less than reservoir pressure and hydraulic fracturing might occur. This risk is minimized by the use of these materials in an upstream inclined core section which reduces the consolidation stresses and improves the stress distribution in the interior of the embankment.

The clayey talus materials are also essentially impervious and have much better shear strength and compressibility characteristics. However, the fines content of much of this material is limited and there does not appear to be a sufficient quantity of clayey talus which could economically produce the primary impervious zone. Consequently, this material will be utilized as a supporting and transition zone for the highly impervious clays.

Two-stage filters are included on the downstream side of the impervious zones and on the upstream side in the drawdown zone to provide a transition between the impervious material and the granular shells. The filters will provide the primary protection against damage resulting from cracking in the core, should any cracking occur. A single-stage filter is used upstream below the drawdown level where the transition will be made from impervious material to a semi-pervious dirty rockfill and alluvium. Since the unit cost of the filter materials will be high, filter zones are made as narrow as possible consistent with safety and efficient construction methods. A four meter width is used for each stage of the downstream filters while 2.0 meters is used for the upstream filters.

Zone 4 on the upstream side of the embankment will be constructed of poorer quality basalt and limestone rockfill from required excavation and river alluvium. High shear strength is not required under the relatively flat 3.0HÑ1V upstream slope and free drainage is not required below the drawdown level. However, this material must have good compressibility characteristics.

River alluvium washed, if required, will be placed downstream of the impervious zones in the Alluvium Zone 5. This material will be pervious to free-draining to prevent buildup of seepage pressures in the downstream portion of the embankment.

The outermost portion of the downstream shell and the drawdown zone of the upstream shell will be constructed of compacted basalt rockfill. This material will be strong, free-draining and relatively incompressible. The larger pieces of rock will be pushed to an oversize zone on the outer slopes to provide wave protection on the upstream side and to avoid restrictive selection criteria during construction.

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

Crest Details. The crest width has been established as 12 meters. This provides enough room for heavy maintenance equipment to operate and sufficient space for additional filters near the maximum reservoir level.

Approximately 2 meters of camber will be provided in the center of the valley to offset post construction settlement. The camber will be provided by locally steepening the slopes near the crest of the dam.

15

Construction Requirements.

Impervious Clay - Zone 1. All of these materials are above the natural ground water table and conventional methods can be used for excavation, transportation and placement of this material. Oversize material does not appear to be extensive and can be economically removed on the fill surface. The natural moisture content of the materials averages approximately 11 percent below the optimum moisture content and, therefore, moisture conditioning will be required prior to compaction. The determination of the required compacted moisture content range will require detailed study during the design phase; however, it is expected that it will be in the range of -2 to +2 percent from standard optimum moisture content.

Compaction will be by a tamping roller with compacted lift thickness of about 15 cm or by a 50-ton pneumatic roller with compacted lift thicknesses of 20 cm. The compacted dry density should be approximately 100 percent of the laboratory maximum standard dry density.

Impervious Talus - Zone 2. This material is available from the required dam and spillway excavation and in Borrow Areas R1 and R2. The material from the required dam excavation will require double handling if the abutments are stripped entirely prior to embankment placement. These materials are very dry and will require moisture conditioning. Oversize materials are not extensive and could be removed on the fill surface or at the excavation site. The gradation of this material is nearly ideal for a 50-ton pneumatic roller, however, a tamping roller would break down some of the gravel particles and produce a better graded impervious zone. Because of the high gravel content, the laboratory

standard compaction test on minus #4 material is not a satisfactory test for compaction and moisture control. The present studies utilized laboratory compaction tests on minus 3'4: material and these indicated good shear strength and permeability properties. The standard to be used for construction should be determined by a test fill in the design phase.

Filters - Zones 3F and 3C. These materials will be processed to conform to the design gradation. Compaction will be in 50 cm lifts with a 10-ton static weight vibratory roller to achieve 85 percent relative density.

Random Rockfill and Alluvium - Zone 4. This material will consist of poorer quality basalt rockfill and limestone from required excavation along with river alluvium. The primary construction requirement is to obtain relatively low compressibility. This will be achieved by placing materials which have rock to rock particle contact with the voids partially filled or filled with fines. The compacted lift thickness will be 50 cm with compaction by vibratory roller. Compaction control will be made with large scale field density tests to assure that the overall porosity is sufficiently low.

Alluvium - Zone 5. This material will consist of river alluvium with less than approximately five percent fines. The test pits excavated in this material above the water table indicate that the material will consist primarily of cobbles and boulders and will behave in a manner similar to rockfill. If excavation, particularly below the water table, were to produce material with too high a fines content for proper compaction, washing of the material to reduce the fines content will be required. The Zone 5

material will be compacted in 50 cm lifts by vibratory roller. Large scale density tests will be performed to assure that satisfactory densities are obtained. There are no standard laboratory tests to compare the density of this type of material and the zone will be instrumented to allow monitoring of its performance during and after construction.

Basalt Rockfill - Zone 6. This material will consist of good quality, hard, fresh to slightly weathered basalt rock. It will be compacted to obtain strong, free-draining, relatively incompressible zones. It will be placed in 1.0 m layers and compacted with a vibratory roller.

Random Fill - Zone 7. This material will consist of required excavation materials not suitable for placement in the interior zones of the embankment. It will be placed in 50 cm lifts and traffic-compacted with the placing equipment.

Instrumentation

The embankment and its foundation will be instrumented to evaluate the performance during and after construction. The instrumentation will monitor seepage, surface movement, pore pressures and internal movements in the embankment and foundation.

Stability Analyses

The upstream and downstream slopes of the maximum dam section for ultimate and initial developments were analyzed for stability. The analyses of the upstream slope assumed that altered weathered marl underlies the river alluvium to be left in place under the upstream cofferdam and that the altered weathered marl found at depth in the foundation under the impervious core extends upstream past the toe of the embankment.

Design Parameters. The determination of the design parameters is described in detail in Appendix D, Construction Materials. The parameters used are summarized on Exhibit J-4.

Loading Conditions. The following loading conditions were investigated for the maximum dam section with crest elevation 200: (ultimate development)

a) Steady seepage. Normal maximum reservoir elevation 193.0, tailwater elevation 30.0, (Exhibit J-5).

b) Rapid drawdown. Reservoir drawdown from elevation 193.0 to elevation 100.0, (Exhibit J-6).

c) Construction case. Embankment completed, reservoir empty, (Exhibit J-7).

d) Seismic. Pseudo-static analysis of steady seepage case (Exhibit J-5).

In addition, the following loading conditions were investigated for the maximum dam section with crest elevation 150.

a) Steady Seepage. Normal maximum reservoir elevation 141.0, tailwater elevation 30.0, (Exhibit J-8).

b) Rapid drawdown. Reservoir drawdown from elevation 141.0 to elevation 90.0, (Exhibit J-9).

c) Construction Case. Embankment completed, reservoir empty, (Exhibit J-10).

d) Seismic. Pseudo-static analysis of steady seepage case (Exhibit J-8).

Method of Analysis. The stability analyses were performed using the Morgenstern-Price limit equilibrium computer method to determine the minimum factor of safety based on effective stress analysis.

For the steady seepage case the piezometric surface used was coincident with the long term phreatic surface. This is a conservative assumption for this dam section.

For the pseudo-static analyses, the seismic coefficient was varied from 0.1 to 0.2. A seismic evaluation of the site will be required during detailed design studies to establish a design earthquake and method of analysis. Also, a dynamic response analysis of the dam under a simulated earthquake loading will be performed using the finite element method.

For the rapid drawdown case, the impervious zones were assumed to have pore pressures developed under full reservoir load minus the change in the hydrostatic pressure. All other materials were assumed to be free-draining.

The developed pore pressures for the construction case were selected as a percentage of the total vertical stress in the impervious zones. These ratios, Ru values, were varied from 0.6 to 0.8 for Zone 1; 0.5 was assumed for Zone 2. Stage construction was not analyzed for crest elevation 200.

Results. The failure surface with the minimum factor of safety and certain other typical failure surfaces investigated for the various loading conditions are shown on Exhibits J-5 through J-10. The minimum factors of safety obtained for the static analyses are summarized as follows:

Loading Condition	Crest Elevation 200		Crest Elevation 150	
	Upstream	Downstream	Upstream	Downstream
Steady Seepage	1.77	1.68	2.17	1.70
Rapid drawdown	1.32	-	1.58	-
End of Construction	1.24	1.68	1.83	1.57

The pseudo-static analyses were performed using seismic coefficients of different magnitudes. The following tabulation indicates the magnitude of seismic coefficient which results in a factor of safety of 1.10.

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

For this feasibility study, the embankment was analysed for stability under two extreme conditions i.e, the lowest elevation of 150 m and the highest elevation of 200 m. These analyses indicate that the embankment is stable for the expected loading conditions. Since the embankment was found to be stable at Crest El. 150 and 200, the embankment at El. 158 (Stage II development) will also be stable. Detailed stability studies will be performed in the design phase when additional laboratory test data become available so that further refinement of the dam configuration can be made.

The use of finite element techniques for determination of the effect of the altered marl lens in the upstream foundation on the stresses and movements of the embankment and foundation should be considered in the final design studies. Finite element studies using soil parameters obtained from dynamic soil tests will be performed to evaluate the stability of the embankment and foundation during seismic loading.

Quantity of Construction Materials.

Embankment excavation and fill quantities were estimated from cross sections taken along the axis of the dam for construction to crest elevations 158, 168, and ultimate development to elevation 200. These cross sections are shown on Exhibits J-11 and J-12.

The quantities of available materials and the material requirements are summarized on Table J-2.

Design Phase Investigations and Testing

Present investigations have confirmed that the foundation conditions are satisfactory for a high embankment dam and that sufficient quantities of satisfactory construction materials are available near the site. However, additional investigations will be required to establish the best axis for the dam and for detailed design of the proposed structures. Information also will be provided to optimize the embankment with respect to cost, use of materials, ease of construction and embankment stability.

Foundation Area. Investigations in the foundation area should include: drilling, large diameter drill holes, test pits, shafts and adits. Drilling is required to accurately define required excavation and fill quantities. Large diameter drill holes will be required to sample and test the altered marl lens

Table J-2

AVAILABLE CONSTRUCTION MATERIALS AND MATERIAL REQUIREMENTS

Zone	Material	Source	CREST EL. 158, RAISABLE		CREST EL. 200 RAISED FROM EL. 158		CREST EL. 168 RAISABLE		CREST EL. 200 RAISED FROM EL. 168		Remarks
			Quantity Available $x10^6 M^3$	Quantity Required $x10^6 M^3$	Quantity Available $x10^6 M^3$	Quantity Required $x10^6 M^3$	Quantity Available $x10^6 M^3$	Quantity Required $x10^6 M^3$	Quantity Available $x10^6 M^3$	Quantity Required $x10^6 M^3$	
1	Primary Source Impervious Clay Secondary Source Impervious Clay	Borrow Area B Borrow Area B1 Borrow Area R1 Borrow Area R2 Borrow Areas A, A1, J1, J2 and R4	1.40 0.97 0.76 0.67 2.63	2.56	0.76 0.67 2.63	1.94	1.40 0.97 0.76 0.67 2.63	2.75	0.76 0.67 2.63	0.75	Borrow Areas B and B1 for Stage II development. Borrow Areas R1, R2, A, A1, J1, J2 and R4 for Ultimate development.
2	Impervious Talus	Required Excavation	2.70	1.35	0.87	0.35	2.61	1.43	0.96	0.27	Talus from Foundation Area and clay and talus from Spillway Excavation.
3F	Fine Filter	Quarry QB1	Unlimited	0.30	Unlimited	0.20	Unlimited	0.32	Unlimited	0.17	
3C	Coarse Filter	Quarry QB1	Unlimited	0.26	Unlimited	0.18	Unlimited	0.30	Unlimited	0.14	
4	Random Rockfill	Borrow Area U Borrow Area D Required Excavation Quarry QL2	1.92 - 2.0 3.20	2.83	1.08 1.04	0.00	1.92 - 2.2 3.20	2.83	1.08 .84	0.00	Borrow Area U for Stage II development. Borrow Area D for Ultimate development. Assumed 40% of River Alluvium from Borrow Areas U and D and 70% of Basalt and 100% of limestone from Required Excavation.
5	Alluvium	Borrow Area U Borrow Area D Required Excavation	2.88 - 0.70	3.14	- 1.62 0.10	0.06	2.88 - 0.73	3.49	1.62 0.07	0.51	Borrow Area U for Stage II development. Borrow Area D for Ultimate development. Assumed 60% of River alluvium from Borrow Areas U and D.
6	Basalt Rockfill	Basalt from Required Excavation Quarry QB1	0.23 Unlimited	2.34	0.20 Unlimited	6.26	.24 Unlimited	4.05	0.19 Unlimited	5.15	30% of Basalt from Required Excavation.
7	Random Fill	Required Excavation	1.44	0.94	0.6	0.00	1.2	0.94	0.84	0.00	Marl from Required Excavation
		Embankment Total		14.32		8.79		16.12		6.99	

23

found in the strata below the riverbed. Test pits will be required on both abutments to obtain samples of talus for laboratory testing. Adits are required on both abutments in the limestone and bituminous marl units to allow visual inspection of the foundation rock, to obtain samples for laboratory testing and to serve as future grouting or drainage adits.

Construction Materials. Investigations of construction materials will be used to define and, if necessary, modify design parameters and construction specifications. Additional investigations will be required in the alluvium materials. These investigations will require special excavation techniques, such as the use of a dragline or backhoe, to excavate the alluvium below ground water. Excavated material will be stockpiled to observe the drainage characteristics and a test fill will be required to determine the compaction characteristics. Test fills will also be required to determine the drainage and compaction characteristics of limestone rockfill and the compaction characteristics of impervious talus. Test blasts will be required for limestone and basalt.

Testing. Additional laboratory testing will be required for construction and foundation materials. In addition, large diameter triaxial shear tests will be required for the river alluvium, limestone rockfill, impervious talus and altered marl found in the riverbed. Dynamic strength tests will be required to define the dynamic parameters of the foundation and construction material.

Field permeability and in-situ shear tests may also be required to better understand the behavior of the foundation material. Additional dispersion tests will be required to

determine the dispersive characteristics of the impervious core material. Laboratory tests on basalt will include concrete aggregate quality and concrete mix designs.

Spillway

General

Spillway facilities at Maqarin Dam will be capable of passing the probable maximum flood (PMF) without endangering Project structures. The spillway will be located in the left abutment and founded on an marly limestones of the Bituminous Marl Unit and will be designed to support the embankment at the spillway approach channel and control structures. The spillway will consist of an approach channel, an ogee control section, a straight, constant-width chute, and a flip bucket to direct water to the natural river channel. A plan of the spillway is shown on Exhibit J-13. A profile, sections and details are shown on Exhibit J-14. The elevations presented in this description are for the recommended plan (Reservoir at El. 150).

The ogee section will consist of three bays, each controlled by a 8.0 m wide by 15 m high tainter gate and will be designed to pass a flow of 5,400 m^3/s with 7.5 m surcharge on the reservoir. All three gates will be lifted by individual gate hoists. The gate dimensions have not been optimized. It is possible that two 12m x 15m gates would be more economical. This alternative should be examined during the detailed design of the project. The ogee crest will be at El. 135. The spillway will be about 360 m long and have a width of 29 m. A dividing wall was located at the third-point of the chute on the river side. This will be confirmed by model studies. The dividing wall will

25

confine flows at low spillway discharge and facilitate proper flip-bucket operation. A section through the weir and a typical section along the chute are shown on Exhibit J-14. The flip bucket lip at the downstream end of the chute has been located at El. 40. A bridge will be built above the spillway ogee to provide access to the dam crest. The mechanical and electrical equipment for gate operation will be serviced from this bridge.

Hydraulic Design

The spillway is designed to pass the probable maximum flood. The PMF at the Maqarin site has a peak flow of 6,400 m^3/s and an 8-day volume of 660 MCM. Based on a pre-design flood routing, this flow will result in a spillway outflow of 5,400 m^3/s at reservoir El. 157.5, which is 7.5 m above normal maximum reservoir elevation (El. 150). The inflow and outflow hydrographs for the PMF flood routing, the spillway discharge rating curve for all three gates fully open, and the area-volume curve for Maqarin Reservoir are shown on Exhibit J-15. The gates will be capable of operating partly open to control smaller discharges.

The approach channel will be lowered from El. 130 at the approach channel inlet to El. 120 at the spillway structure to improve the spillway discharge efficiency. The spillway is designed for a discharge coefficient of 2.02 at reservoir El. 150. The approach-channel alignment will guide the flow from the reservoir to the spillway crest except that there is cross flow from the reservoir across the wall. The velocity in the approach channel will be about 3.5 m/s for the maximum discharge of 5,400 m^3/s.

The crest of the spillway will be at El. 135. The concrete ogee will be designed so that atmospheric pressure

will be maintained for the condition of maximum normal head of 15 m with full-gate opening.

The discharge over the ogee will be conveyed by a straight chute about 300 m long to a flip bucket then into a discharge channel. The minimum slope of the chute was set at about eight percent to maintain supercritical flow. A dividing wall will be located at the third-point of the chute on the river side. A constant height of 8.0 m was used for the dividing wall. The end walls will be in 10 m high; sufficient to contain the air-entrained flow at maximum discharge.

The flip bucket will be located so that the plunge pool action will occur in the river and the associated erosion will not undermine the bucket structure. Hydraulic model tests will be required to verify the detail. The flip-bucket lip will be at least 5.0 m above the maximum tailwater elevation to develop good jet action and provide adequate aeration to minimize cavitation erosion to the structure. Releases will discharge into the Yarmouk River channel about 200 m downstream of the dam.

Foundation and Structural Design

The concrete ogee weir will be founded on sound rock, at El. 100, about 25 meters below the natural ground level. The bedrock consists of marly limestone and has an adequate bearing capacity for the crest structures. Seepage will be controlled with a grout curtain and a drainage curtain, which will reduce the uplift and provide safety against piping. The chute will be founded on the marly limestone. The permanent exposed cut slopes in the rock and overburden will be at 1.5H:1V. However, slopes of 1H:1V will be used when they will be supported by backfill.

Spillway piers will be designed to withstand unbalanced water loads and unbalanced trunnion reactions, caused by installing stop logs across one bay with maximum headwater flow in the adjacent bay.

The spillway chute foundation may require rock anchoring and gunite protection. For the cost estimate, the rock anchors were assumed to be 10 m long, spaced 3.0 m on center, each way. For this estimate 680 10-meter long anchors were included. Box drains will be provided under the foundation of flow to eliminate uplift due to seepage.

The spillway bucket will be founded on the Bituminous Marl Unit. Side walls will be designed for hydrodynamic loads developed from the flow in the chute. Hydraulic model tests will be used to aid in evaluating the hydraulic loads. A concrete protective slab will be placed downstream of the flip bucket to prevent erosion.

Raising Maqarin Dam

The adopted spillway layout will allow raising the fill dam with a minimum of structure removal. In addition to the gates, which can be salvaged, only the concrete of piers and bridge will be removed. The remaining concrete would be covered with shell material of the dam. The core of the raised dam would be upstream of the Stage II spillway. The contact between the spillway and foundation and the contact between the spillway and the core of the fill dam will be designed to assure a reliable barrier against seepage.

The high-level spillway would be located up the valley side in the same relative position. It is intended that the same general configuration would be used. The required flood surcharge will be reduced to 5.0 m because of the larger reservoir capacity and resultant reduced spillway discharge at the higher elevation.

River Diversion During Construction

The facilities for diversion of the Yarmouk River during construction consist of upstream and downstream cofferdams and a tunnel located in the left abutment. The flow of the river will be diverted through this tunnel during construction of the dam from mid-1979 to late-1981. The date of closure will depend on construction progress and streamflow. Once the spillway has been completed and the dam embankment is above the elevation of the spillway crest, the diversion tunnel can be closed. The diversion closure gate will be set in position and a concrete tunnel plug will be placed. Closure will occur at the beginning of the wet season. The brief interruption of flow from above the dam because of the closure will be acceptable because the water

supply below the dam will be adequate to meet the downstream requirements. A profile of the diversion for the recommended plan is shown on Exhibit J-13; a tunnel section, and sections through the inlet and outlet are shown on Exhibit J-16.

The diversion tunnel will be about 900 m long with an inside diameter of 6.5 m. The tunnel was sized to discharge 500 m^3/sec at a velocity of 15 m/sec. This discharge corresponds to a flood with a recurrence interval of about 20 years. The diversion tunnel was designed for free-flow discharge. Losses were computed for bell-mouth entrance conditions, for flow through a vertical gate opening, for a 50 degree and 10 degree bend, for friction and for free-flow exit conditions. The head loss coefficients used in the computations are shown below:

	Headloss Coefficient
Entrance	0.20
Vertical Gate	0.10
50-degree bend (R=50 m)	0.05
10-degree bend (R=50 m)	0.01
Friction	1.56
Exit	1.00
Total	2.92

Headloss equals coefficient times $V^2/2g$

A head of 33.8 m is required to pass the design-flood discharge of 500 m^3/s. The level of the pool upstream of the cofferdam will be at El. 61.8; the upstream cofferdam will have a freeboard of 0.2 m at design discharge. The discharge capacity of the diversion tunnel could be increased to about 700 m^3/s by raising the upstream cofferdam without a substantial cost increase.

30

An approach channel 140 m long will lead to the intake portal. The channel invert will be constructed to El. 30. The portal excavation will be into a rock face with 10 to 15 m of rock cover. Excavation slopes will be 1H:1V in rock and 1.5H:1V in overburden.

The diversion tunnel will be driven through bituminous marl. Conventional methods will be used for excavation and the tunnel will be lined with concrete to a thickness of 0.6 m. Tunnel supports, spaced at 1.0 m, were assumed for 50 m from each portal and for 10 percent of the remaining length. Rock bolts will be installed 1.5 m on-center over 240 degrees of the excavated diameter for 20 percent of the unsupported length. Shotcrete and wiremesh will be installed over the entire unsupported length. Tunnel slope will be 0.0055 and the invert elevation at the exit portal will be about El. 25.

A 25 m long discharge channel will extend from the exit portal to the river channel. The excavation slopes in the downstream channel will be the same as for the upstream channel.

Cofferdams will be constructed upstream and downstream from the main embankment to provide protection to construct the fill dam. The cofferdams will have upstream and downstream slopes of 2H:1V and include an impervious core and a rock shell. The crest of the upstream cofferdam will be at El. 62. The downstream cofferdam will be about 12 m high with crest El. 37. The material for these dams will come from Borrow Areas A or B for the impervious material and U or D for the rockfill. The upstream cofferdam will be incorporated into the main embankment and the downstream cofferdam may be removed when the diversion tunnel is closed.

Low-Level Outlet

The low-level outlet facilities include an intake, 50 m of concrete-lined tunnel downstream from the intake to the diversion tunnel, a steel outlet conduit 300 m long, and a control facility.

The main purpose of the low-level outlet is to provide a means for evacuating the reservoir under emergency conditions. The outlet also can be used for controlled initial filling of the reservoir and to make irrigation releases if the power facilities are shut down.

The invert elevation of the low-level intake structure (El. 50) was selected to permit almost total evacuation of the reservoir. The intake is below the elevation of the computed 50-year sediment level. The outlet should be operated periodically to keep the extreme downstream part of the reservoir clear from sediment and to ensure that it is functioning properly. The trashrack structure is semi-circular and flow can enter from both sides, the front and the top. The average velocity through the trashrack at maximum discharge of 60 m^3/sec is 0.5 m/sec. A section through the intake and outlet, and valve chamber details are shown on Exhibit J-16.

From the intake, water will travel through a 2.3 m concrete-lined inclined shaft about 50 m to the diversion tunnel. Under the impervious core on line with the grout curtain, the flow will enter a 1.8 diameter steel pipe which will be encased in concrete for the initial 10 m length. Flow into the steel pipe will be controlled by a 1.8 m butterfly valve. Access to this valve will be through the lower drainage adit. The steel pipe will be 300 m long and will terminate in a valve house at the downstream end of the

diversion tunnel. Flow through the valve house will be regulated and dissipated by a 1.5 m Howell-Bunger valve which will be protected by a 1.5 m Rota valve.

The capacity of the outlet works with the reservoir at El. 55 is 21 m^3/s; sufficient to meet the peak irrigation requirements. The capacity of the outlet was based on a coefficient of discharge with valve full open of 0.80 and losses for trash racks, entrance conditions, bends and friction. The capacity of the outlet works at normal maximum water surface elevation (El. 150) is 50 m^3/s. The outlet, acting alone can empty the reservoir from normal maximum water surface elevation to El. 55 in about 150 days. If the spillway and power facilities are used, the reservoir can be emptied in 60 days. These estimates are based on average wet-season inflow. The valve can be throttled to produce discharges less than the maximum. The degree of throttling can be calibrated from laboratory data supplied by the manufacturer with supplemental field calibration if necessary.

Powerplant at Maqarin Dam

The powerplant is located about two kilometers downstream from Maqarin dam on the left bank. The plant will have an installed capacity of 20 MW in two generating units. The location of the powerplant is shown on Exhibit J-13 and sections of the tunnel, gate shaft, intake, surge tank and powerplant are shown on Exhibit J-17.

Water Conductor

The power intakes will be located upstream from the spillway approach channel. The intake structure will consist of a reinforced concrete box structure with trashracks on the upstream face. The bottom of the intake

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

The water conductor will consist of a 3.2 m diameter concrete lined tunnel 1730 m long; a 2.3 m diameter concrete and steel lined tunnel 150 m long; and a bifurcation at the power units. Tunnel supports spaced at 1.0 m intervals were assumed for 50 m from each portal and for 10 percent of the remaining length. It was also assumed that rock bolts would be installed 1.5 m on-center over 240 degrees of the excavated diameter for 20 percent of the unsupported length. Shotcrete and wire mesh would be installed over the entire unsupported length. The water conductor will be designed for conditions expected under Stage III development as well as for Stage II conditions.

The 3.2 m diameter tunnel will be concrete lined with the concrete lining 0.35 m minimum thickness. No reinforcement will be provided except in zones of weak or fractured rock. Maximum velocity in the 3.2 m tunnel will be approximately 2.5 m/s. The 2.3 m tunnel will be steel lined and encased in concrete 0.2 m thick. The steel lined section begins 150 m upstream from the powerplant where the rock cover is less than 40 percent of the maximum head. The transition from 3.2 m to 2.3 m will occur over a length of 10 m. The bifurcation will be provided at the powerhouse and butterfly valves will be installed to protect the generating units.

A gate shaft will be located about 275 m downstream from the intake structure. The shaft and superstructure will be about 126 m high with the top of the shaft at El. 200. A 50-ton-mounted hoist will be installed in the superstructure. The gate shaft will house two in-line 3.2 m by

3.2 m clear-opening wheel gates. Sections of the tunnel intake, and gate shaft are shown on Exhibit J-17.

A surge tank will be needed to provide the powerplant with the regulating capability necessary for Jordan's relatively small power system. The surge tank will be located about 320 m upstream from the powerstation. The tank will be about 180 m high and for preliminary assessment is considered to have an internal diameter of 3.2 m. The diameter of the surge tank was based on an analysis of full-load rejection at maximum reservoir level and full-load acceptance at minimum reservoir level. The proposed surge tank would limit the pressure rise on the power units to about 30 percent. The final tank to accomplish the same purposes may differ in configuration but not appreciably in cost.

Powerhouse

Maqarin powerplant, shown on Exhibit I-17, will be a conventional structure 20 m long and 19 m wide. The house will include a machine hall with two generating bays, an erection bay including a 35-ton crane, and a control area. The minimum foundation level will be at El. -1 and the centerline of the distributor will be at El. 3.

The installed capacity will be 20 MW in two units. Each generator will have a nominal rating of 13.8 kV, 11.1 MVA 0.9 pf at 60°C temperature rise and will be capable of continuous operation at 115 percent of rated MVA without injurious temperature rise. The generators will be static excitation systems. The generators are designed to permit generation with a turbine discharge of 20 m^3/s at 128 m net head which corresponds to the maximum gross head. The turbines will be vertical-shaft Francis-type machines

35

designed for a rated head of 120 m. The turbines will release 20 m^3/s, which is the irrigation system capacity, and produce approximately 12 MW at the minimum net head which is about 77 m. The turbines will have a slow governor time to minimize pressure variations. It is planned that when the dam is raised for ultimate development the generating equipment will be changed.

Transmission

A substation will be installed at the powerplant which will include one three-phase power transformer to serve both generating units. It will be oil insulated, self-cooled and rated at 26 MVA, 13.8/66 kV. A single-circuit 66-kV transmission line will lead from the switchyard to Irbid about 31 km away. The line current will be 224 amperes and the voltage drop over the length of the line will be about 4.4 percent. The conductor size will be 795 MCM ACSR and the towers will be spaced, on the average, at 150 m. A one-line diagram of the major electrical features is shown on Exhibit J-18.

Powerplant at King Talal Dam

The powerplant at King Talal Dam will have an installed capacity of 2.0 MW in one generating unit. A plan and sections of the powerplant are shown on Exhibit J-19.

Water Conductor

The existing low-level outlet and diversion tunnel will be used for the power facilities. The intake for the existing low-level outlet is at El. 116. The outlet tunnel has a diameter of 3.5 m and passes through a valve chamber prior to joining the diversion tunnel which has a diameter of 6.5 m.

The steel power conduit will begin 80 m upstream from the exit portal of the diversion tunnel. The diameter of the steel penstock will be reduced from 6.5 m in the diversion tunnel to 1.5 m. About 45 m downstream from the convergence the steel conduit will bifurcate into a 1.5 m bypass, which will continue to the end of the diversion tunnel, and a 0.75 m penstock. The penstock will be placed in a 2.0 m diameter unlined tunnel from the diversion tunnel to the powerplant. The penstock will be 30 m long and seated on concrete saddles. The steel penstock will be 20 mm thick. The maximum velocity in the penstock will be about 3.5 m/sec. A 2.0 m diameter tailrace tunnel will discharge the powerplant releases back into the diversion tunnel outlet.

If the powerplant is shut down, or if a large discharge is required through the outlet facilities, the flow which cannot be accomodated by the powerplant will be discharged through the 1.5 m diameter by-pass. The steel by-pass conduit will be 15 mm thick and supported on concrete pedestals which will be anchored in the diversion tunnel. A butterfly valve will be installed to control the flow to a ring-jet type discharge regulations valve through which the water will be discharged into the Zarqa River.

Powerhouse

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

The turbine will be designed to operate under heads ranging from 45 m to 83 m and will produce 2.0 MW at a rated net head of 67 m with a rated discharge of 3.4 m^3/s. The generator will be rated at 2,222 kVA with a 0.9 power factor. The generator is capable of continuous operation at 115 percent of rated kVA. The turbine will be a vertical-shaft Francis-type machine operating at a speed of 1000 revolutions per minute.

Transmission. A step-up substation will be provided at the powerplant which will include an oil insulated, self-cooled three-phase power transformer rated at 2,600 kVA, 2.4/33 kV. A single-circuit 33-kV transmission line will connect with the Amman-Salt transmission line at a substation about 9 km from the powerstation. The conductor size will be 2 MCM ACSR and the towers will be spaced, on the average, at 150 m. A one-line diagram of the major electrical features is shown on Exhibit J-20.

Diversion to East Ghor Main Canal

Diversion facilities to the East Ghor Main Canal (EGMC) were designed for two conditions. The first condition, and the recommended plan, consists of a conventional diversion dam at the existing diversion point on the Yarmouk River. The second condition consists of two intakes to the EGMC located on the left bank of the river with no permanent structures more than half-way across the river.

Diversion Dam

The recommended diversion facilities for Stage II development will consist of a diversion dam constructed across the Yarmouk River immediately downstream from the EGMC intake and a sediment sluiceway. The size and configuration

of the facilities were based on a design by Energoprojekt and as shown on Exhibit J-21. This concept is based on the previously known field conditions and is considered to be adequate for estimating the cost of the final structure. Additional data collected during the design stage may indicate the need for some modifications to this design; however, the overall concept or costs are not expected to change significantly.

The hydraulic height of the structure to divert 20 m^3/s into the EGMC is estimated to be 3.0 m. The diversion structure will be an uncontrolled concrete weir with a short downstream apron. The downstream apron will be underlain by free-draining material as protection against uplift. The weir will be about 60 m long. The elevation of the top of the weir is estimated to be at El. -202.5; which would result in a weir 5.5 m high from the bottom of the foundation. A 0.8 m diameter steel pipe could be embedded in the weir to provide controlled releases for downstream users when the flow in the river is less than 20 m^3/s. The releases could be controlled by a spherical valve placed at the downstream end of the pipe. A pipe coupling could be provided at the valve so that a pipe may be attached to the valve. This pipe could be run to the Yarmouk Triangle area and could deliver water with only minimal losses. A booster pump may be required to provide pressure to the pipeline.

As designed by Energoprojekt, the desilting facility consists of an open channel parallel to the river at the entrance to the intake. The intake to the approach channel has two openings, 5.0 m wide by 1.0 m high and 5.0 m wide by 1.5 m high. The openings are protected by trashracks. A parallel training wall separates the desilting works from

Yarmouk Project, Khalid Bin Al Wilid-Wadi Arab Scheme, Phase B - Preliminary Design, Volume VI, MSB-F, Adasiye Diversion Structure, Energo Projekt, June 1967.

the riverbed. The slope and dimensions of the channel will be determined during final design to minimize the sediments in the diversion flows.

Flushing the sediment through the desilting facilities is accomplished by raising a hand operated radial gate located at the downstream end of the desilting works.

For river flow in excess of 50 m^3/s, the desilting works and walls will be flooded. Protection against erosion downstream from the weir will be provided by blanketing the slopes and river bottom with two layers of interconnected gabions.

Uncontrolled Diversion to EGMC. It may be necessary to construct the diversion facilities so that no permanent structures extend more than half-way across the Yarmouk River. The diversion facilities for this condition will make use of the existing intake and tunnel and additionally a new tunnel, intake, and sediment sluiceway. A plan and details of this scheme are shown on Exhibit J-22.

A 1.0 m deep basin will be excavated in the riverbed parallel to the river on the Jordan side to stabilize the flow before it enters the approach channel. This drop acts as a broad-crested weir. The head developed across the weir will draw water from the entire river to the intake.

Each intake will be excavated so that the invert will slope toward the tunnel at a rate of about five percent. The intake area will have a width of about 150 m at its widest point in the middle of the Yarmouk River and will narrow to 15 m at the tunnel entrance. A concrete barrier, 1.0 m high will be installed half-way across the River at the downstream end of the intake.

The existing tunnel has an inside diameter of 3.0 m and a length of about 1000 m. The new tunnel will have a standard horseshoe shape with an inside diameter of 3.5 m and a length of 1300 m. Both tunnels will discharge into the main canal immediately above the proposed desilting works.

The sediment collected in the diversion system will be passed back into the Yarmouk River through four 1.0 m by 1.0 m box culverts and a 60 m long canal section. A gate structure and four sluice gates, located at the downstream end of the culverts, will be used to control the water through the desilting works.

The main canal section will be located on top of the box culvert intake. This will permit the least sediment-laden water to be skimmed off the top and passed on down the canal.

Hydraulic studies indicate that sufficient head will be developed from the proposed configuration to divert up to 20 m^3/s into the EGMC intake. The installation of the concrete barrier and the head differential across the width of the channel will develop a diversion efficiency of about 70 percent. With two intakes, the overall efficiency is expected to be 90 percent. Hydraulic model studies will be necessary to confirm the efficiency and the effectiveness of the desilting works.

Side Wadi Diversion Structures

A portion of the flow of Wadis Yabis, Kufrinja, and Rajib are available to meet the irrigation requirements of the Project. From an inspection trip, it was learned that no weir is presently located on Wadi Rajib, that the weir on Wadi Kufrinja is damaged, and that the weir across Wadi

Yabis is in fairly good repair. Estimates of capacity of the diversion were made and discussions were held with members of the Natural Resources Authority on operation and capacity.

Suitable mapping is not available for preliminary design or rehabilitation of these weirs. Therefore, locations and required repairs were determined in the field and costs of improvements were estimated on the basis of a typical diversion weir and connecting canal to the EGMC. These typical features are shown on Exhibit J-23.

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

Wadi Yabis Diversion

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

Wadi Kufrinja Diversion

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

Wadi Rajib Diversion

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

Railroad Relocation

The Himma branch line of the Hejaz Railroad runs along the Yarmouk River Valley. This branch line will be inundated by Maqarin Reservoir, and therefore, studies of its relocation were necessary.

Maps to a scale of 1:10,000 are available and were used for selecting alignments and for computing excavation quantities, tunnel lengths and bridge lengths and heights. Because the terrain over most of the alignment is very steep, the quantity estimates taken from these maps are approximate.

The alignments studied were along the north (Syrian) side of the river. Alignments were laid out at El. 165 and El. 210. The estimates of cost are adequate for any minor revision needed to fit the relocation to the terrain. The alignment and a profile for the alignment at El. 165 are shown on Exhibit J-24.

The relocation begins at the existing alignment at El. 165 on the ridge between Wadi Meidane and Wadi Ehrer. The relocated alignment generally follows the El. 165 contour until it reaches the dam site. From the damsite, the elevation of the alignment decreases along a two percent slope until it reconnects with the existing track. The total length of the relocated track is about 21 km. This alignment requires 6 tunnels with a total length of about 2,500 m and 6 bridges.

The maximum gradient was set equal to two percent, which is the limiting gradient of the existing line. The minimum radius of curvature was 120 m, also a criterion for the existing line.

The earthwork quantities were taken from cross sections drawn every 0.5 km along the alignment using a typical road bed section.

The tunnels are horseshoe shaped with an internal diameter of 3.6 m. Four tunnel standards are available for use in different types of material. No geologic information is available for this study and costs were based on 1971 prices for actual tunnel construction updated to 1977.

The bridges consist of simple box girders in spans of 30 m to 40 m. The bridges will be constructed in accordance with Hejaz Railway standards.

Ruble masonry walls were used as retaining walls. The quantities for these walls were based on standards of the Jordan Ministry of Public Works.

Drainage culverts were sized using the Rational formula and drainage areas measured on 1:25,000 scale maps. The other parameters were taken from "Rainfall Intensities in Jordan - For Use in Engineering Design", Ibbit, September 1969. Rainfall with a recurrence interval of 25 years was used in the design. In addition to the major culverts, 1.0 m diameter drain-pipe culverts were included every 200 m. Quantities were based on the standards of the Jordan Ministry of Public Works.

Initial Reservoir Filling

An estimate was made of the time required to fill Maqarin Reservoir during the initial period of operation. The irrigation requirements were based on average climatic

conditions and the water supply was based on average hydrologic conditions. A release of 25 MCM per year to the Yarmouk Triangle was assumed during the entire fill-period. It is estimated that, under average conditions, the reservoir will fill in about five to six years.

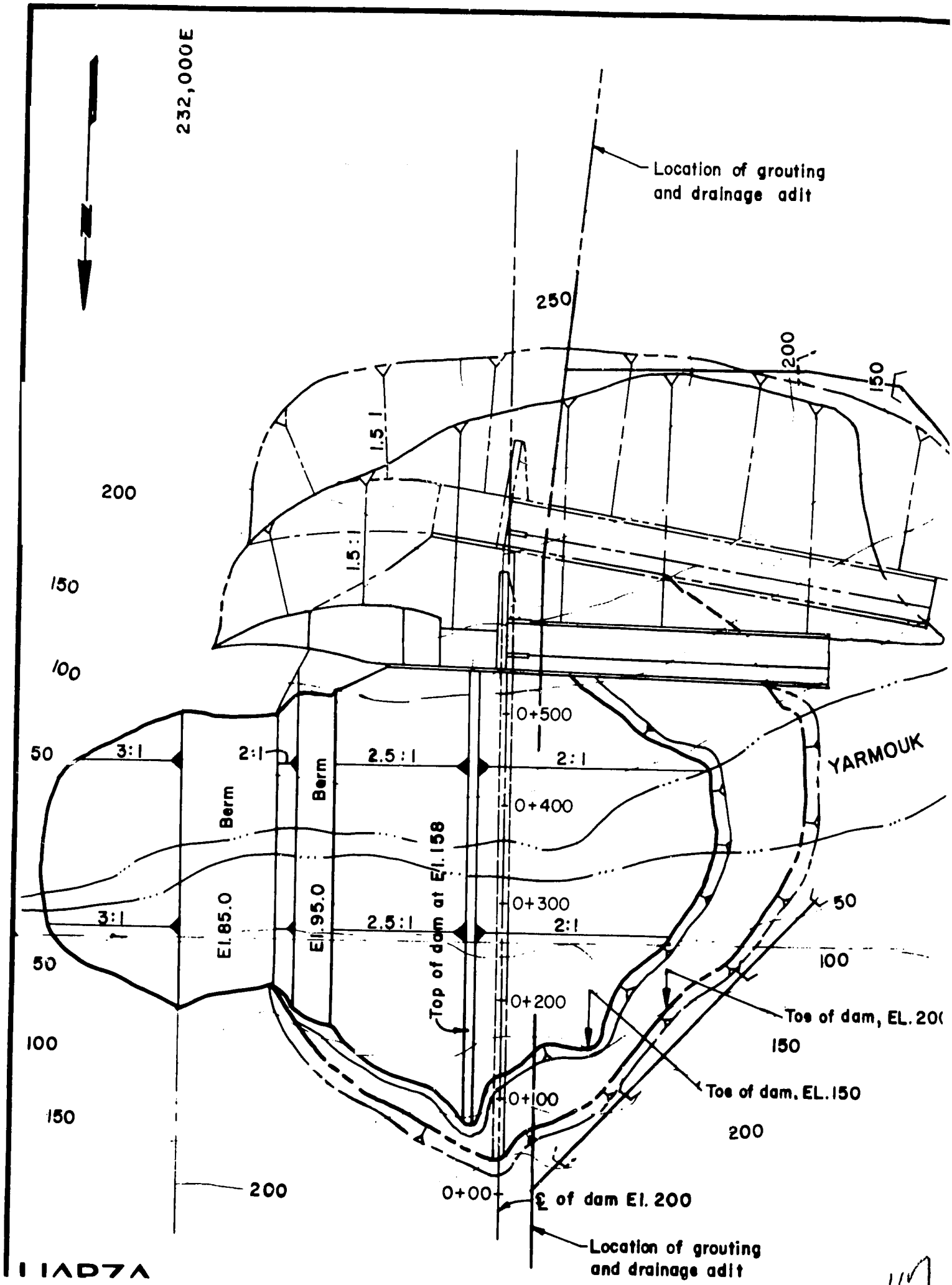
The water supply available to meet the Project requirements consists of the reservoir inflow, the flow generated between the dam and the intake to the EGMC (interflow) and the side-wadi flow. The reservoir inflow at Maqarin has been adjusted for anticipated diversions above the reservoir. This adjustment is discussed in Appendix A, Hydrology, Use of the interflow and side-wadi flow to meet Project requirements is discussed in Appendix C, Operation Studies.

The M&I requirements were based on estimates of population and per capita use for each year. Population and use estimates are given in Appendix C, Operation Studies.

It was assumed that the total irrigation requirement would be supplied to the converted area (12,842 ha) each year. The irrigation supply for the new-land area (12,511 ha) was based on the schedule for installing the sprinkler systems. According to this schedule, irrigation of the new-land area will follow the schedule shown below. The conversion area and total area are also shown:

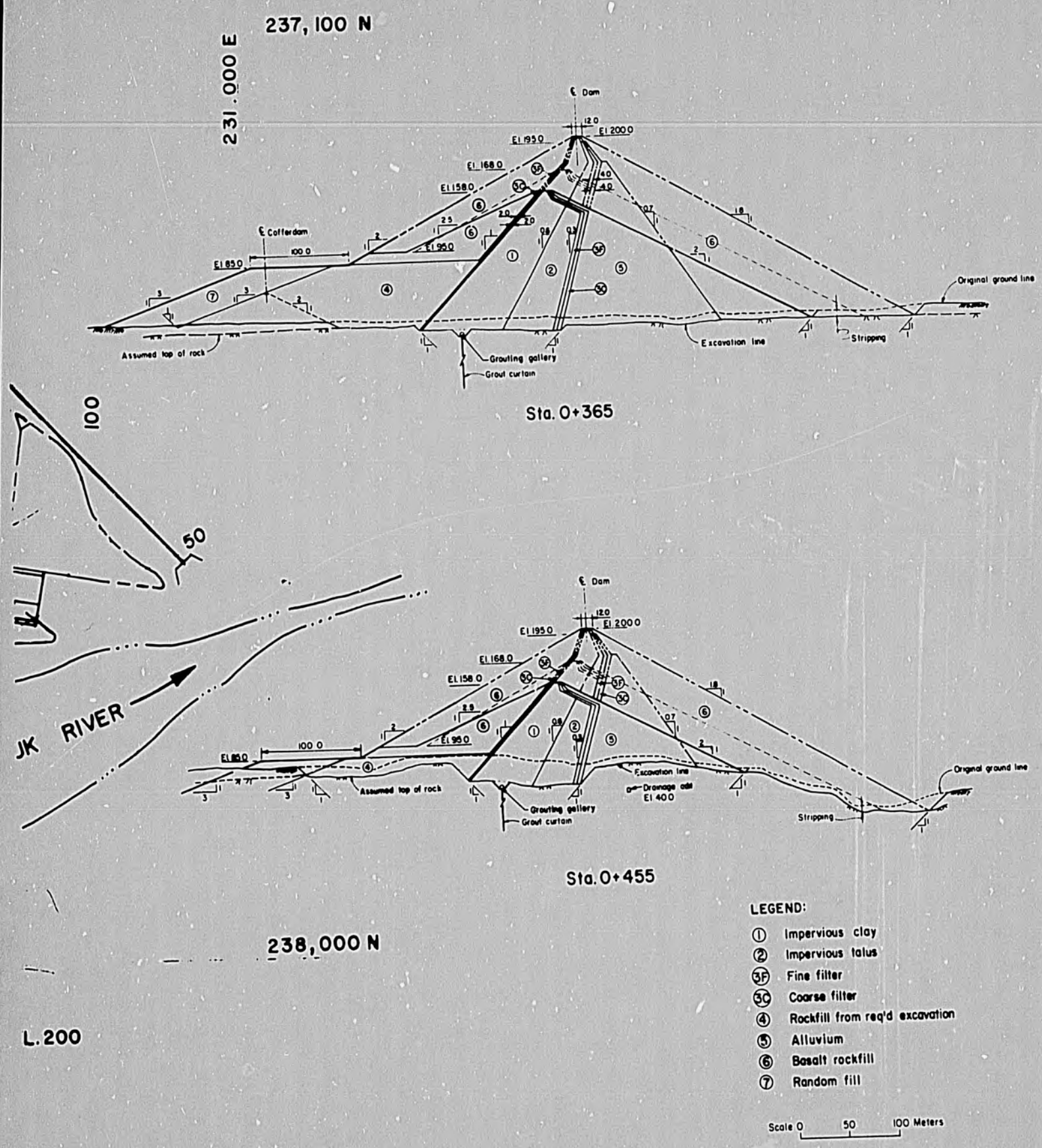
IRRIGATION SCHEDULE

Year	Converted Area (ha)	New-Land Area (ha)	Total Area (ha)
1978	12,482	-	12,482
1979	12,482	-	12,482
1980	12,482	-	12,482
1981	12,482	-	12,482
1982	12,482	7,543	20,385
1983	12,482	11,158	24,000
1984	12,482	12,511	25,353


232,000E
Location of grouting and drainage adit
250
200
150
1.5:1
1.5:1
200
150
100
50
3:1
2:1
2.5:1
2:1
Berm
Berm
0+500
0+400
YARMOUK
Top of dam at El. 158
El. 85.0
El. 95.0
3:1
2.5:1
2:1
0+300
50
50
100
0+200
Toe of dam, EL. 20(
100
150
Toe of dam, EL. 150
0+100
150
200
200
0+00
℄ of dam El. 200
Location of grouting and drainage adit

47

EXHIBIT J-1



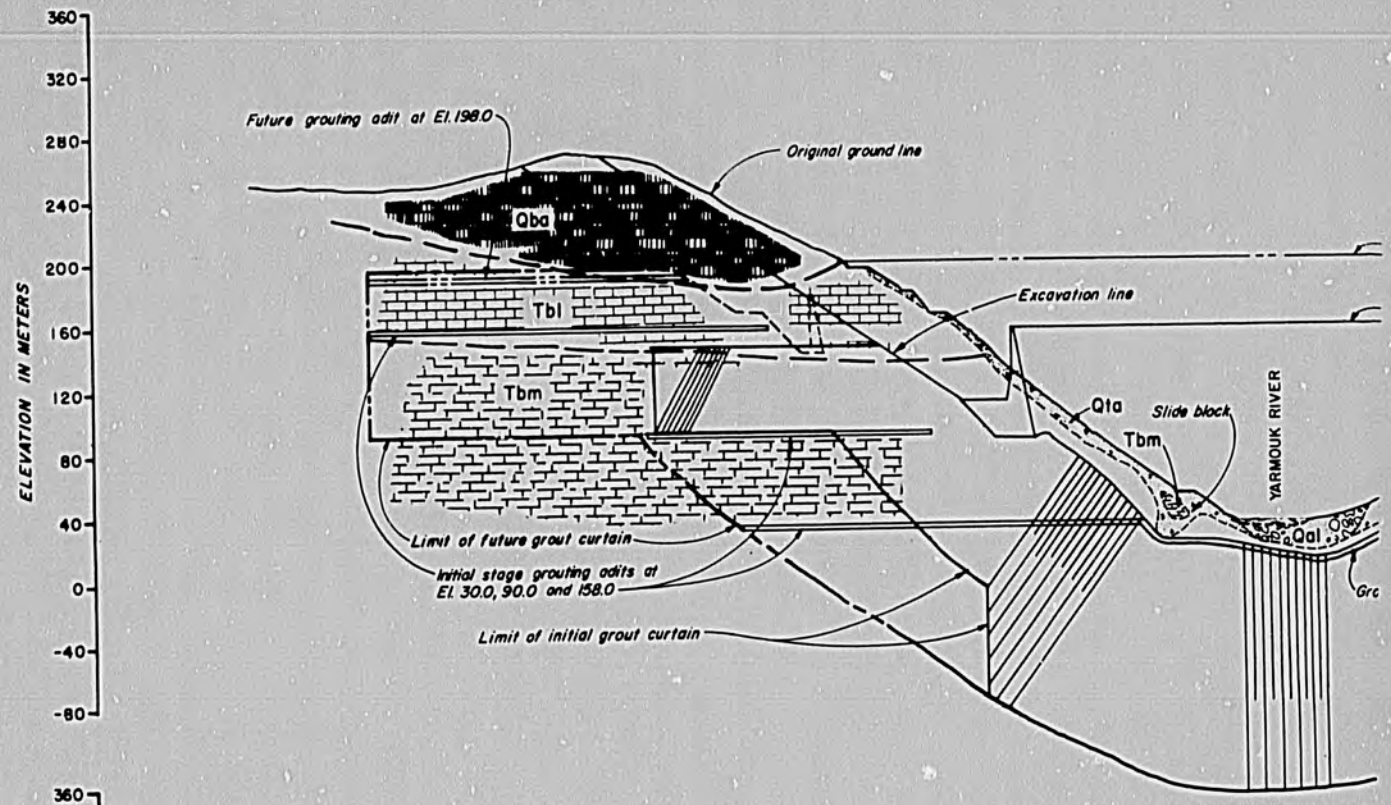
LEGEND:

1. Impervious clay
2. Impervious talus
3F. Fine filter
3C. Coarse filter
4. Rockfill from req'd excavation
5. Alluvium
6. Basalt rockfill
7. Random fill

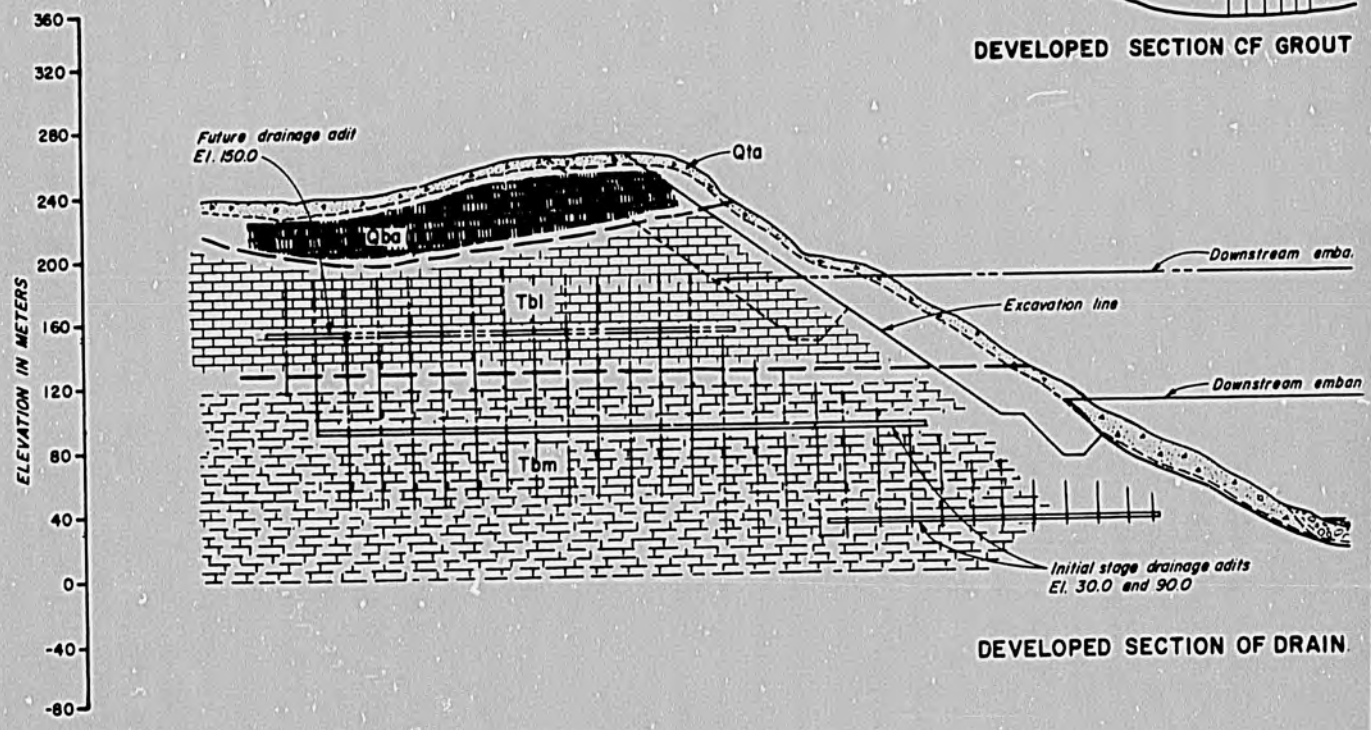
Scale 0 50 100 Meters

MAQARIN DA
GENERAL PLAN AND SECTION
JORDAN VALLEY IRRIGATION PROJE
STAGE

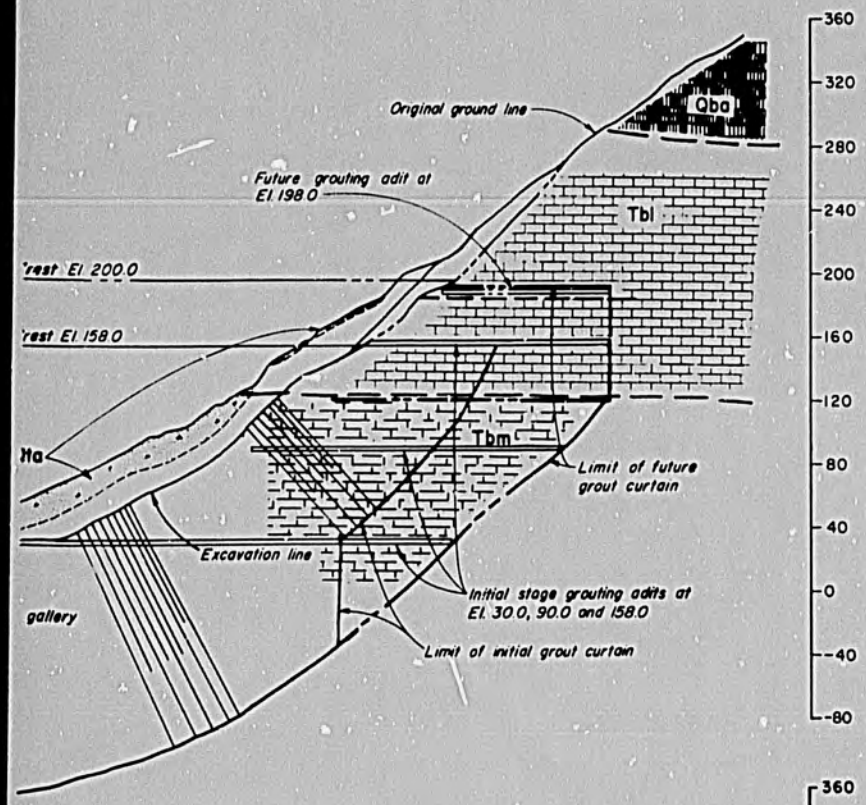
48



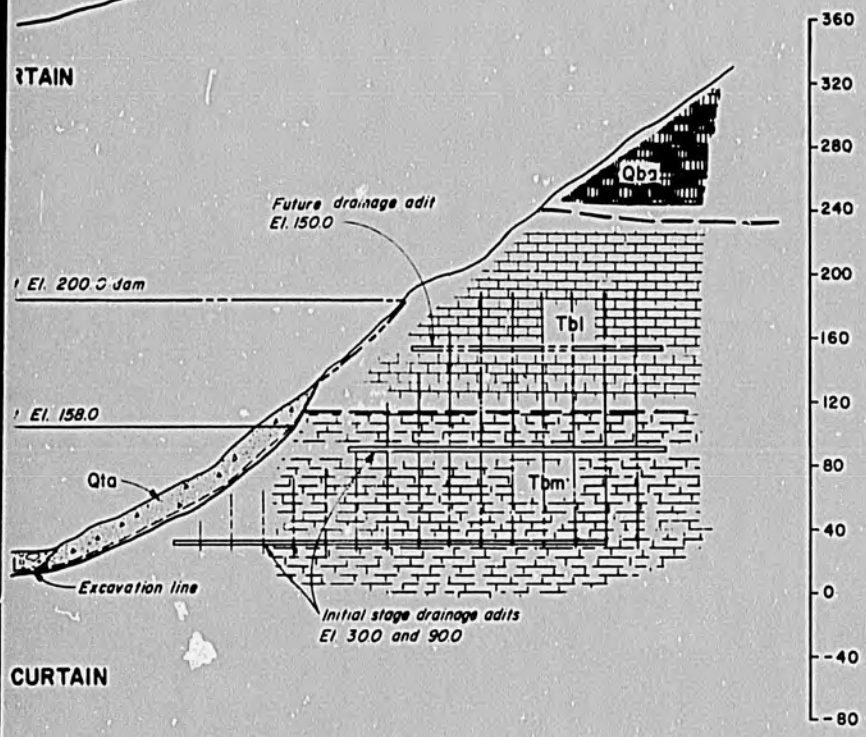
DEVELOPED SECTION OF GROUT



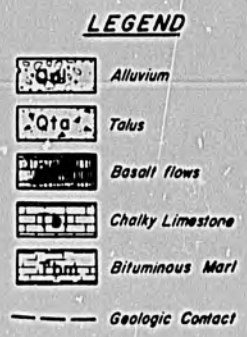
DEVELOPED SECTION OF DRAIN



RTAIN



CURTAIN

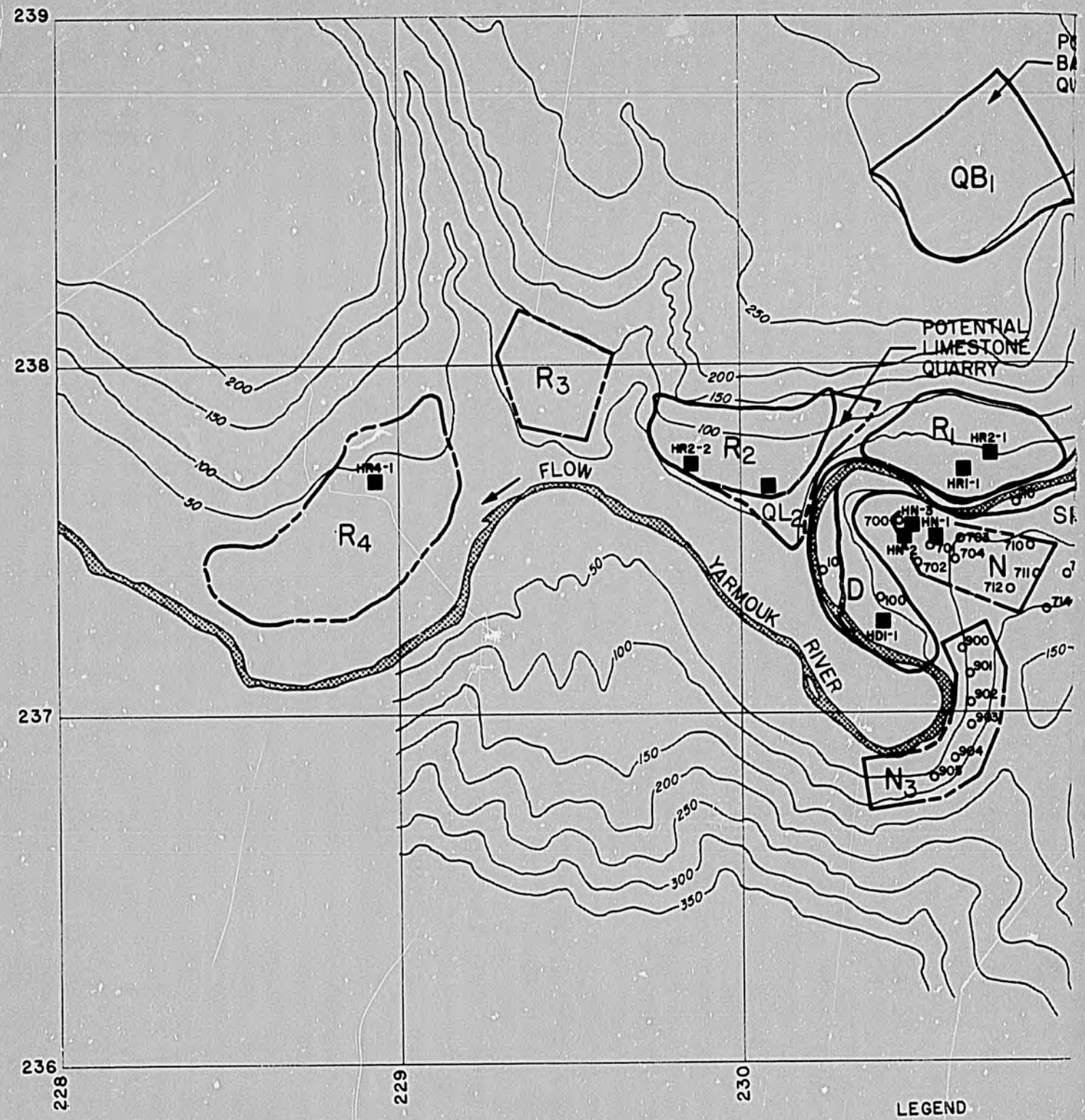


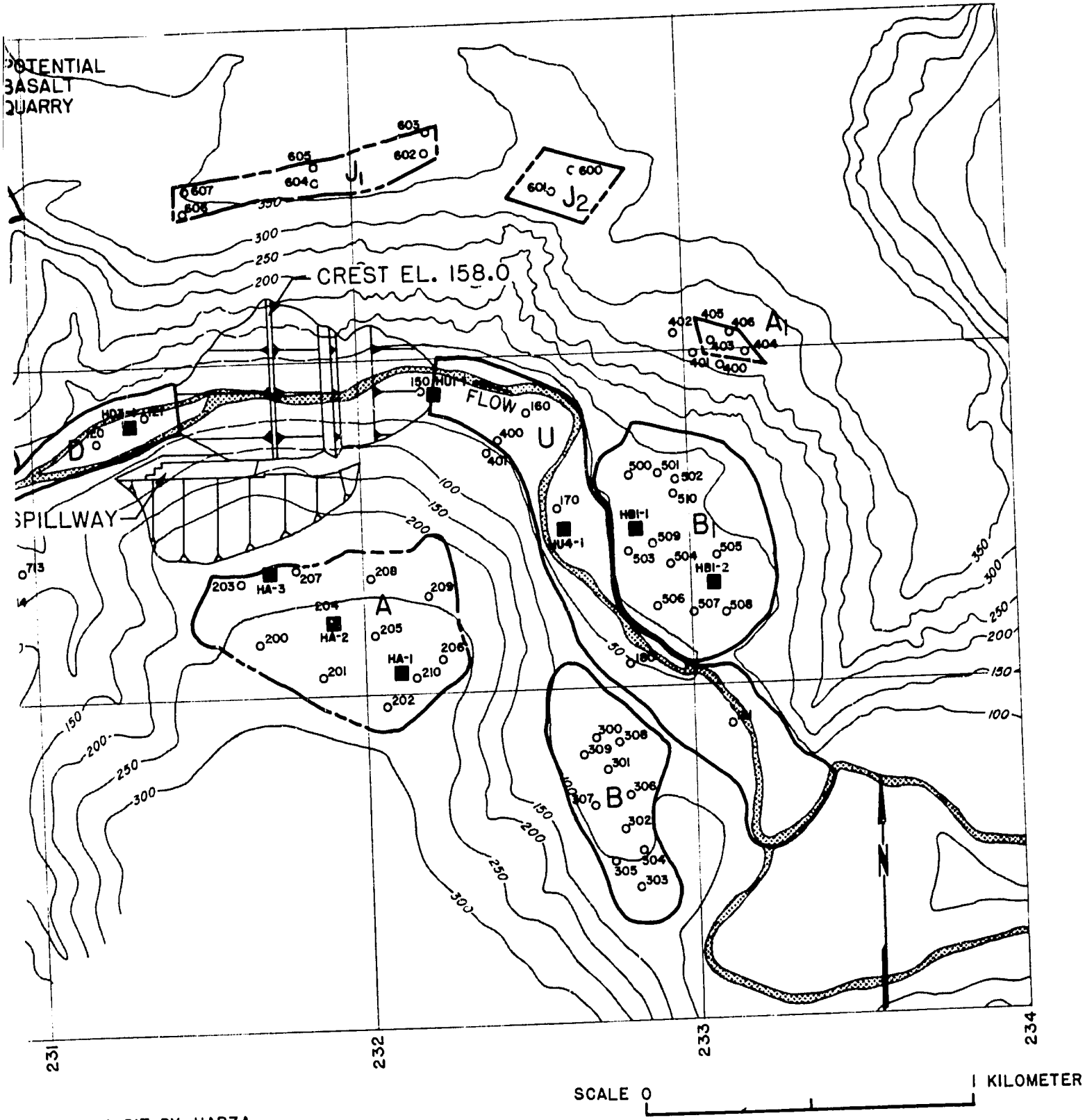
SCALE 0 120 METERS

MAQARIN DAM
GROUT CURTAIN AND
DRAINAGE CURTAIN PROFILES

JORDAN VALLEY IRRIGATION PROJECT

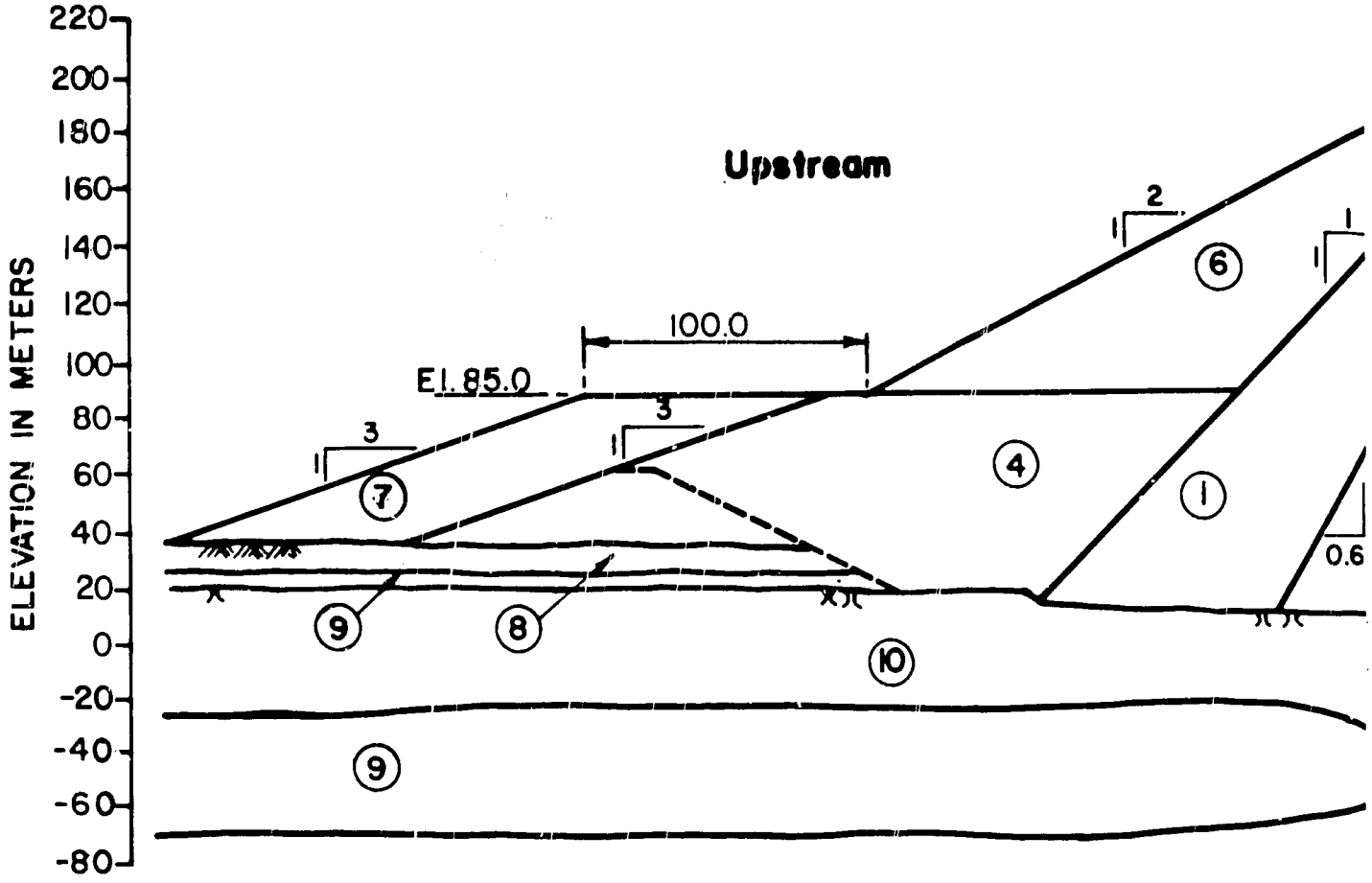
STAGE II


239
238
237
236
228
229
230
QB1
POTENTIAL LIMESTONE QUARRY
R3
R2
R1
R4
QL2
D
N
N3
HR2-2
HR2-1
HR1-1
HR4-1
HN-3
HN-1
HN-2
HD1-1
FLOW
YARMOUK RIVER
250
200
150
100
50
300
350
LEGEND
LOCATION
LOCATION
LIMIT OF PI
LIMIT OF P

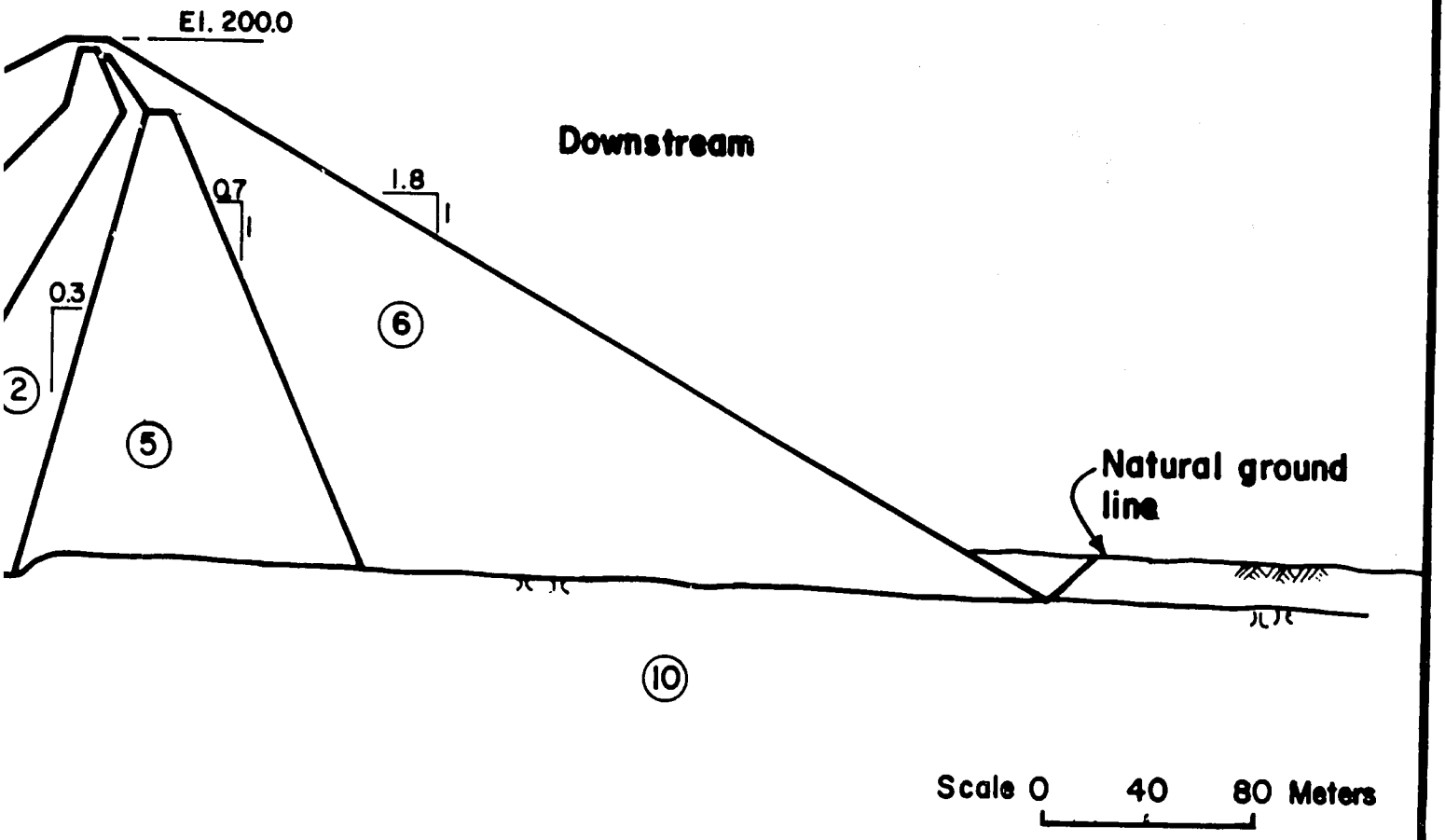


OF TEST PIT BY HARZA
OF TEST PIT BY ENERGOPROJEKT
PROPOSED PRIMARY BORROW AREA
PROPOSED SECONDARY BORROW AREA

MAQARIN DAM
CONSTRUCTION MATERIALS EXPLORATION
JORDAN VALLEY IRRIGATION PROJECT
STAGE II



MATER	
ZONE	DESCRIPTION
1	Impervious Clay $\sigma_n < 7.0$ kg/cm^2
1	Impervious Clay $\sigma_n > 7.0$ kg/cm^2
2	Impervious Talus
4	Random Rockfill(from Req'd Excavati
5	Select Alluvium
6	Basalt Rockfill $\sigma_n < 7.0$ kg/cm^2
6	Basalt Rockfill $\sigma_n > 7.0$ kg/cm^2
7	Random fill
8	Insitu River Alluvium
9	Altered Marl
10	Fresh Marl.



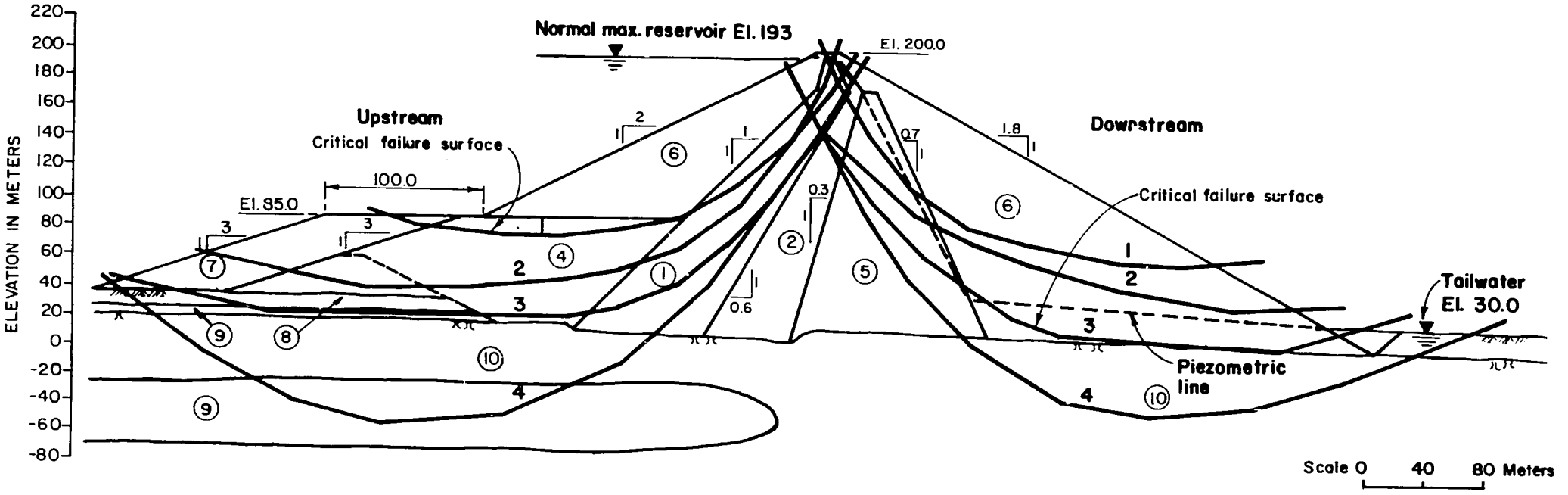
LEGEND				
γm tons/m^3	γ Sat tons/m^3	C' kg/cm^2	ϕ' Degree	R_u
1.83	1.89	0.0	23.5	0.6–0.8
1.83	1.89	2.0	10.0	0.6–0.8
1.92	1.98	0.0	34.0	0.5
2.00	2.20	0.0	36.0	0.0
2.06	2.26	0.0	38.0	0.0
2.10	2.34	0.0	43.0	0.0
2.10	2.34	0.0	40.0	0.0
1.85	2.02	0.0	30.0	0.0
2.09	2.23	0.0	34.0	0.0
2.02	2.02	0.0	28.0	0.0
2.02	2.02	5.0	34.0	0.0

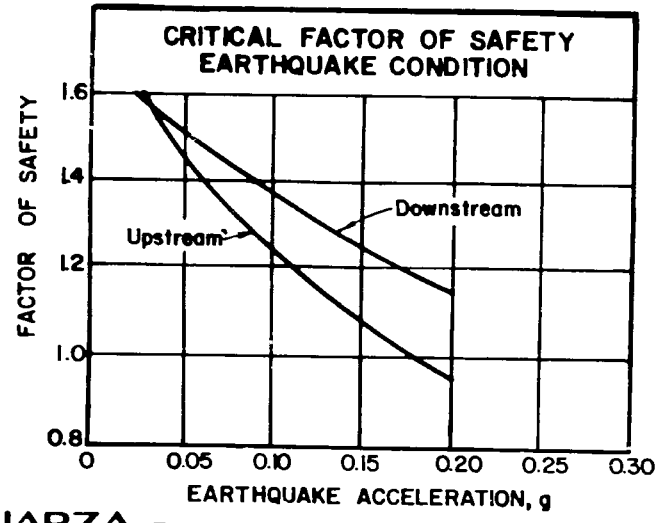
NOTES:

1. Material properties of filter were considered the same as the adjacent rockfill shells.
2. R_u is defined as the ratio of construction pore pressure and total vertical stress.

MAQARIN DAM SLOPE STABILITY EMBANKMENT AND FOUNDATION MATERIAL PARAMETERS

JORDAN VALLEY IRRIGATION PROJECT

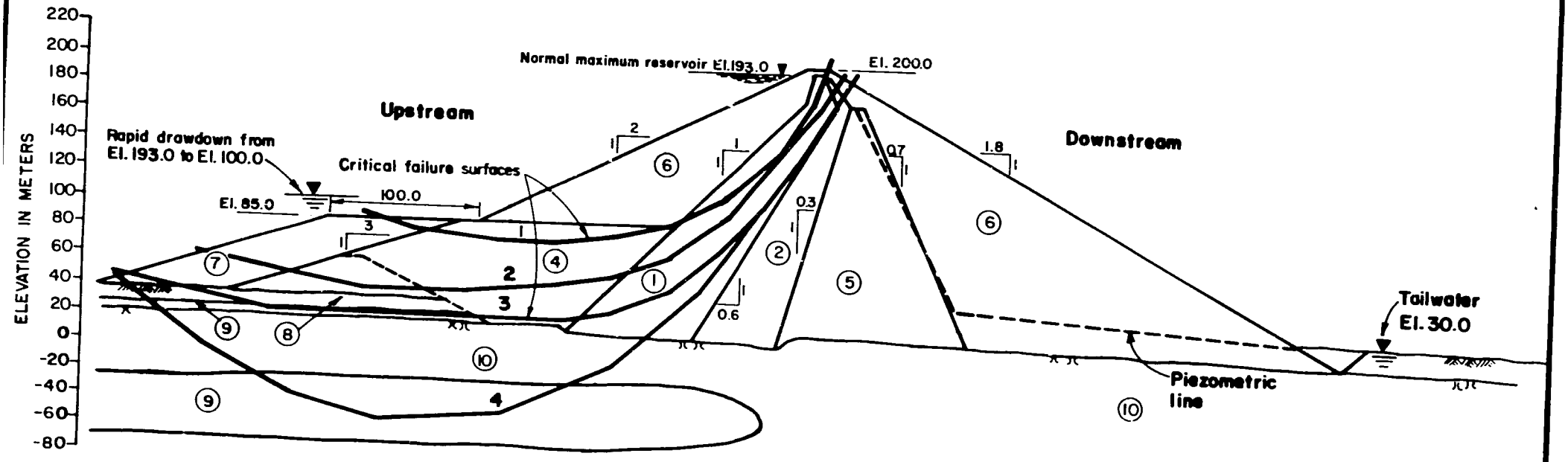




FACTORS OF SAFETY									
ANALYSIS		REPRESENTATIVE FAILURE SURFACE							
		UPSTREAM				DOWNSTREAM			
		1	2	3	4	1	2	3	4
STEADY STATE	STATIC	1.77	2.14	2.07	3.58	1.89	1.69	1.68	2.30
	EARTHQUAKE 0.10g	1.24	1.41	1.37	2.31	1.56	1.38	1.37	1.90
	EARTHQUAKE 0.15g	1.08	1.21	1.17	1.98	1.43	1.26	1.25	1.74
	EARTHQUAKE 0.20g	0.95	1.06	1.02	1.75	1.31	1.16	1.15	1.61

HARZA ENGINEERING COMPANY · JANUARY 1978

MAQARIN DAM - CREST ELEVATION 200.0
SLOPE STABILITY - STEADY SEEPAGE
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

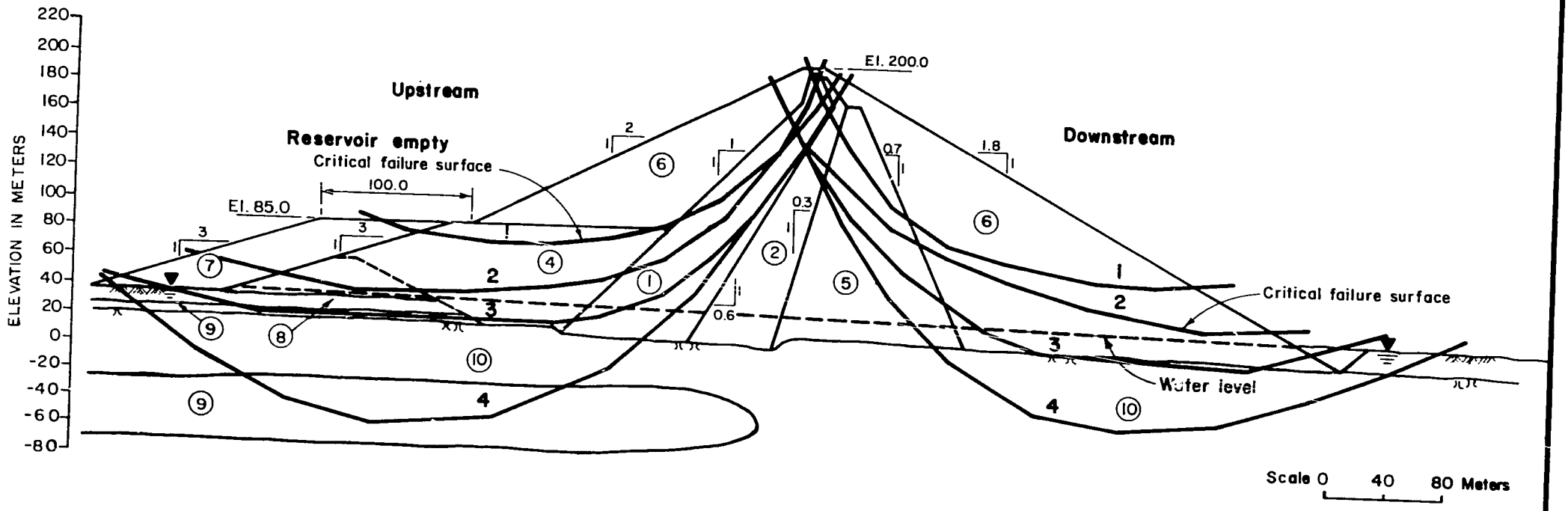


Scale 0 40 80 Meters

FACTORS OF SAFETY									
ANALYSIS		REPRESENTATIVE FAILURE SURFACE							
		UPSTREAM				DOWNSTREAM			
		1	2	3	4				
RAPID DRAWDOWN	STATIC	1.32	1.46	1.39	2.57	—	—	—	—

HARZA ENGINEERING COMPANY · JANUARY 1978

MAQARIN DAM - CREST ELEVATION 200.0
SLOPE STABILITY - RAPID DRAWDOWN
JORDAN VALLEY IRRIGATION PROJECT
STAGE II



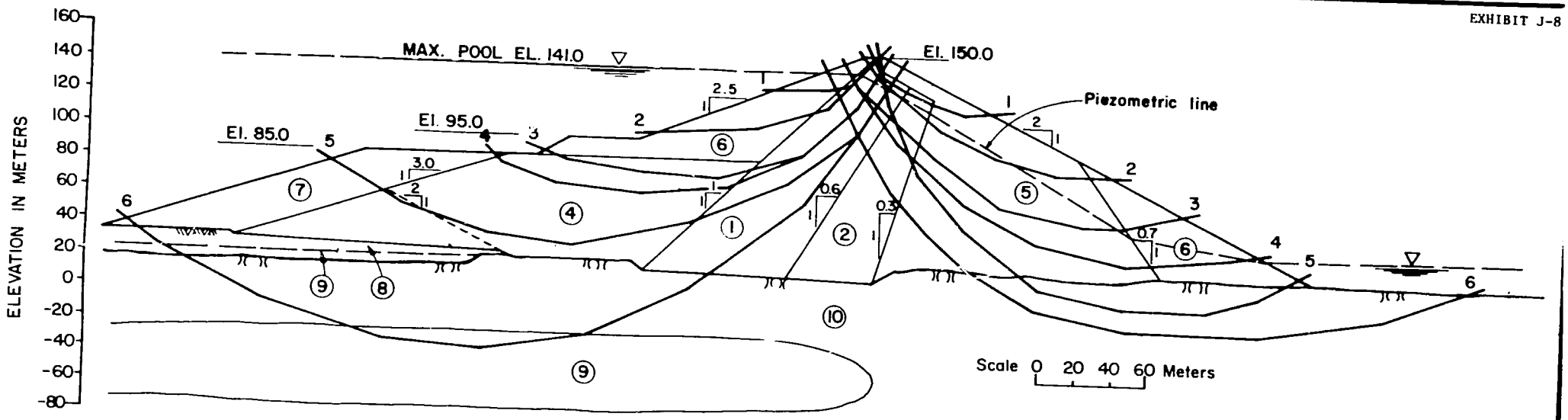
FACTORS OF SAFETY									
ANALYSIS		REPRESENTATIVE FAILURE SURFACE							
		UPSTREAM				DOWNSTREAM			
		1	2	3	4	1	2	3	4
CONSTRUCTION*	Zone 1 Ru = 0.8	1.24	1.57	1.25	2.43	1.86	1.70	1.79	2.56
	Zone 1 Ru = 0.7	1.29	1.64	1.33	2.48	1.86	1.71	1.80	2.56
	Zone 1 Ru = 0.6	1.35	1.70	1.41	2.52	1.86	1.72	1.80	2.56

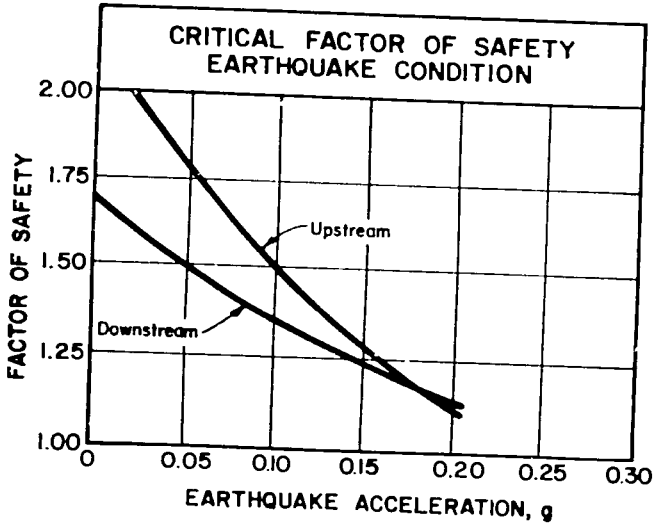
*Zone 2 Ru = 0.5 for all construction analyses

MAQARIN DAM - CREST ELEVATION 200.0
SLOPE STABILITY - END OF CONSTRUCTION

JORDAN VALLEY IRRIGATION PROJECT
STAGE II

IARZA ENGINEERING COMPANY · JANUARY 1978



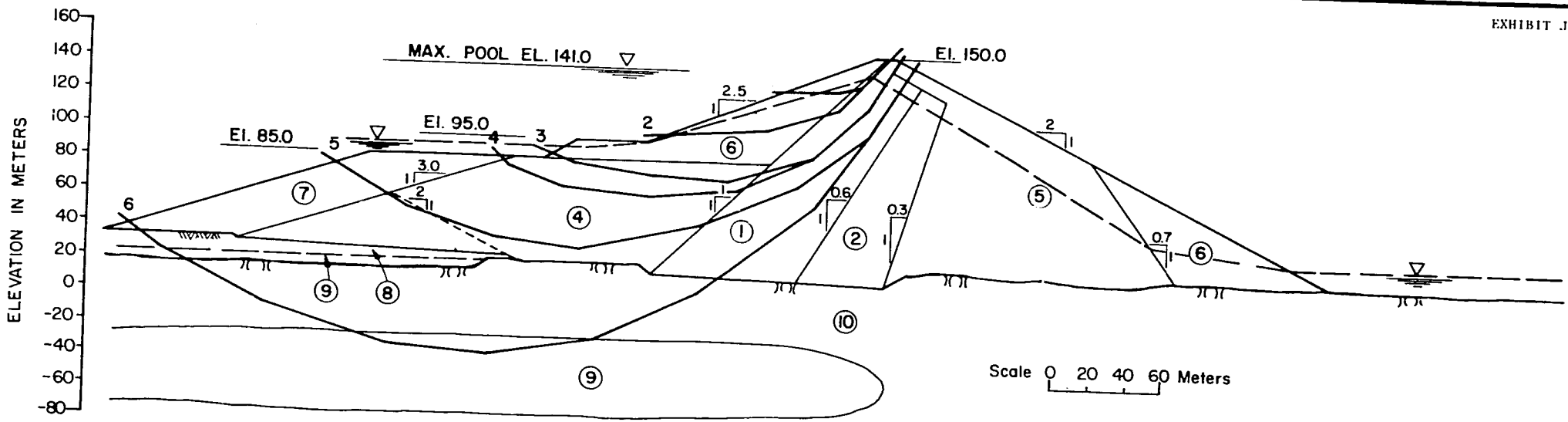


FACTORS OF SAFETY

ANALYSIS		REPRESENTATIVE FAILURE SURFACE											
		UPSTREAM						DOWNSTREAM					
		1	2	3	4	5	6	1	2	3	4	5	6
STEADY SEEPAGE	STATIC	2.17	2.17	2.49	2.80	3.72	4.81	1.70	1.78	1.82	1.72	2.42	2.37
	EARTHQUAKE 0.10g	1.59	1.49	1.63	1.68	2.07	2.59	1.36	1.44	1.50	1.40	2.00	1.91
	EARTHQUAKE 0.15g	1.40	1.28	1.40	1.46	1.71	2.12	1.24	1.31	1.38	1.29	1.84	1.75
	EARTHQUAKE 0.20g	1.25	1.12	1.23	1.32	1.47	1.80	1.14	1.19	1.28	1.19	1.72	1.61

HARZA ENGINEERING COMPANY JANUARY 1978

MAQARIN DAM - CREST ELEVATION 150.0
SLOPE STABILITY - STEADY SEEPAGE
JORDAN VALLEY IRRIGATION PROJECT
STAGE II



DRAWDOWN FROM EL. 141.0 to EL. 90.0

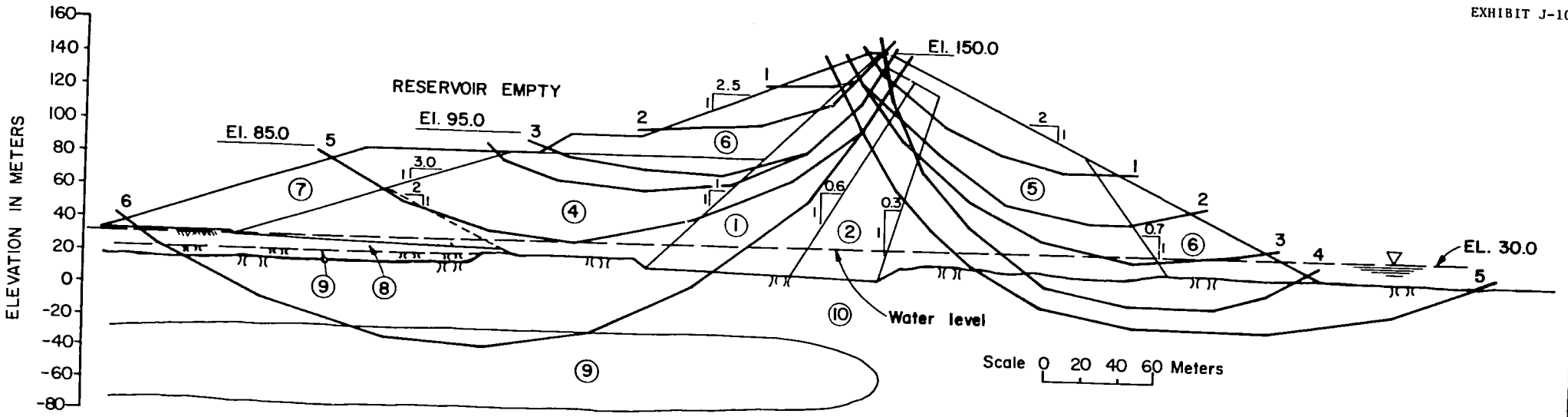
FACTORS OF SAFETY

ANALYSIS		REPRESENTATIVE FAILURE SURFACE											
		UPSTREAM						DOWNSTREAM					
		1	2	3	4	5	6	1	2	3	4	5	6
RAPID DRAWDOWN	STATIC	2.43	2.18	1.58	1.61	2.29	3.43	—	—	—	—	—	—

IARZA ENGINEERING COMPANY · JANUARY 1978

MAQARIN DAM - CREST ELEVATION 150.0
SLOPE STABILITY - RAPID DRAWDOWN
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

EXHIBIT J-10

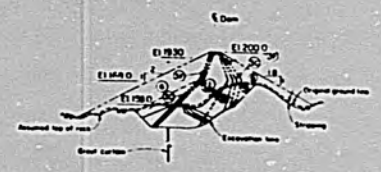


FACTORS OF SAFETY													
ANALYSIS		REPRESENTATIVE FAILURE SURFACE											
		UPSTREAM						DOWNSTREAM					
		1	2	3	4	5	6	1	2	3	4	5	6
END OF CONSTRUCTION	Zone 1 R_u = 0.6	2.06	2.00	1.99	2.25	3.06	3.48	1.60	2.04	2.05	2.91	2.80	—
	Zone 1 R_u = 0.7	1.99	1.96	1.91	2.18	2.96	3.41	1.59	2.03	2.04	2.90	2.79	—
	Zone 1 R_u = 0.8	1.93	1.92	1.83	2.12	2.85	3.35	1.57	2.02	2.03	2.90	2.78	—
	Zone 2 R_u = 0.5	For all end of construction analysis											

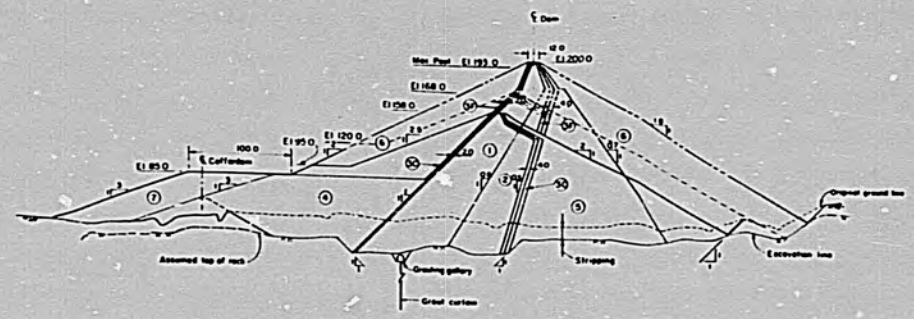
MAQARIN DAM - CREST ELEVATION 150.0
SLOPE STABILITY - END OF CONSTRUCTION
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

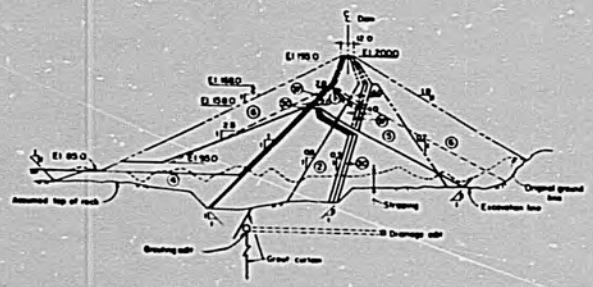
EXHIBIT J-11



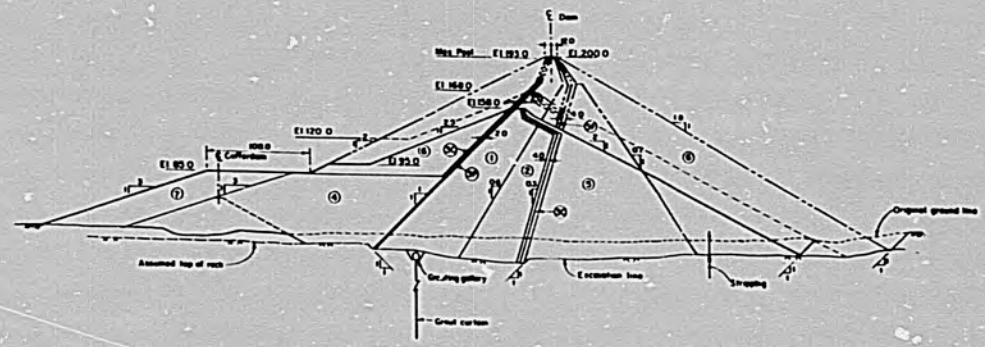
Sta. 0+075



Sta. 0+255



Sta. 0+165



Sta. 0+310

LEGEND

1. Impervious clay
2. Impervious talus
3F. Fine filter
3C. Coarse filter
4. Random rockfill
5. Alluvium
6. Basalt rockfill
7. Random fill

Scale 0 50 100 Meters

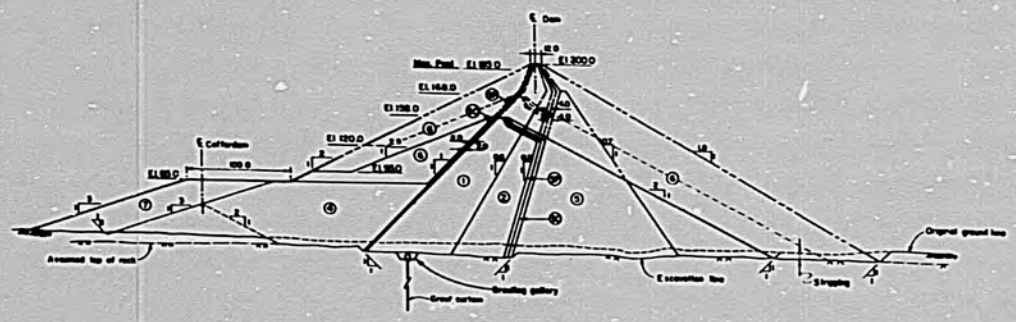
NOTE

See Exhibit I for station location

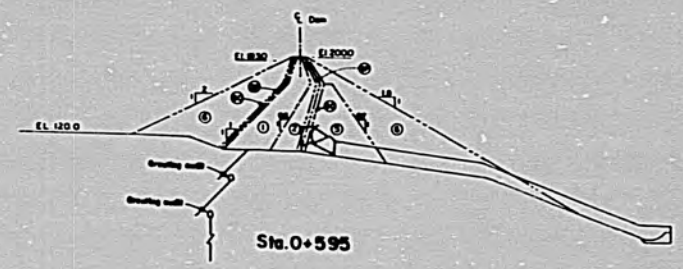
HARZA ENGINEERING COMPANY · JANUARY 1978

MAQARIN DAM
EMBANKMENT SECTIONS
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

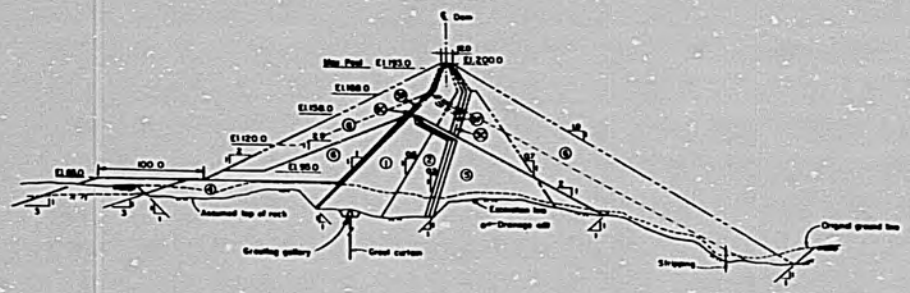
EXHIBIT J-12



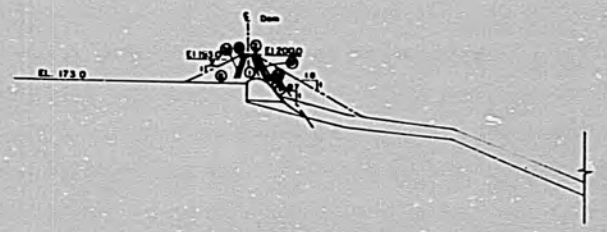
Sta. 0+365



Sta. 0+595

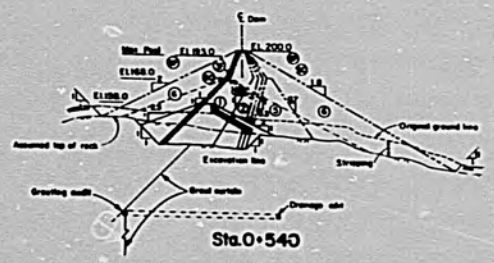


Sta. 0+455



Sta. 0+680

NOTE
See Exhibit 1 for station location



Sta. 0+540

LEGEND:

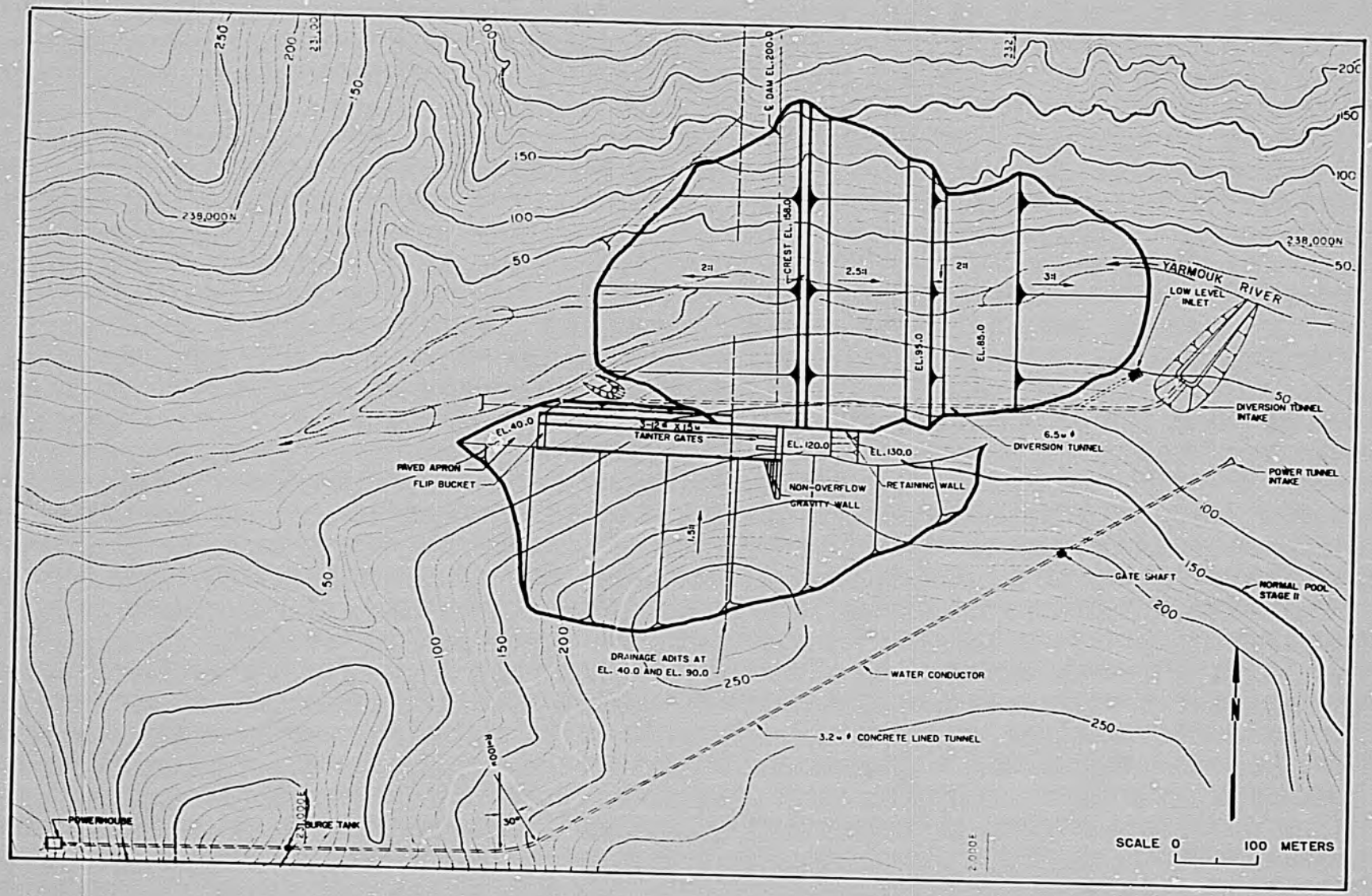
1. Impervious clay
2. Impervious talus
3F. Fine filter
3C. Coarse filter
4. Random rockfill
5. Alluvium
6. Basalt rockfill
7. Random fill

Scale 0 50 100 Meters

MAQARIN DAM
EMBANKMENT SECTIONS
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

IARZA ENGINEERING COMPANY · JANUARY 1978

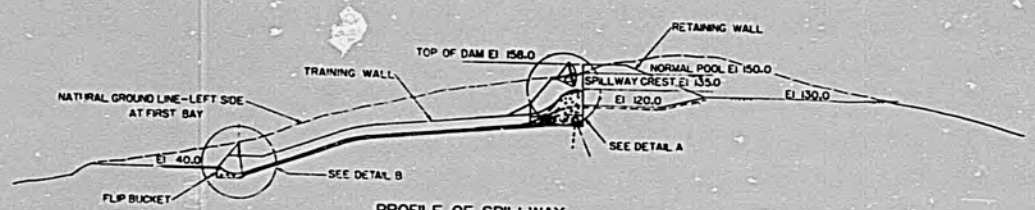
62



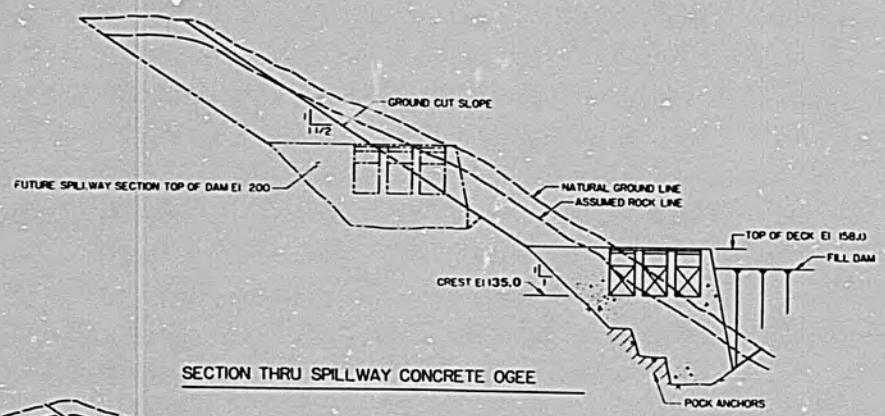
HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

MAQARIN DAM
CREST ELEVATION 158.0
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

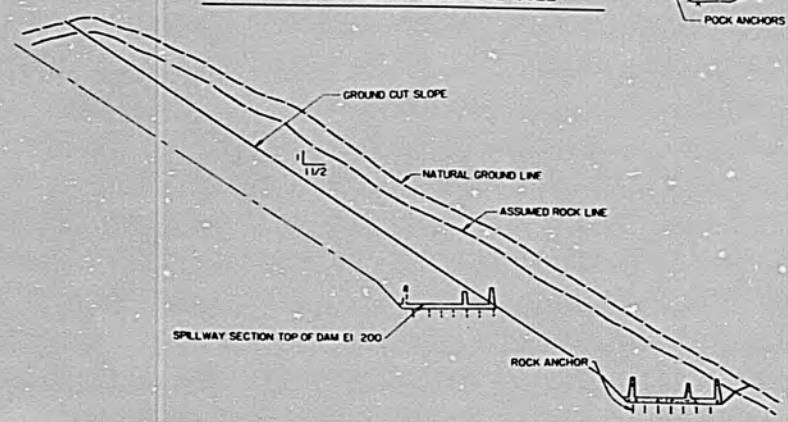
EXHIBIT J-14



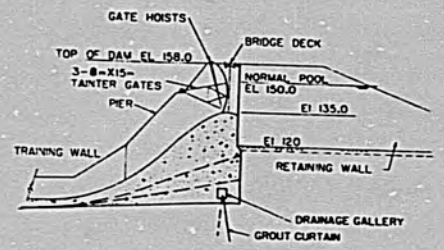
PROFILE OF SPILLWAY



SECTION THRU SPILLWAY CONCRETE OGEE

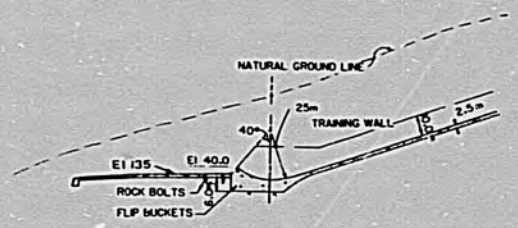


TYPICAL SECTION THRU SPILLWAY



DETAIL A

SCALE 0 50 METERS

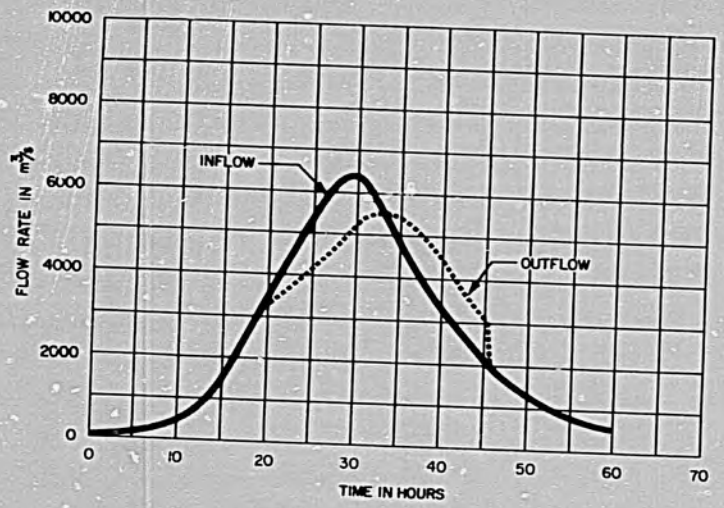


DETAIL B

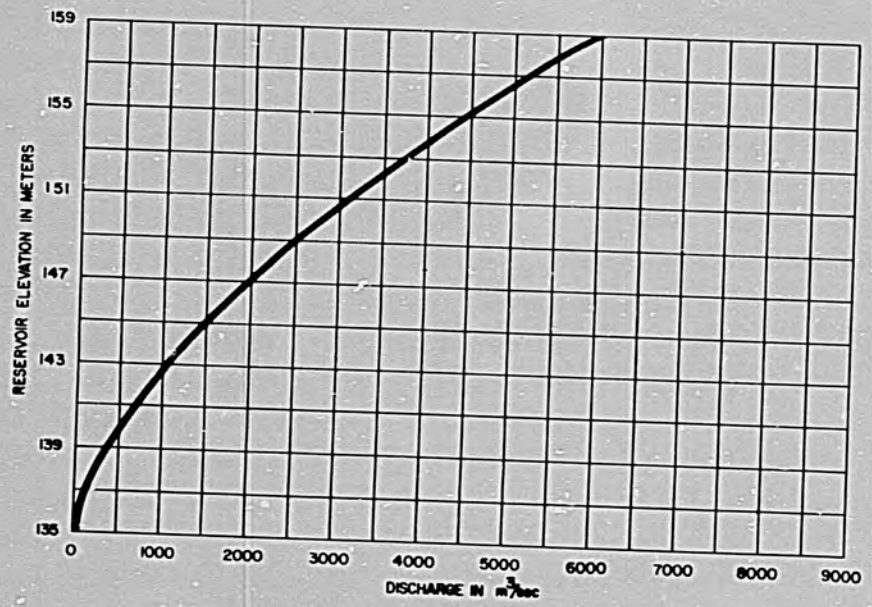
HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

MAQARIN DAM SPILLWAY
PROFILE AND SECTIONS
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

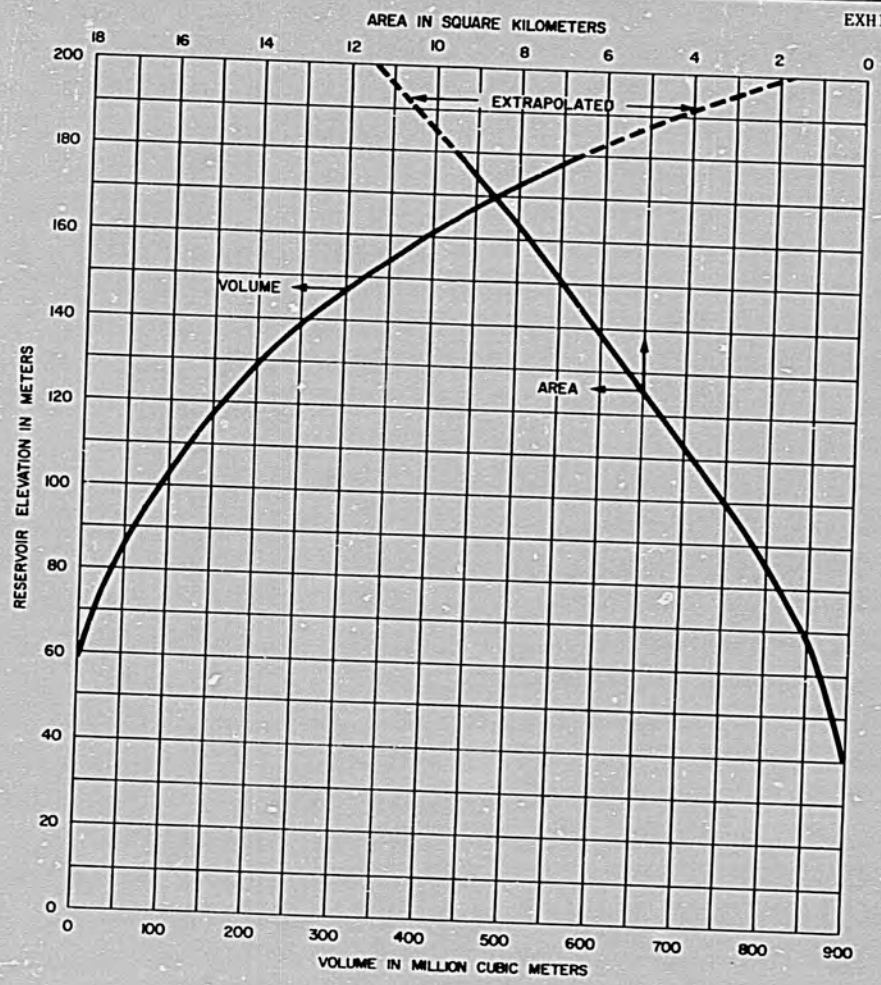
EXHIBIT J-15



PMF FLOOD ROUTING



SPILLWAY DISCHARGE RATING CURVE
(3 GATES, FULLY OPEN)

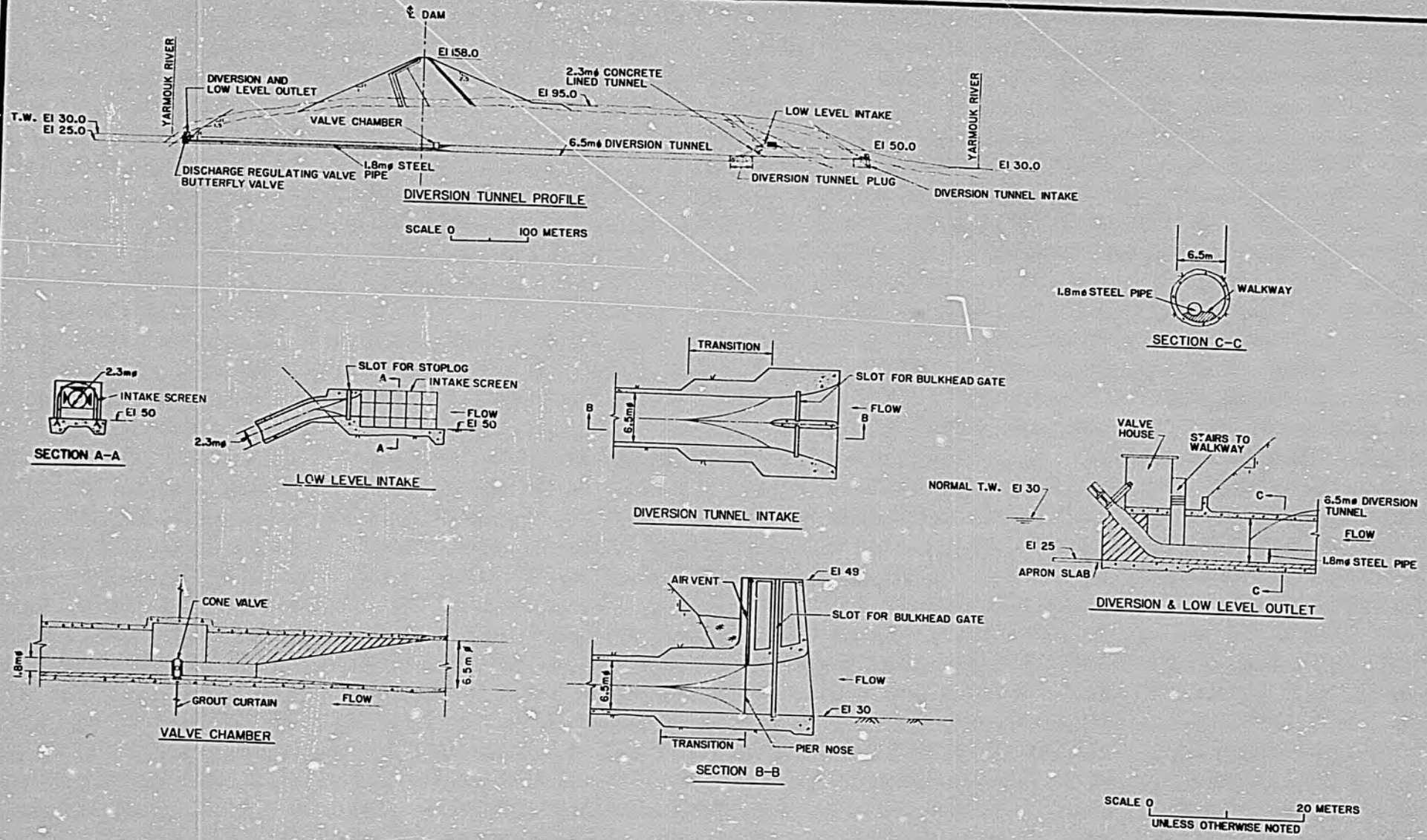


AREA VOLUME CURVE

JARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

SPILLWAY HYDRAULIC DATA
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

EXHIBIT J-

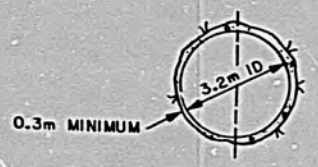


HARZA OVERSEAS ENGINEERING COMPANY JANUARY 1978

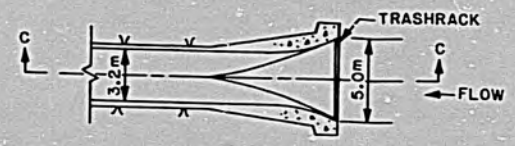
DIVERSION TUNNEL AND OUTLET WORKS

JORDAN VALLEY IRRIGATION PROJECT

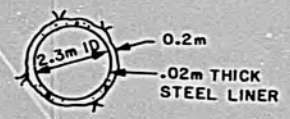
STAGE II



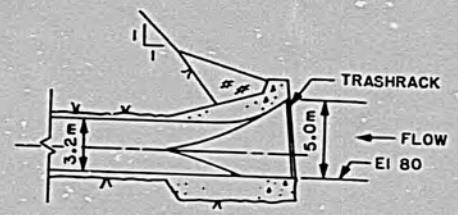
TYPICAL TUNNEL SECTION



POWER TUNNEL INTAKE

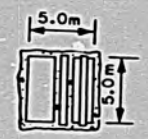


TYPICAL PENSTOCK SECTION

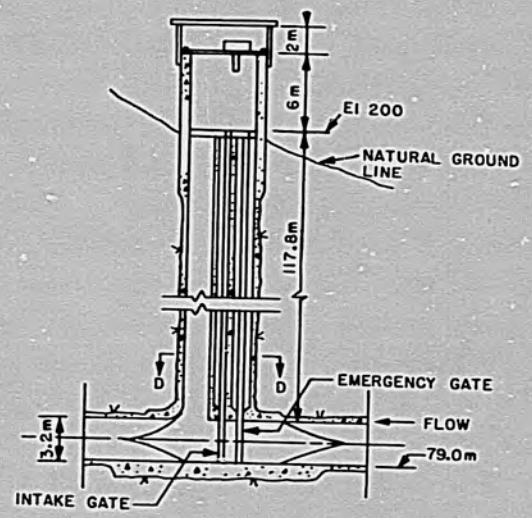


SECTION C-C

SCALE 0 5 METERS

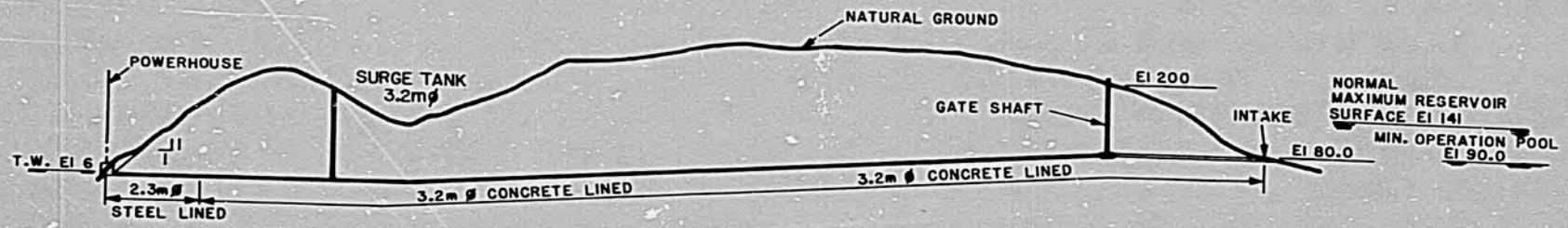


SECTION D-D



GATE SHAFT

SCALE 0 10 METERS

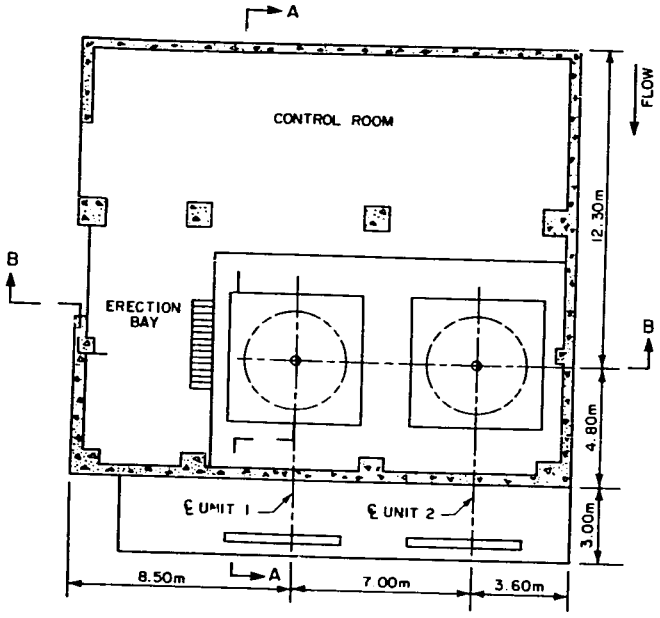


PROFILE

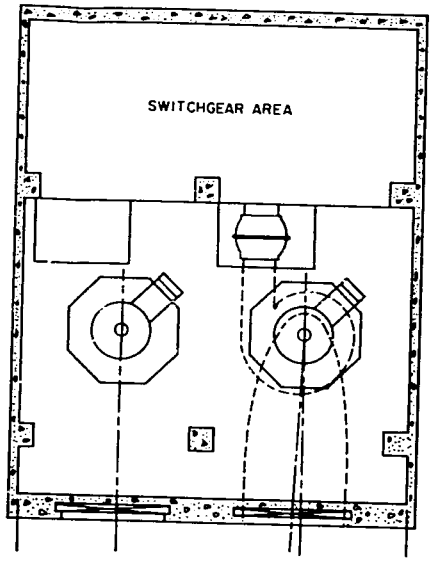
SCALE 0 50 METERS

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

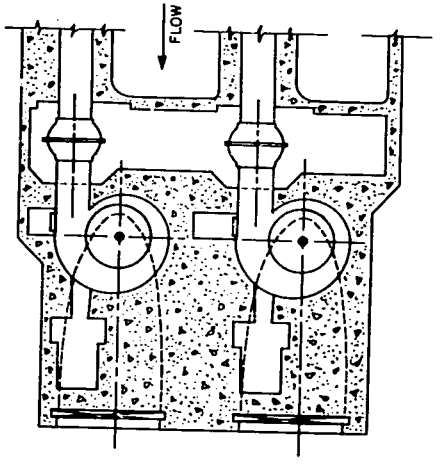
MAQARIN POWERPLANT
PLAN AND SECTIONS
JORDAN VALLEY IRRIGATION PROJECT
STAGE II



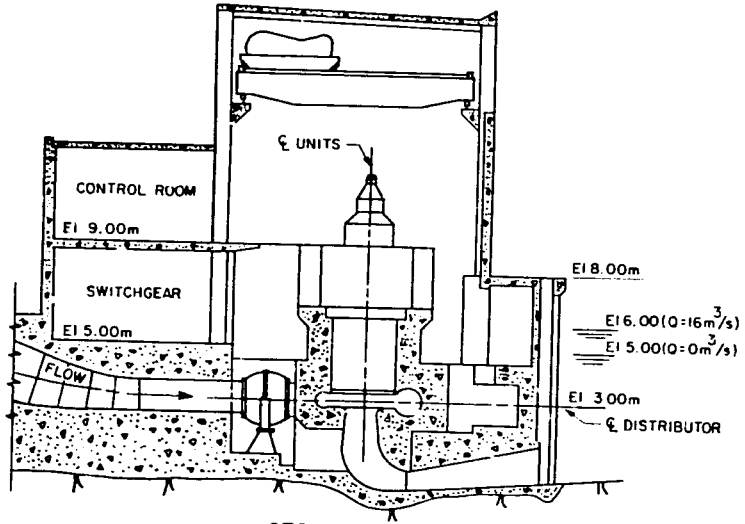
PLAN El 9.00m



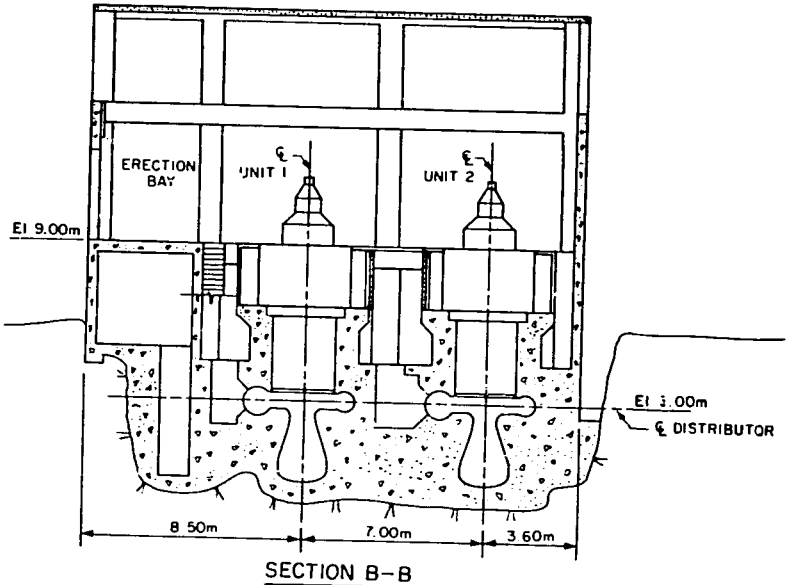
PLAN El 5.00m



PLAN El 3.00m



SECTION A–A

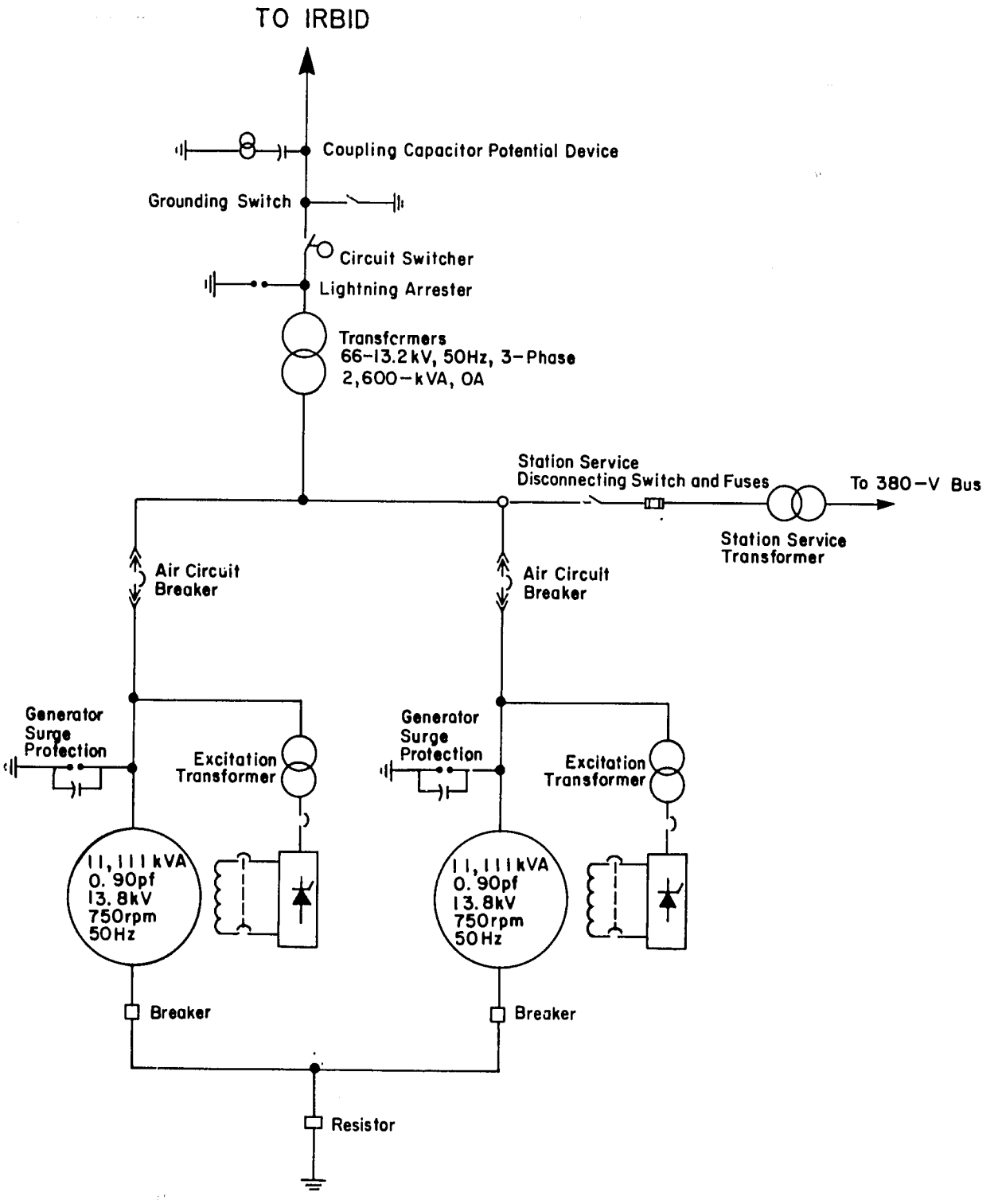


SECTION B–B

SCALE 0 5 METERS

MAQARIN POWER PLANT
PLAN AND SECTIONS
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

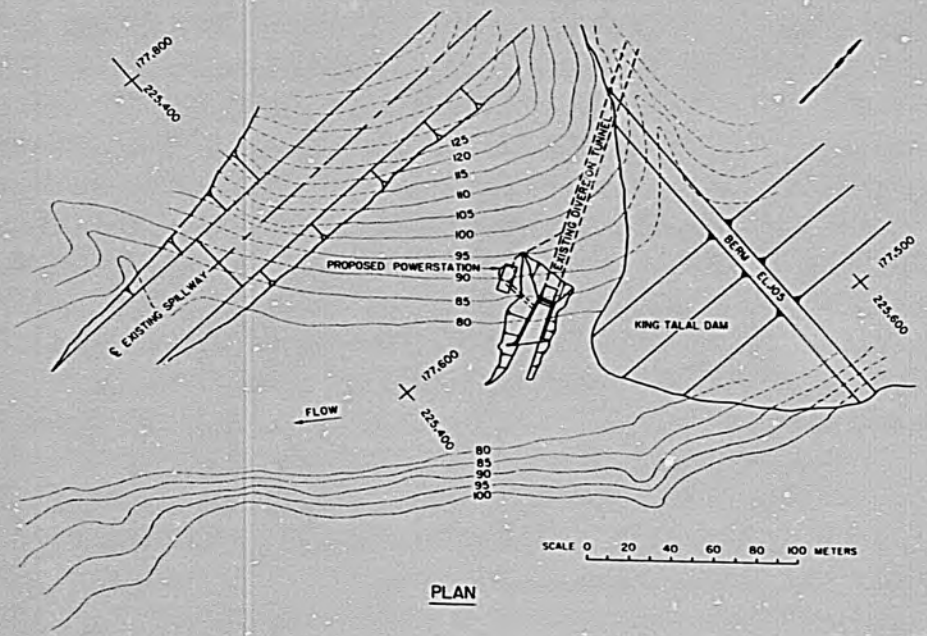


MAQARIN POWERPLANT
SINGLE LINE DIAGRAM

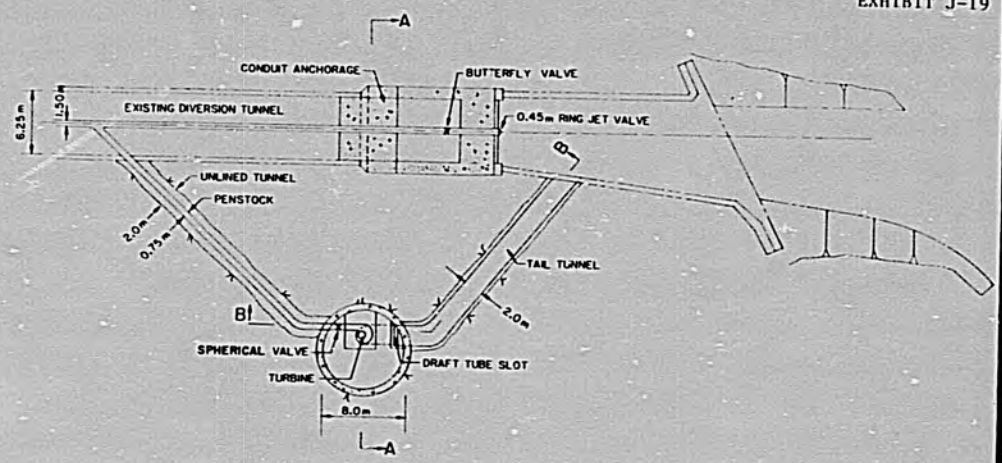
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

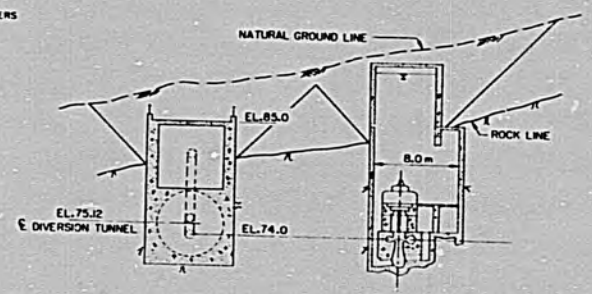
EXHIBIT J-19



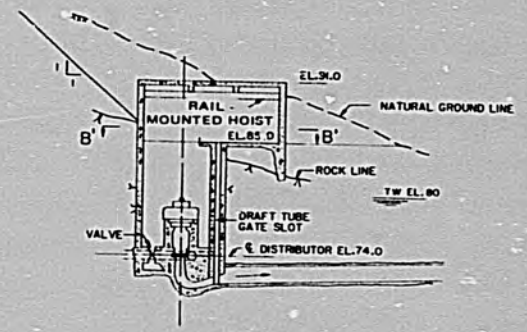
PLAN



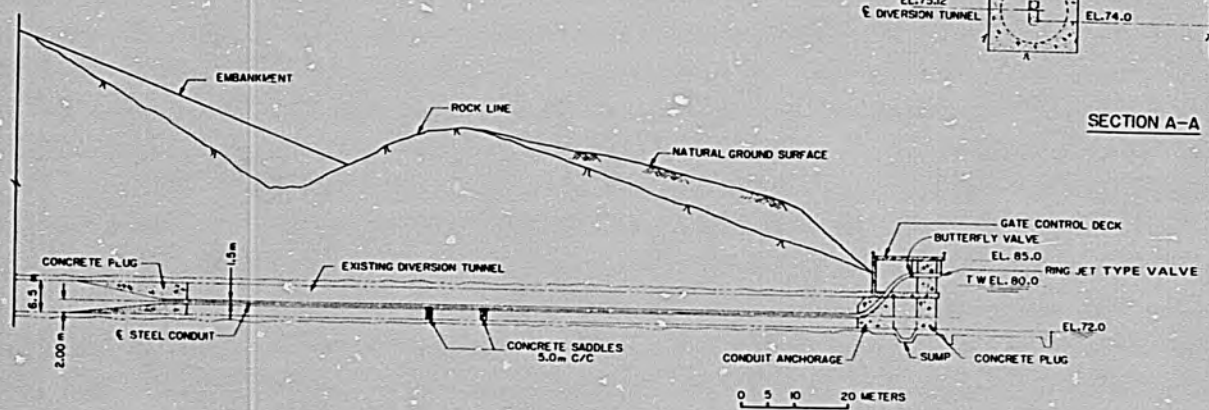
SECTIONAL PLAN



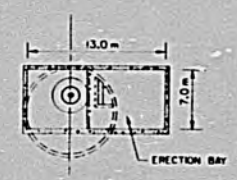
SECTION A-A



SECTION B-B



SECTION THRU DIVERSION TUNNEL

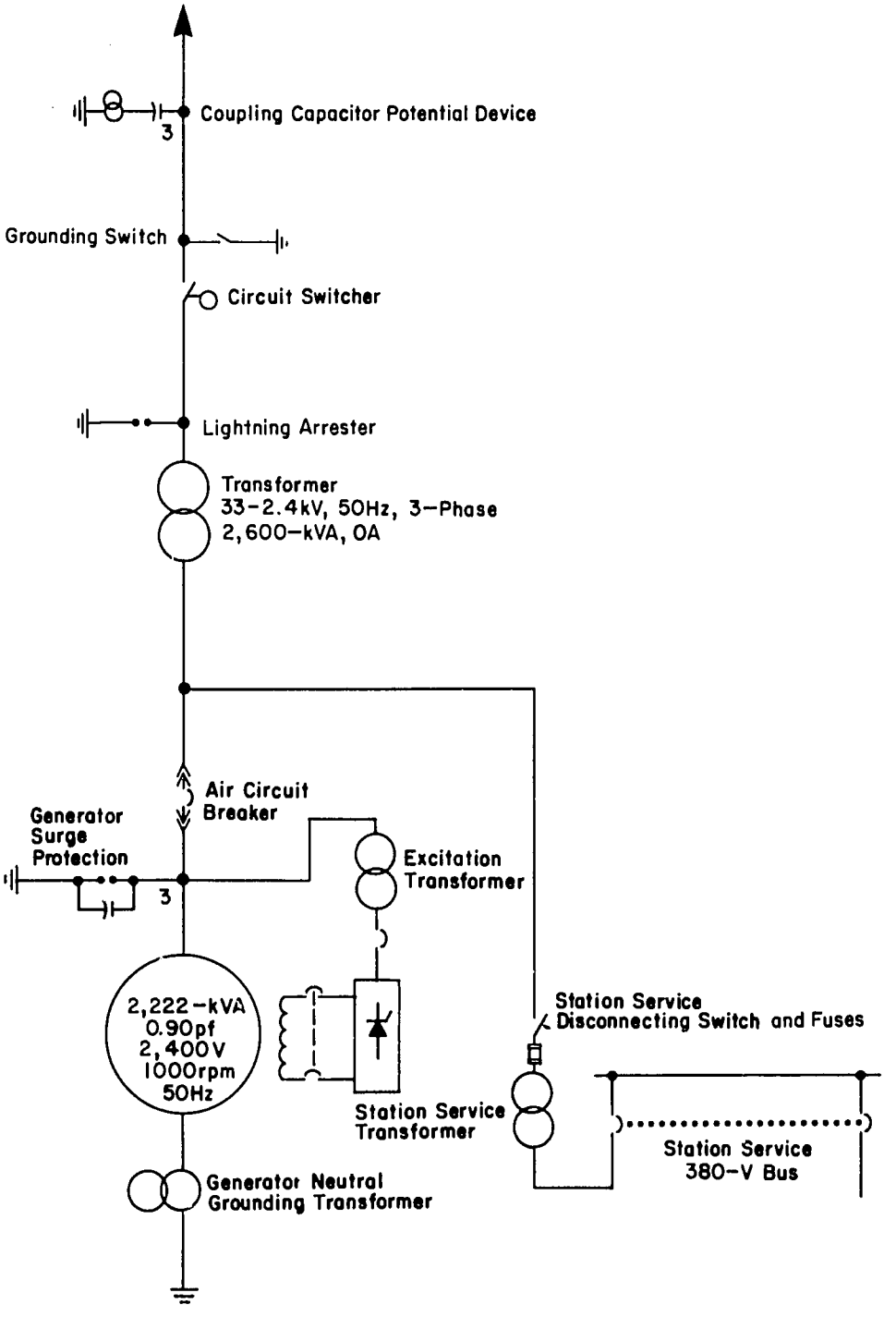


SECTION B'-B'

SCALE 0 5 10 15 20 METERS
EXCEPT AS INDICATED

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

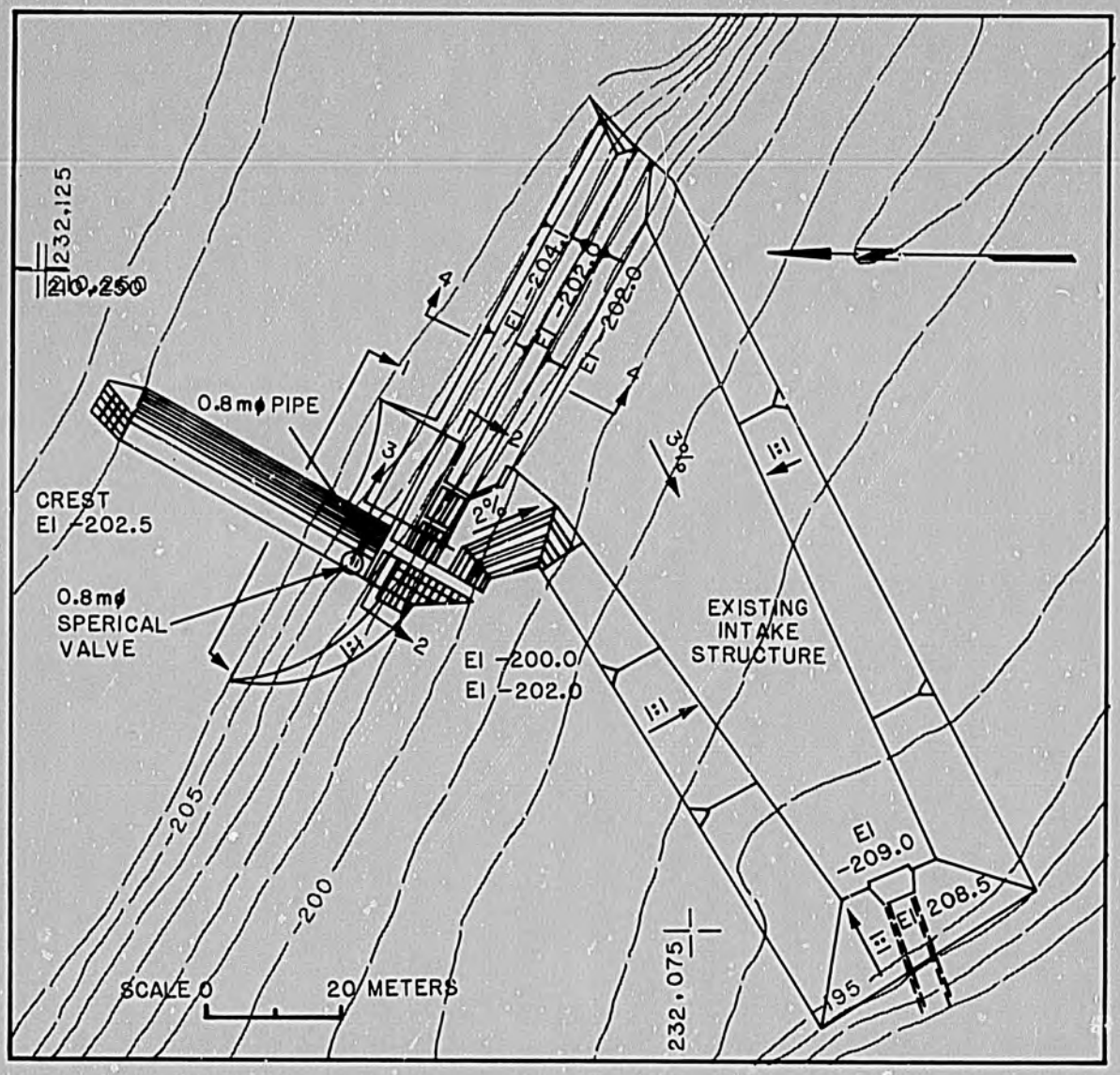
KING TALAL POWERPLANT
PLAN AND SECTIONS
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

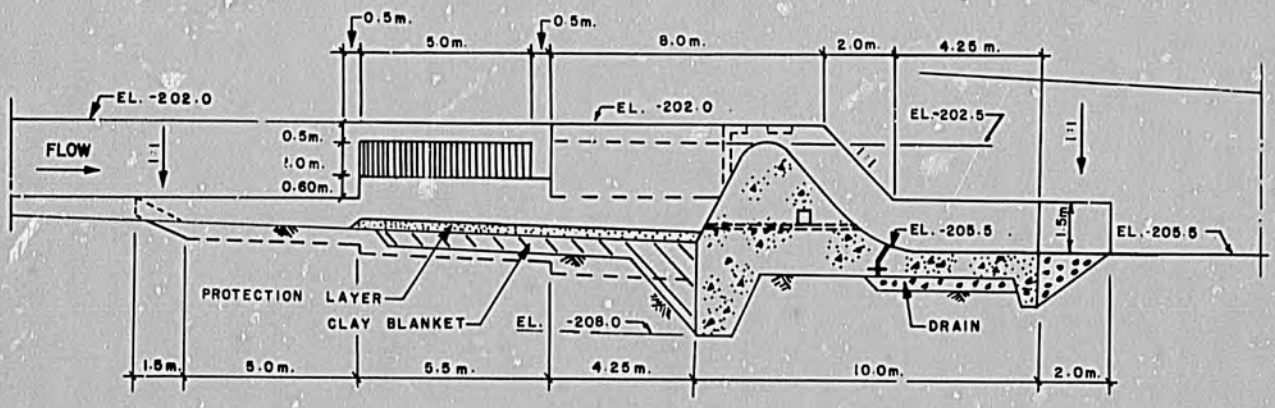


KING TALAL POWERPLANT
SINGLE LINE DIAGRAM

JORDAN VALLEY IRRIGATION PROJECT
STAGE II

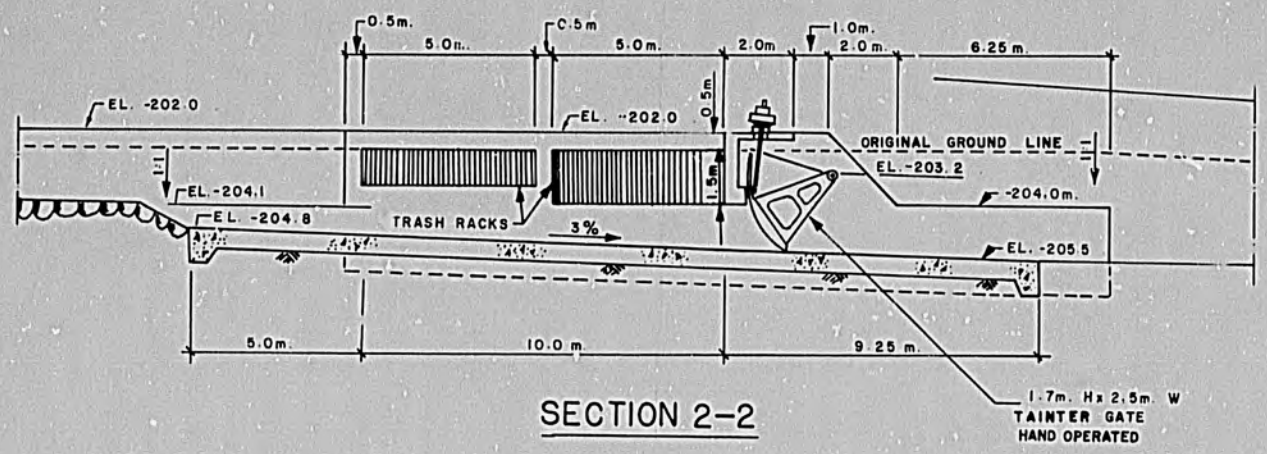
HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978



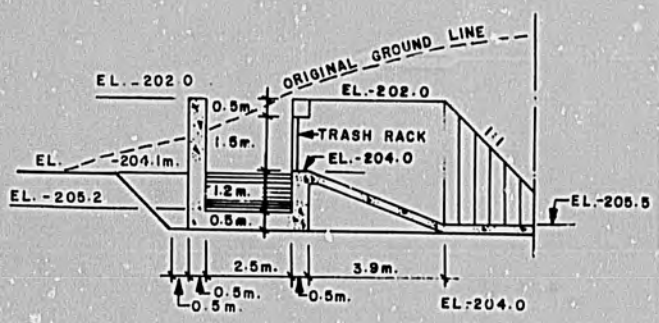


SECTION I–I

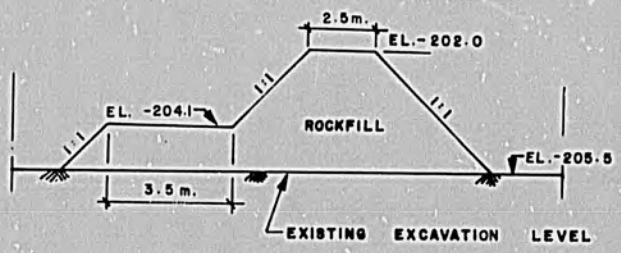
HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978



SECTION 2-2



SECTION 3-3



SECTION 4-4

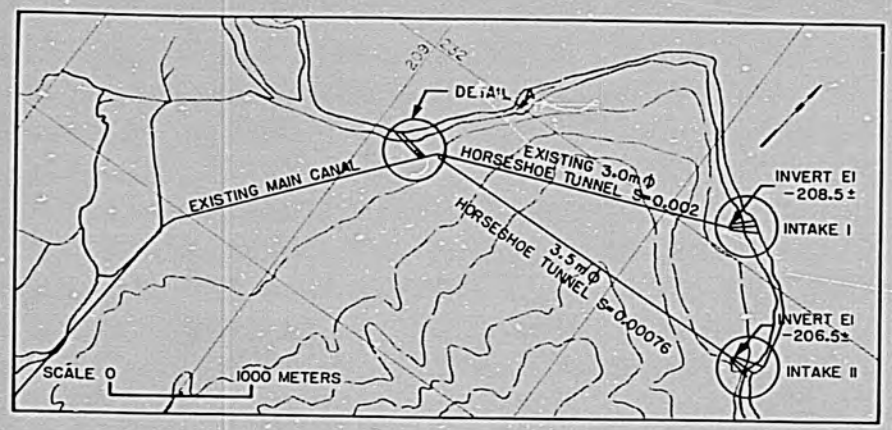
SOURCE DOCUMENT:
"YARMOUK PROJECT-KHALID BIN AL WALID-WADI ARAB SCHEME", VOLUME VI, ENERGOPROJEKT, JUNE 1967.

SCALE 0 5 METERS

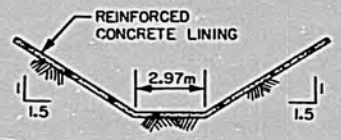
CONTROLLED DIVERSION STRUCTURE PLAN AND SECTIONS

JORDAN VALLEY IRRIGATION PROJECT

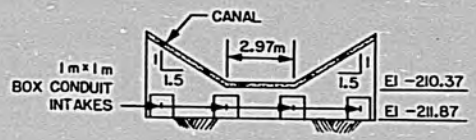
STAGE II



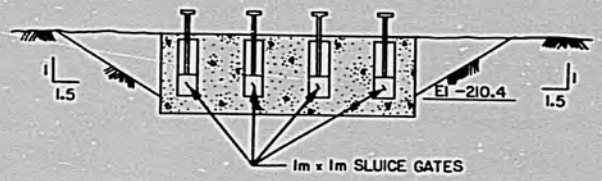
GENERAL PLAN



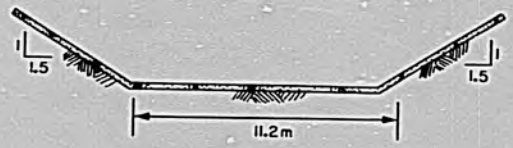
TYPICAL SECTION
EXISTING CANAL



SECTION 1-1



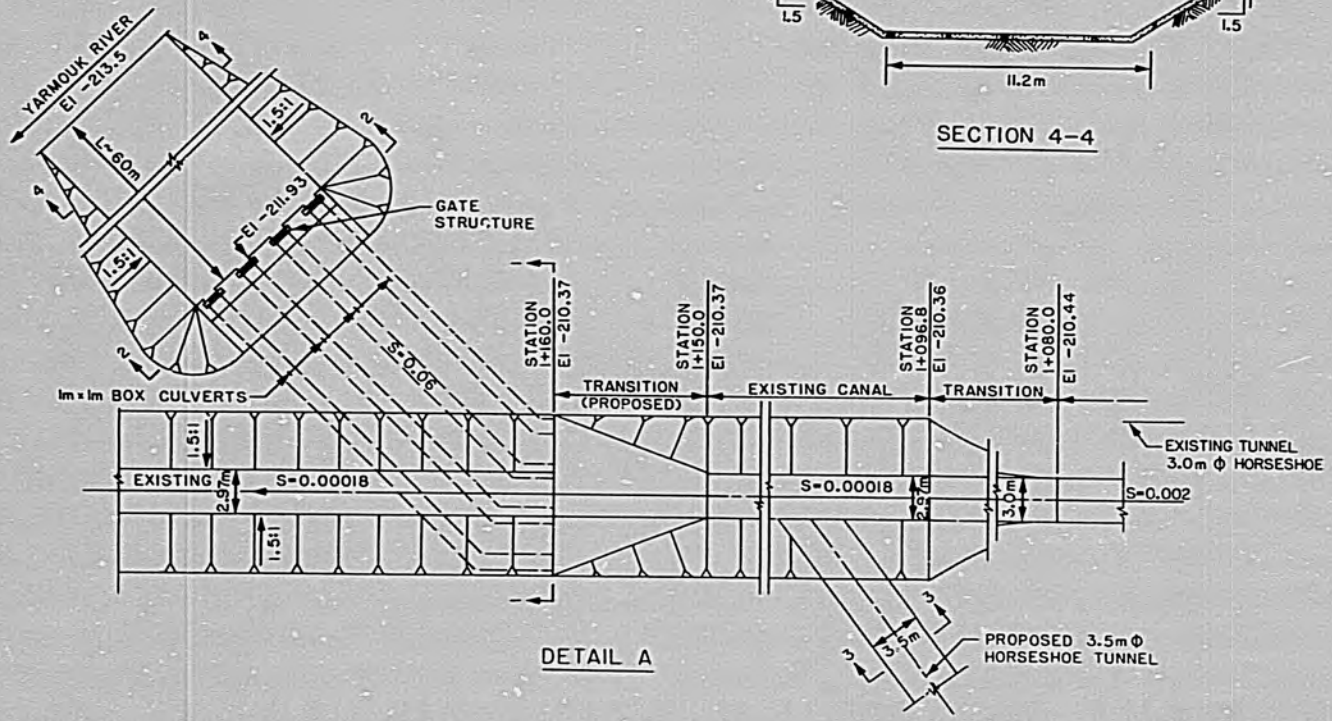
SECTION 2-2
GATE STRUCTURE



SECTION 4-4

SECTION 3-3
PROPOSED TUNNEL

TYPICAL SECTION
EXISTING TUNNEL



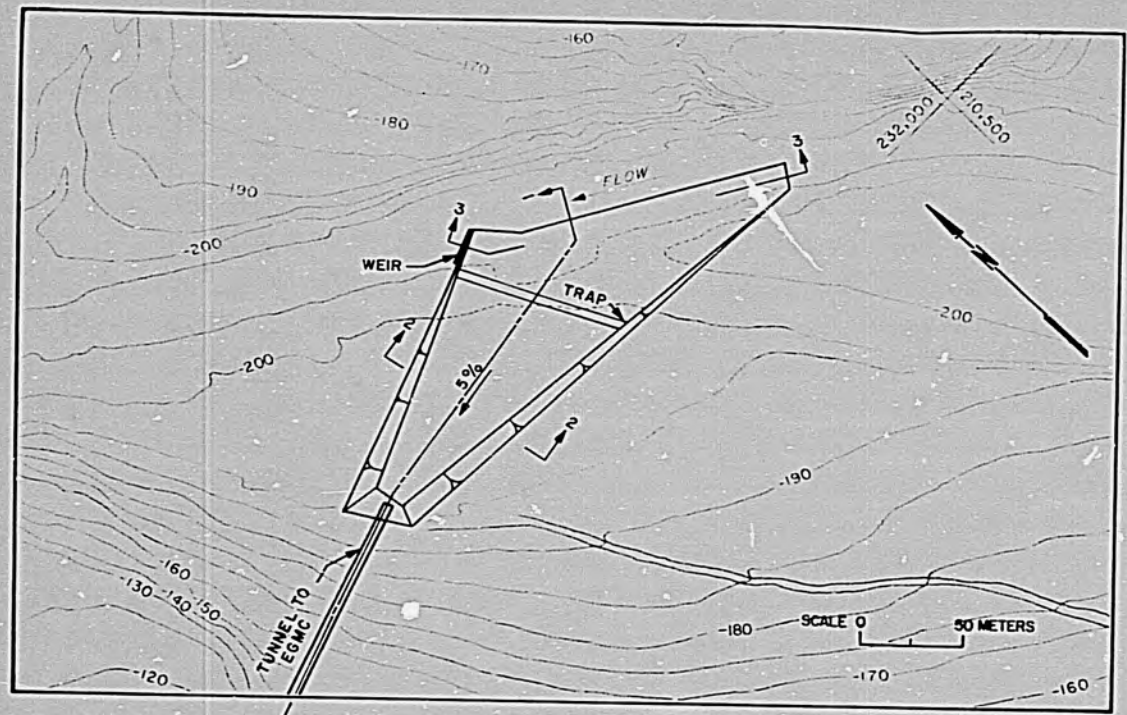
DETAIL A

SCALE 0 5 METERS

UNCONTROLLED DIVERSION STRUCTURE PLAN AND SECTIONS

JORDAN VALLEY IRRIGATION PROJECT
STAGE II

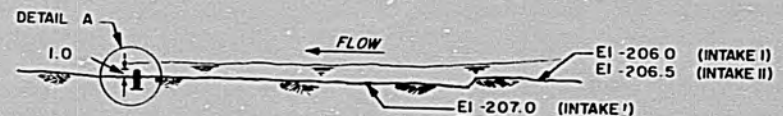
HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978



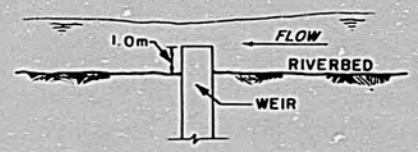
TYPICAL PLAN

SECTION 2-2

(NOT TO SCALE)

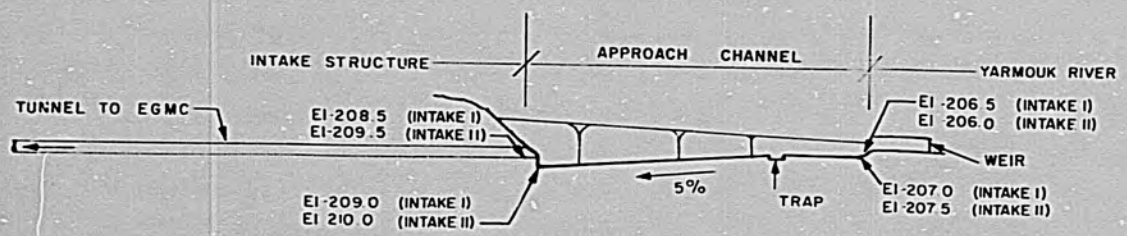


SECTION 3-3



DETAIL A

(NOT TO SCALE)



SECTION I-I

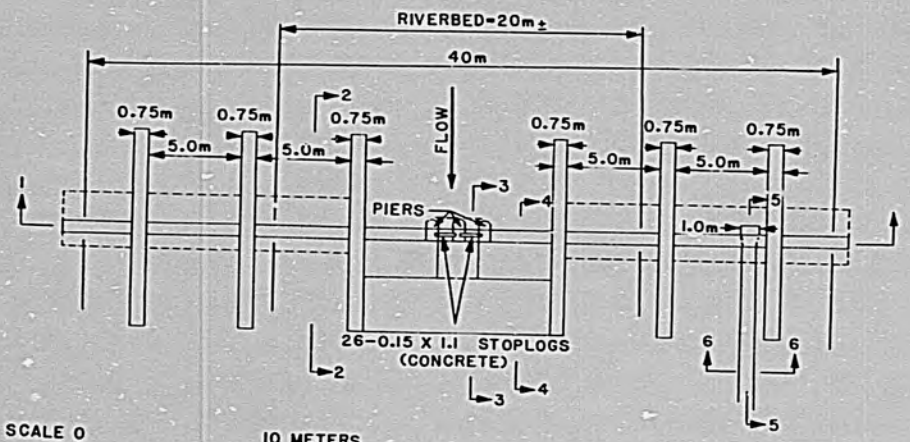
NOTE: LOCATION OF INTAKE STRUCTURE SHOWN ON SHEET 1.

ARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

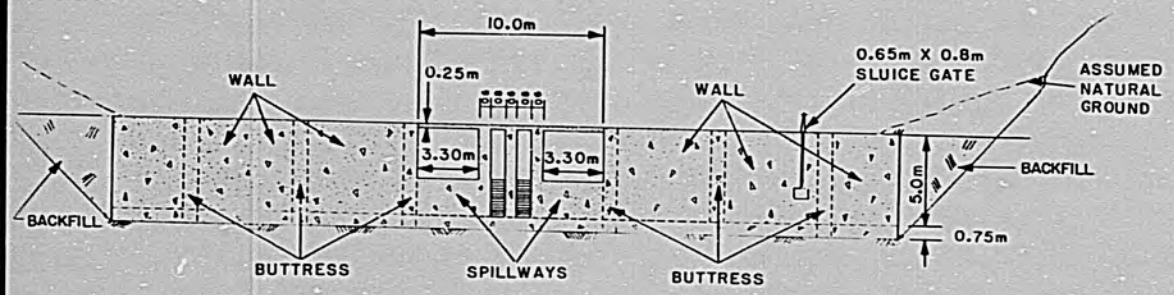
UNCONTROLLED DIVERSION STRUCTURE PLAN AND SECTIONS

JORDAN VALLEY IRRIGATION PROJECT
STAGE II

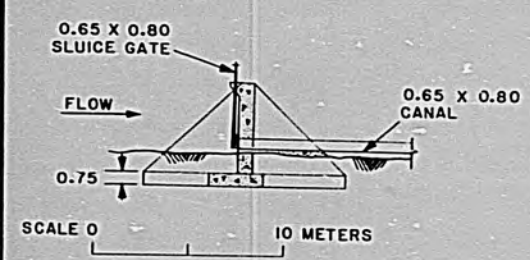
EXHIBIT J-23



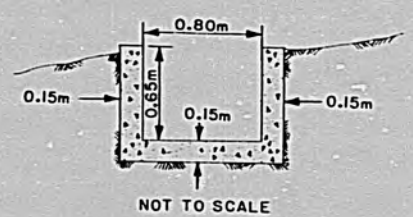
PLAN



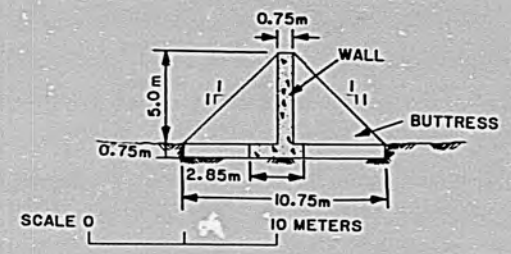
SECTION 1-1



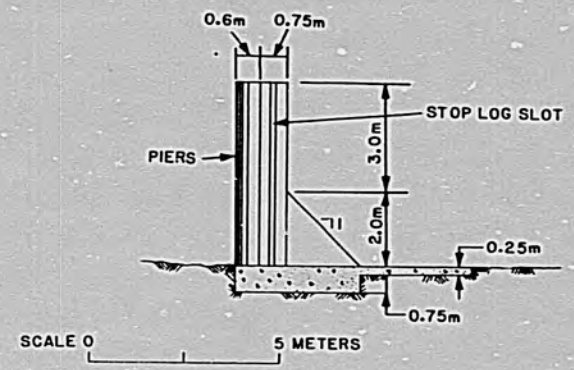
SECTION 5-5
DIVERSION ORIFICE



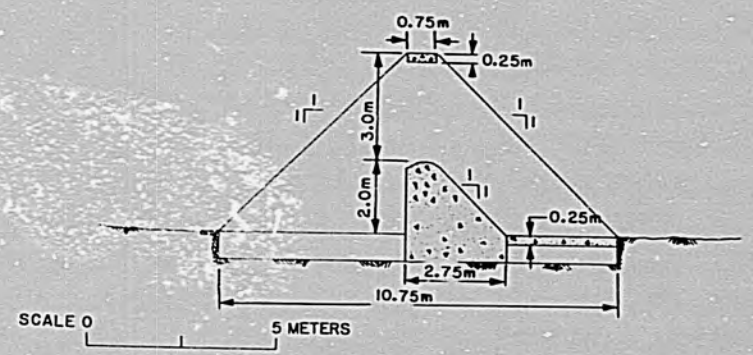
SECTION 6-6
DIVERSION CANAL



SECTION 2-2
BUTTRESS



SECTION 3-3

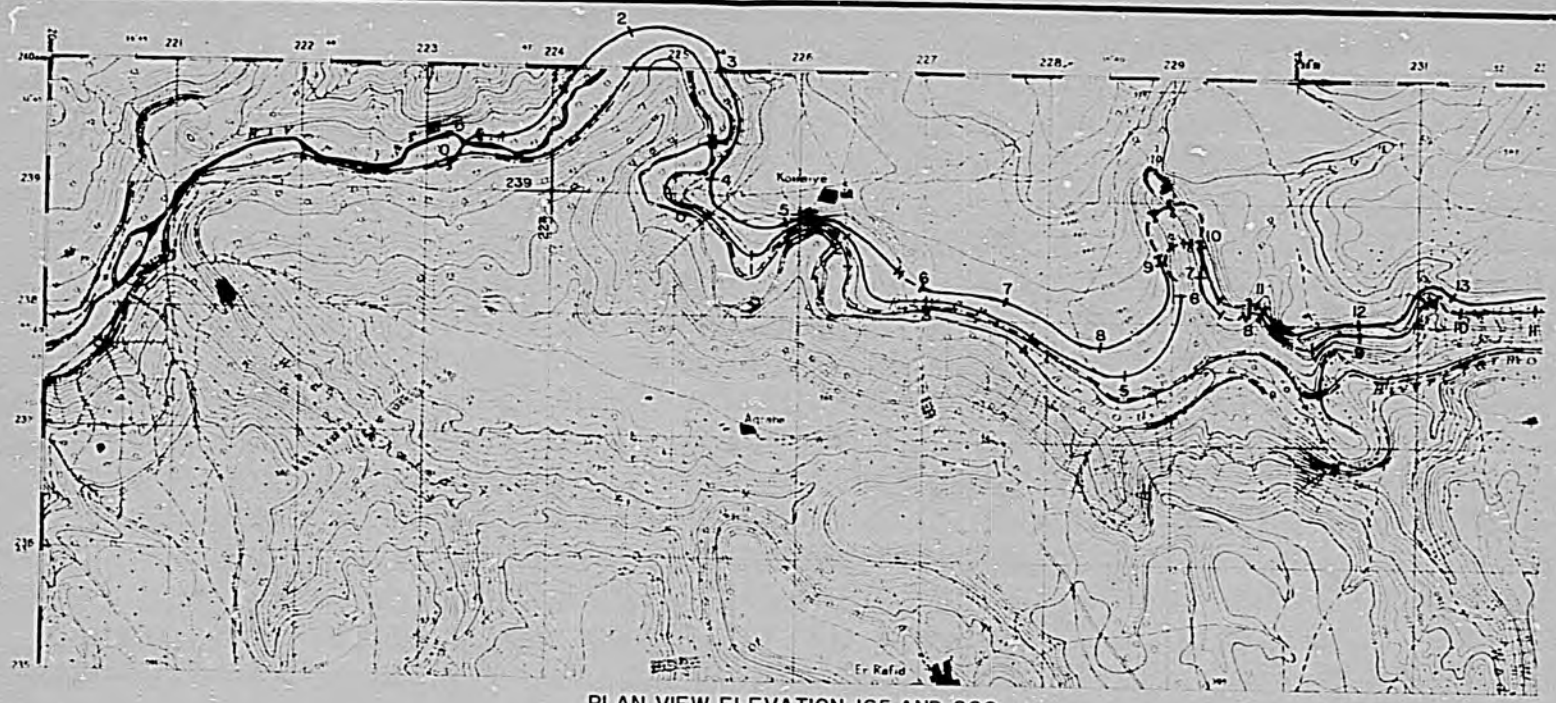


SECTION 4-4
UNCONTROLLED SPILLWAY

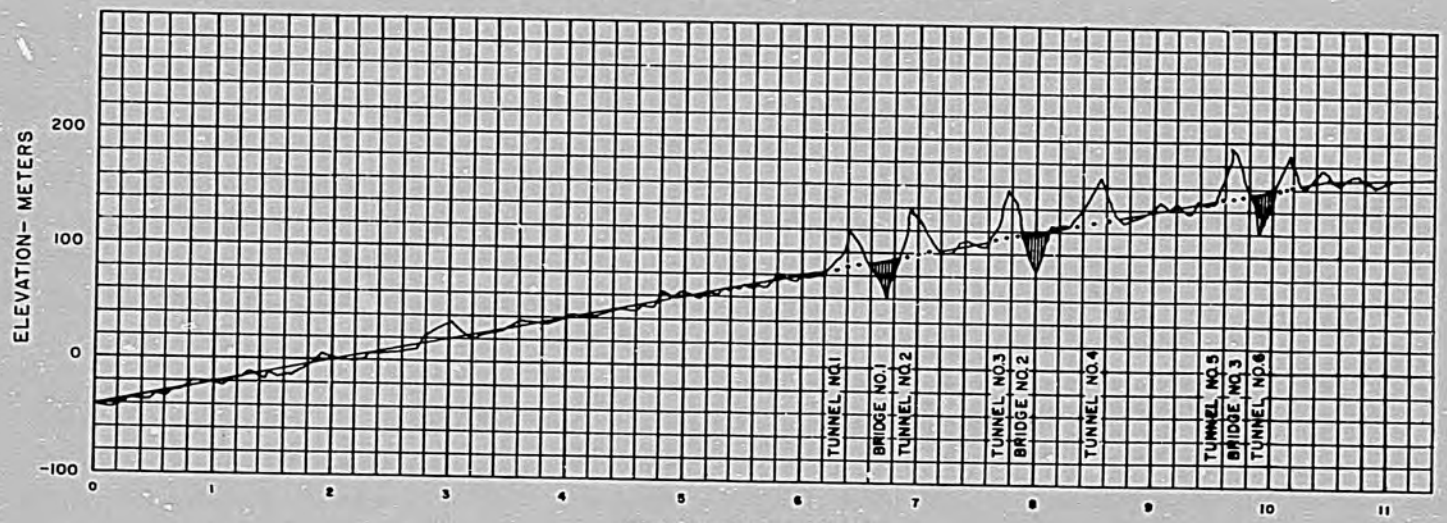
HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

TYPICAL
SIDE WADI DIVERSION
PLAN AND SECTIONS
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

EXHIBIT J-24
SHEET 1 of 2



PLAN VIEW ELEVATION 165 AND 200



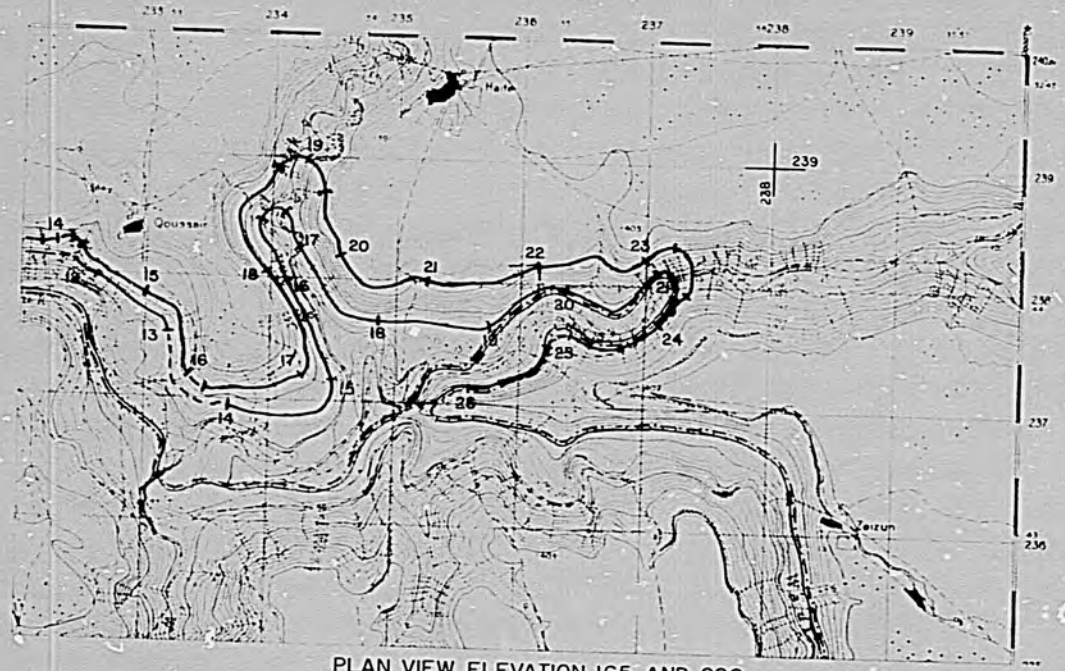
PROFILE ELEVATION 165

HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

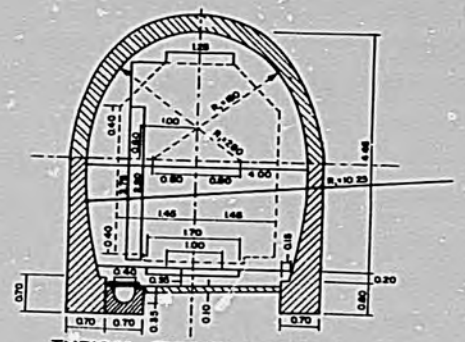
RAILROAD RELOCATION PLAN AND PROFILE

JORDAN VALLEY IRRIGATION PROJECT
STAGE II

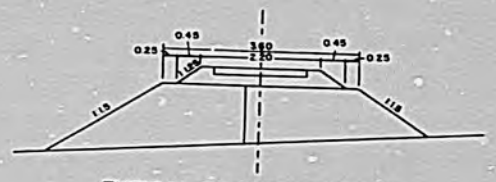
EXHIBIT J-24
SHEET 2 of 2



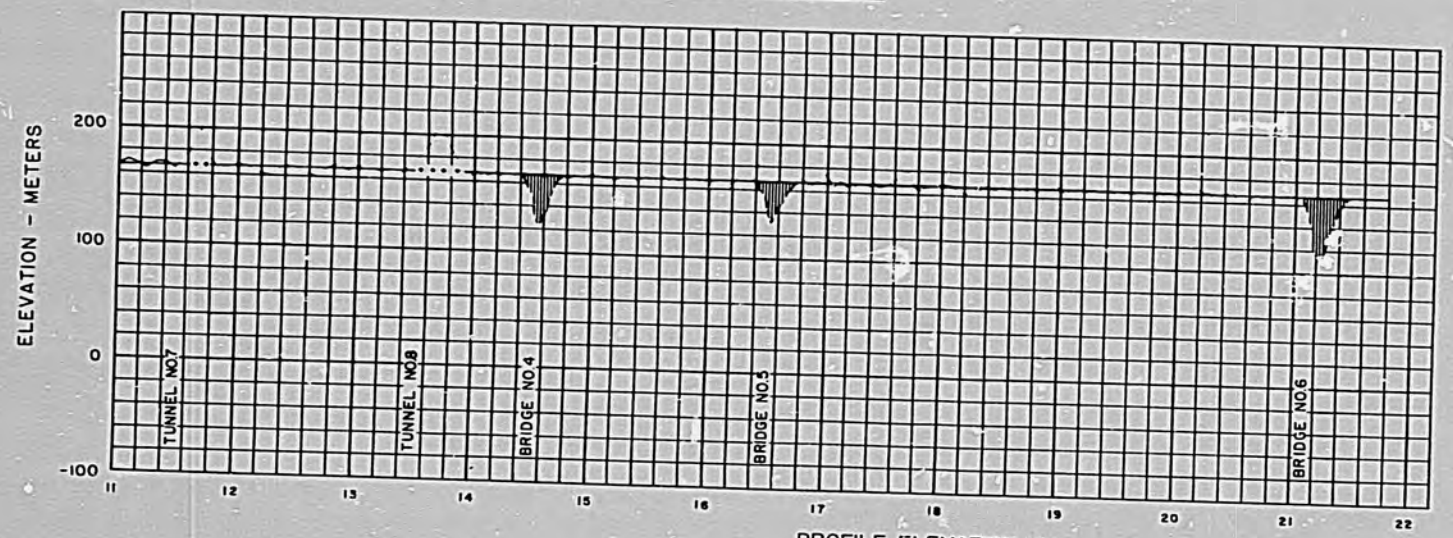
PLAN VIEW ELEVATION 165 AND 200



TYPICAL TUNNEL SECTION



TYPICAL ROADBED SECTION



PROFILE ELEVATION 165

LARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

RAILROAD RELOCATION
PLAN AND PROFILE
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

Appendix K

PRELIMINARY DESIGN OF IRRIGATION FACILITIES

Table of Contents

	Page
Introduction	K-1
General Design Concepts	K-1
Method of Irrigation	K-2
Types of Sprinkler System	K-2
Field System	K-3
Collective Irrigation System	K-3
Individual Farm System	K-4
Type of Farm System	K-4
Water Delivery to Farms	K-5
Source of Pressure	K-6
Sizes of Pumping Plants and Carrier Pipes	K-6
Headgate Unit Concept	K-6
Alternative Irrigation Systems	K-6
Surface Irrigation Systems	K-7
Hose-basin Irrigation System	K-9
Hose-pull Sprinkler Irrigation System	K-9
Mechanically Moved Systems	K-9
Solid Set Sprinkler Systems	K-10
Permanent-Set Sprinkler System	K-10
Trickle or Drip-Irrigation System	K-10
Conclusion	K-11
Conversion Concepts	K-11
Design Criteria	K-15
Layout	K-15
New Lands	K-15
Conversion Lands	K-19
Designation of Components	K-19
Farm Systems	K-20
System Capacity	K-20
Infiltration Rate	K-21
Sprinkler Lines and Sprinkler Spacing	K-21

19

Appendix K (Cont'd)

	Page
Time of Set and Spacing	K-22
Pressure Losses	K-22
Valves and Hydrants	K-22
Application Efficiency	K-22
Water Holding Capacity	K-22
Alternative Farm Systems	K-23
On-going Projects	K-23
Low Pressure System	K-24
Distribution Network	K-25
System Capacity	K-25
Sizing of Specific Components	K-25
Velocity and Pressure Levels	K-25
Main Canal Extension and Appurtenances	K-26
Canal	K-26
Wadi Crossings	K-26
Cross Drainage Structures	K-27
Control Structures	K-28
Protective Structures	K-29
Pumping Plants	K-29
Overall Layout of System	K-30
Summary of Net Irrigable Areas	K-30
Irrigation System Layout	K-33
Design of Distribution and Sprinkler System	K-37
Extension of the EGMC	K-37
Pumping Stations	K-37
Pressure Pipe Network	K-40
Pipe Size Selection	K-41
The Rajib-Arda Area	K-45
Gravity Diversion	K-45
Pump Diversion	K-46
Farm Irrigation System	K-50
Portable Farm Systems	K-51
Sprinkler	K-51
Farm Main Line	K-52
Drainage System	K-52
Surface Drainage System	K-53
New Surface Drains	K-53

Appendix K (Cont'd)

	Page
Upgrading of Existing Surface Drains	K-54
Sub-Surface Drainage System	K-55
Observation Wells and Piezometers	K-57
Operational Characteristics of System	K-57
Operation of the Farm System	K-57
Farm Management Support	K-58
Flows into Pipes	K-60
Water Supply Allocations	K-61
Automatic Control of Water in the EGMC	K-62
General	K-62
Objective of Automatic Control	K-62
Basic Facts About Main Canal	K-63
Equalizing Storage Requirements	K-63
Alternative Automation Concepts	K-65
Automatically Operated Gates	K-66
Dynamic Regulation	K-67
Recommendation	K-67
Components of Recommended Automatic System	K-67
Cost Estimate	K-68
Economic Consideration	K-68
Future Development for Communications	K-69
Irrigation Project Operation and Maintenance	K-70
Operation and Maintenance Headquarters	K-70
Operation	K-71
On Farm Irrigation	K-71
Watermaster Areas	K-72
Sequence of Project Water Control Events	K-73
Maintenance	K-74
Project Operation and Maintenance Organization	K-75
Construction Program	K-75
Preconstruction Activities	K-75
Areas to be Developed Annually	K-76
Construction Considerations	K-78
Pipe Manufacture	K-78
Contractual Concepts	K-79
Stream Lining Administrative Procedures	K-80
Conclusion	K-81

LIST OF TABLES

Table Number	Title	Page
K-1	Comparative Costs of Different Farm Systems	K-5
K-2	Storage Tank Capacity - When Hours of Irrigation Are Less than 22 Hours/Day	K-8
K-3	Cost Estimate of the Alternative Irrigation Method for a 4-Hectare Farm	K-12
K-4	Comparative Costs of Collective Vs. Individual Pump Systems	K-13
K-5	O&M of Collective Vs. Individual Pump System	K-16
K-6	Relative Annual Costs	K-17
K-7	Layout Components - Net Area Served & Design Turnout Flow	K-34
K-8	Main Canal Extension - Characteristics & Appurtenances	K-38
K-9	Characteristics of Pumping plants	K-39
K-10	Most Economical Pipe Size	K-44
K-11	Pumping Characteristics	K-46
K-12	Gravity Alternative - Rajib Arda Area	K-47
K-13	Pumping Alternative - Rajib Arda Area	K-48
K-14	Gravity Vs. Pumping-Rajib Arda Area	K-49
K-15	Annual Average Water Demand and Supply	K-64

LIST OF EXHIBITS

Exhibit Number	Title
K-1	Present Development
K-2	Proposed Development
K-3	Typical Layout of Pumping Station
K-4	Pressure Pipe Distribution Network (6 Sheets)
K-5	Nomograph For Pipe Size Selection
K-6	Gravity Carrier Pipe & Diversion Alternative Rajib-Arda Area
K-7	Typical Layout of the Pipe Network
K-8	Construction & Installation of Observation Wells
K-9	Irrigation Demand
K-10	Operation and Maintenance Organization

Appendix K

PRELIMINARY DESIGN OF IRRIGATION FACILITIES

Introduction

The proposed irrigation system will include conversion to sprinkler of irrigation of 12,842 hectares of land presently surface irrigated by water delivered through small concrete lined canals and commanded by gravity from the East Ghor Main Canal (EGMC) and a sprinkler irrigation system for 12,511 hectares of presently unirrigated land. Of the unirrigated land, only 10,564 hectares have been identified by a soil survey. The remaining 1,947 hectares are considered potentially irrigable at this stage although soil surveys have not been conducted to determine their location and productive capability.

The land presently irrigated lies in the northern part of the Jordan Valley. The presently unirrigated area lies both above and below the EGMC, in the gorges of side wadis, and in the southern part of the Jordan Valley beyond the command of the present EGMC.

The following sections summarize both the overall layout and planning concepts, and the design criteria used for the proposed irrigation system. Exhibit K-1 shows the present irrigation status of the Valley and the location of the project lands, while Exhibit K-2 shows the proposed development as a result of this study.

General Design Concepts

This section summarizes the concepts adopted for design of the proposed irrigation and drainage system. These concepts were either previously approved by the Jordan

Valley Authority or its predecessors, or were developed and are recommended as a result of this study.

The previously approved concepts were adopted for three similar sprinkler irrigation projects designed by Dar Al-Handasah and which are presently being constructed in the Valley. For a more detailed discussion and justification, the reader is referred to the "18-km Sprinkler Alternative 1973" report and the "Design Notes" of the East Ghor Canal Extension Project - Oct. 1974. Concepts developed as a result of this study are presented later in detail.

Method of Irrigation

The scope of work states that "Previous studies have established that the method of irrigation to be adopted for all new areas and existing gravity areas should be the sprinklers." The selection of sprinkler irrigation was adopted for the other projects because of the rather shallow soils of the Valley, the high cost of land grading, the relatively higher efficiency of sprinklers compared to surface methods, and the relative costs of labor and sprinkler equipment. However, the proposed irrigation system has the adaptability to serve, with on-farm modifications, other methods of irrigation.

Types of Sprinkler Systems

Different types of sprinkler systems were studied to arrive at the recommended one. These systems ranged from Field Systems whereby the same system is used for more than one individual farm, to a Project System where a collective water distribution system is used, with individual farm equipment. The latter system was adopted because of its ease of management and its adaptability to a wider choice of farm cropping patterns.

Field System. In this system the distribution network and irrigation equipment (sprinkler lines and sprinkler heads) are owned by a cooperative of farmers and are rotated for use among farmers. Such a system implies the constructio of an open channel water delivery network so that the sprinkl n system composed of the pump and other equipment, can be er rotated among farmers. This system does not make use of the elevation and location of the EGMC (regarded as the main conveyor) to irrigate by gravity pressure part of the down-slope area.

A similar system with a collective distribution pipe network delivering water to each farm turnout was also considered. This alternative proposed a farm system to be shared among a group of farmers. Efficient running of such a system would create operational problems such as:

1. Developing a rotation procedure when farmers are not required to follow a predetermined farm cropping pattern.

2. Requiring inspection and maintenance of sprinkler equipment each time it is tranferred between farmers.

3. Requiring that the distribution network and the irrigation sprinkler equipment flow capacities be adequate to meet peak requirements and allow rotation of equipment among farmers.

Collective Irrigation System. In this system, the irrigation equipment can be operated on more than one farm unit at a time. A wide range of equipment was considered including self-propelled volume guns and center pivots serving as many as 100 hectares at a time. Use of such equipment necessitates uniformity in cropping or water

requirements. With center pivots, different crops with different water requirements may be grown provided they cover large areas. The area allocated to one crop should form either a belt around the center pivot or a sector of the circle covered by the center pivot.

The capacity of the sprinkler heads and the speed of the pivot arm must be adapted to meet the requirements of each crop grown. Hence this would create engineering complexities and complicate management requirements during operation of the project. Every time a farm selects a new crop to grow, he will need to review sprinkler output to assure that the water requirements will be met.

Individual Farm System. In order to leave to the farmer the choice of his own cropping pattern, with the guidance of the Authority, individual farms with complete independent irrigation equipment are recommended. For this system the farmer will own the irrigation equipment required for irrigating his farm. However, the total project area allocated to each crop is fixed by the Authority.

The area of the farm unit and the design water requirement per farm will be discussed in the following sections.

Type of Farm System

A comparative study of possible sprinkler systems for an individual farm size of about four hectares indicated that a semi-portable farm system was the most economical. Table K-1 gives the initial investment for both the farm mainline and the sprinkler lines for the farm system for each of the following three systems:

1. The recommended semi-portable system with a portable sprinkler line.

2. Solid-set system with a buried farm mainline and portable sprinkler lines set in place for the whole season, and covering the whole irrigated area.

3. Permanent system where all farm mains and sprinkler lines are buried.

Table K-1

COMPARATIVE COSTS OF DIFFERENT FARM SYSTEMS

	Initial Investment		
	Semi-Portable	Solid Set	Permanent
	(JD Per Farm of 3.888 Hectares)		
Farm Main	800	1,150	1,300
Sprinkler Line	650	6,500	8,400
Total	1,450	7,650	9,700

Water Delivery to Farms

Either a rotation or demand delivery system may be followed for supplying individual farms with water. A rotation system was selected for the following reasons:

1. The sizes of pipes and the cost of the network is lower.

2. The efficiency of conveyance and of management will be higher since not all the water supply is stored.

3. The same 7-day rotation, including one day-off, presently used for the areas already under surface irrigation in the Valley, can be followed.

4. The available moisture that can be stored in the root zone of crops to be grown is adequate to allow for such a rotation.

Source of Pressure

Whenever possible and economically justified, gravity flow shall be used to supply the pressure required for sprinklers. The economic comparison shall consist of comparing the annual cost of providing the required pressure by gravity conveyance pipe against that of a conveyance pipe and a pumping plant.

Sizes of Pumping Plants and Carrier Pipes

Whenever pumping needs are being analyzed it is possible to use either smaller pipes and larger pumping plants or larger pipes and smaller pumping plants. The selection of pump and pipe size combinations shall be based on the calculation of the annual cost while maintaining the pipe flow velocity within the accepted limits.

Headgate Unit Concept

Under the headgate unit concept every group of farms is served from one headgate unit main pipe (HUM). This concept shall be followed in the layout of the sprinkler system. Rotation water delivery among farms on each HUM will eventually become the responsibility of the farmers, thus saving the JVA considerable expense. This is described in the Operations and Maintenance section of this report.

Alternative Irrigation Systems

The portable sprinkler system designed in this study, is based on a spacing of 12x18 meters between the sprinkler and flyline positions, respectively. The water is delivered at the farm turnout at a minimum pressure of 3.5 kg/cm^2 and a flow of 5.44 l/s continuously for 22 hours/day.

The purpose of this section is to describe alternative farm irrigation systems and to show that the proposed water

delivery system satisfies the requirements of any of the methods that can be substituted totally or partially with some on-farm modification.

On this project, especially in the converted area, some farmers might not like to change to the portable sprinkler system due to:

1. Their cropping pattern, kind of crop grown and their belief that sprinklers do not fit their crops; example, banana growers.
2. Their belief that most of the water under sprinkler irrigation evaporates before it reaches the soil surface, especially during the hot summer period.
3. Their desire to change to other methods of irrigation; such as trickle or permanent irrigation systems.

Alternative irrigation systems which can be adapted to the proposed rotational water delivery with minor modifications are described and discussed in the following sections of this report.

Surface Irrigation Systems

These systems include furrow, border and basin irrigation. These systems require that lands be graded to slopes of 0-2% in the direction of flow. They are adaptable to most crops; and may have high labor requirements.

These systems can be adopted by the farmers on the project with the following on-farm modifications:

a. Land should be graded to a uniform slope.
b. A storage tank is needed with its capacity dependent upon the hours of irrigation per day, as shown in Table K-2.

Table K-2

STORAGE TANK CAPACITY - WHEN HOURS OF IRRIGATION ARE LESS THAN 22 HOURS/DAY

Hours of Irrigation	Delivered Flow liters/sec	Delivered Flow (m^3/hr)	Delivery (hrs/day)	Time difference (hours)	Storage Tank Capacity m^3	Flow to be handled by Irrigators (m^3/hr)
4	5.44	19.584	22	18	353	107.83
5	5.44	19.584	22	17	333	86.18
6	5.44	19.584	22	16	314	71.92
7	5.44	19.584	22	15	294	61.58
8	5.44	19.584	22	14	275	53.96
9	5.44	19.584	22	13	255	47.92
10	5.44	19.584	22	12	236	43.18
11	5.44	19.584	22	11	217	39.31
12	5.44	19.584	22	10	196	35.92

One limitation of these systems is that the water application efficiency is normally less than 60%, which is lower than normally obtained by use of sprinklers. However, high efficiencies are attainable by application of good management techniques to properly designed systems.

Hose-basin Irrigation System

This can be an highly efficient method of irrigation, but normally uses a high labor input. It can be a very successful method for irrigating orchards and small vegetable crops.

The on-farm modifications are mainly:

a. Land grading and installation of basins.

b. Installation of a storage tank as described above (Table K-2).

c. Flexible polyethylene hoses to replace the aluminium fly-line and sprinklers.

Table K-2 shows that as the number of hours of irrigation per day increases the capacity of the storage tank and the flow to be handled by the irrigator decreases.

Hose-pull Sprinkler Irrigation System

This system is mainly used for irrigation of orchards and short-row crops. It has an efficiency similar to the portable sprinkler system and operates at the same pressure. The number of hours per set per day can be adjusted by adjusting the number of sprinklers per hose and the nozzle size of each sprinkler. It has medium labor requirements. The on-farm modification needed is to replace the portable alumin8m fly-lines with fixed PVC sub-mains.

Mechanically Moved Systems: These systems are mainly:

a. Side roll wheel move

b. Trail-line systems, skid or wheel mounted tractor moved

92

c. Traveller system; not adaptable on the Project because of its high water application rate.

All of the mechanically moved systems are adaptable to short annual crops, except for skid or wheel mounted tractor moved trail-line systems that can be used in orchards. They are similar to a portable sprinkler system with almost the same labor requirements. No on-farm modifications are needed.

Solid-Set Sprinkler Systems

This system uses buried mains and portable laterals (flylines) with sprinklers which completely cover the irrigated area. This system has a very low labor requirement. It has a better application efficiency than the portable system and is commonly used for irrigation of annual crops and orchards. No irrigation system modifications are necessary. The only limitation is that it is very expensive.

Permanent-Set Sprinkler System

This system is similar to the solid-set system mentioned above except that the mains and sub-mains are buried PVC pipes. Although it is expensive, it can be utilized to cool the crops when the ambient temperature increases above a certain maximum which will affect the physiology of the crops.

Trickle or Drip-Irrigation System

This system has a very high application efficiency and a high coefficient of uniformity. It is an economical method for use in orchards where relatively wide sprinkler spacings would be used. The labor requirement is low. This system is well suited to soils and water with salinity hazards. It needs flushing from time to time to prevent clogging of emitters. The on-farm modifications needed are:

a. Filtration system at the farm turnout or hydrants.

b. Rigid PVC pipe for mains and low density polyethylene for laterals.

c. Emission points (emitters) per tree instead of sprinklers.

The fixed and operating cost on each method are tabulated in Table K-3 which is presented for comparative purposes only.

Conclusion

The proposed water delivery system can be utilized for any of the alternative irrigation methods described above, with slight on-farm modifications. Only in surface irrigation methods will energy already furnished for sprinkling be lost when farmers choose surface methods. This is not a serious problem since, in a major part of the project (especially in the conversion area) where this is most likely to happen, water is being delivered under pressure created by elevation differences (gravity), and not by pumping. Good management must be exercised on gravity irrigated farms to obtain high efficiencies because of limited water allocations.

Conversion Concepts

The updating of a previously submitted report covering alternatives for converting surface-irrigated areas to sprinklers resulted in adopting the "Collective System". In this system a pressure pipe network will replace the existing concrete-lined canals. For areas lying adjacent to the EGMC, pumping plants will be required to supply the required pressure, while for the areas below the EGMC where elevation differences are adequate, gravity will supply the required pressure. Two independent networks will be required, each serving a group of farms.

Table K-3

COST ESTIMATE OF THE ALTERNATIVE IRRIGATION METHOD FOR A FOUR-HECTARE FARM

System	Moves/ day	Description	Cost (JD)	Operating Cost/Year (JD)
Hand Moved Sprinkler	2	Laterals, elbows & sprinklers	278	31
Wheel Line System	2	Wheel line & sprinklers	700	55
End Tow System	2	Lateral line-skid units	260	80
Trail Line System	1	Trail line machine complete with sprinklers	750	18
Solid Set System	1-2	Pipes, couplers & sprinklers	2,500	17
Permanent System	1-2	Lateral lines, fittings, sprinklers installed	2,700	10
Traveller unit with hose		Rain gun, hose, pump, gear head & diesel engine	1,200	100
Trickle Irrigation System		Laterals & emitters at tree spacing (Say, 5x5m)	2,900	10
Hose Basin System		Laterals & orifice	2,400	10

Prices are based on retail prices in California, U.S.A.

An alternative would be to maintain the present canal system but install an electric power distribution network to furnish each farm or two with a small pump and electric motor to develop the required pressure for sprinkling. The investment costs for the two systems are shown by Table K-4.

Table K-4

COMPARATIVE COSTS OF COLLECTIVE VS. INDIVIDUAL PUMP SYSTEMS (Initial Investment)

	Collective System (JD/Ha)	Individual Pump System (JD/Ha)
Pumps & Motors	213.200	200.000
Pipe Network	982.300	-
Overhead Electric Network	-	407.200
Farm System	642.000	642.000
TOTAL	1,838.100	1,249.800

The investment costs are based on an average farm size of 3.888 ha and indicate a relative advantage for the individual pump system. However, an analysis of annual costs for both systems reveals that they cost about the same.

The following discussion shows the results of the analysis of the annual cost studies. The annual capital costs are based on the useful life for the various components at a 6% interest rate. Three differentials between the two systems were considered for this analysis:

1. Power Differential. With the collective system, pumping will be required for only a narrow strip of land adjacent to the EGMC. The other areas will obtain pressure by gravity. For the individual system, every farm would require power for pumping from the existing small canals. Furthermore, the efficiency of larger central pumping stations of the collective system will be higher. The overall efficiency of 70 to 80 or greater HP pumps and motors approaches 70%, while for small pumps of less than 15 HP it may be as low as 56 percent. The calculated savings is based on a kilowatt hour charge of JD 0.012 and 5,500 hours of operation per year. Each hectare of the individual system will require 0.21 HP of additional installed power with an annual power cost of JD 14.730 per hectare.

2. Water Economy. With the collective system, water that is not used by the various farmers will not be lost but remains in the pipe system. With the individual system, all water turned into the open canals must either be used or wasted. An assumed figure of 10% is associated with this saving. On the basis of a total average requirement of 12,000 m^3 per hectare per year and a cost of JD 0.007 per m^3 this gives JD 8.400 as an added annual cost of water for the individual system.

3. Operation and Maintenance. It is difficult to arrive at an exact figure for the extra cost associated with the operation and maintenance required for hundreds of small pumps and motors as compared to operating and maintaining one pump,

but it is likely to be more expensive. Also, the operation of one plant requires less manpower than operating many small ones, even though it may be argued that the farmer himself will do the pump operation. The management and control of water deliveries by the JVA, should also be an advantage of the collective system.

The operation and maintenance costs given in Table K-5 shows the collective system costs are less by JD 3.560 per hectare annually. Table K-6 gives the annual costs of both systems and results in recommending the collective system.

Design Criteria

Layout

Layout is defined for this study as the plan of the arrangement of the individual farm plots, the network of pipelines including carriers, distributaries and headgate unit mains, and the access roads serving the farm plots.

The following are the general principles on which the recommended sprinkler irrigation layout was based for the New Lands and for those converted (Conversion Lands) from surface irrigation.

New Lands. These lands are not included in the present Project and the provisions of Law No. 12 of 1968. The layout criteria assumes this Law will be applied to all such lands. The main layout criteria are as follows:

1. The area of each farm plot shall be between 3 and 5 hectares, according to Law No. 12 of 1968 of the Hashemite Kingdom of Jordan.

Table K-5

O & M OF COLLECTIVE VS INDIVIDUAL PUMP SYSTEM

(Annual Costs in JD/hectare)

	Collective System		Individual Farm System	
	Percent of Initial Investment	JD/ha	Percent of Initial Investment	JD/ha
Initial Investment	100.0	1,838,100	100	1,249,800
Spare Parts	2.5	5.300	3.5	7.000
Maintenance Labor	0.5	1.100	1.0	2.000
Operation Labor	0.3	0.640	0.8	1.600
TOTAL		7.040		10.600

Table K-6

RELATIVE ANNUAL COSTS
(Collective vs Individual Conversion systems)

Item	Initial Cost (JD/ha)	Life (Yrs)	Capital Recovery	Annual Cost (JD/ha)
Individual System				
Pumps & Motors	200.000	8	0.1610	32.200
Farm System	642.600	a/	0.1135	72.940
Electrical	407.000	20	0.0872	35.490
		Sub-Total		140.630
Power Differential				14.730
Added Water Cost				8.400
O&M Differential				3.560
	Total Individual System			167.320
Collective System				
Pumping Plants	213.200	15	0.1030	21.960
Farm System	642.600	a/	0.1135	72.940
Pipe Network	982.300	40	0.0665	65.320
	Total Collective System			160.220

a/ Useful Life is considered as 40 years for the fixed equipment and 8 years for the portable equipment.

100

2. The shape of the farm plot shall preferably be rectangular, and as close as possible to 215 m x 180 m. This gives a net farm area of about 3.9 hectares excluding roads, etc. The length may be exceeded but not the width.

3. As closely as practicable the farms are to be arranged with the longest dimension parallel to the contour lines.

4. Farms shall be grouped into "Tertiary" Headgate Units where groups of farms have one common Headgate Unit Main (HUM) pipeline supplied from one turnout on the Distributary Pipe. Each farm plot shall have an individual turnout on the HUM pipeline leading to a Farm Main which in turn supplies portable fly-lines with sprinkler heads. A typical HUM is shown on Exhibit K-3 along with the complete Typical Layout of the Pipe Network.

5. The required pressure at the Headgate Unit Main turnout on the Distributary Pipes shall be at least 3.5 kg/cm^2. Thus, the Carrier Pipe system along with necessary pumping shall be designed and located to provide this pressure.

6. The location of the carrier and distributary pipes shall be guided by the following considerations:

   a. Areas of high elevations above the pipe shall be kept to a minimum to reduce pumping costs.

   b. Existing road and canal rights-of-way will be used as much as possible to minimize land expropriation, construction of service roads, wadi crossings and excavation.

7. All Headgate Unit Mains and other pipe lines shall have a 10 m right-of-way and surface drainage ditch on their lower side. All roads shall have a 3 m wide gravel surface and lead to the Yarmouk-Dead Sea road.

8. Every effort shall be made to arrange the layout to reduce loss of irrigable land.

Conversion Lands. The conversion area was consolidated and sub-divided into farms of 3 to 5 hectares and has been under well-organized irrigated agriculture for the last 12 to 14 years. This area lies below the elevation of EGMC and is presently served by a concrete-lined distribution system of canals. The sprinkler layout will follow the existing farm boundaries. The existing farm plot boundaries will be retained and the farm-to-market roads will be graded and surfaced.

The distributary pipes will run along the west bank of the EGMC and the Headgate Unit Mains will run along existing roads on the side opposite the existing lined canals. It is not deemed advisable to lay the pipes in the canals. The surface irrigation system will be maintained and remain in operation until the completion of the pipe system. In fact, it may be advisable to keep it in good order after completion of the pipe network.

Designation of Components. A composite-number identification system has been followed. The first number designates the location in kilometers downstream from the entrance to the EGMC, or its extension. The second number represents the distance from the beginning of the Carrier and the third from the beginning of the Distributary. The letters G, C, Z, LP and HP shall precede designations to indicate gravity,

conversion (to sprinklers), Zor, Low Head Pumping and High Head Pumping, respectively. The letter R and L shall precede distances to indicate the direction right or left, while facing in the direction of flow.

Farm Systems

System Capacity. The sizing of irrigation system components shall be based on meeting the peak irrigation flow requirements for alfalfa, delivered 23 hours per day, six days a week. If a crop with a higher peak flow requirement is planted then only a fraction of the farm could be planted, or the seventh day could be used for irrigation.

The peak flow adopted for design is 193 mm. Since, during the peak month, the crop water use may not be constant an empirical approach adopted from the US Department of Agriculture[2/] was used to determine the peak or critical period consumptive use demand rate.

$$Up = 0.034\ (Um)^{1.09}\ (I)^{-0.09}$$

Where: Up = peak critical period consumptive use demand rate in mm/day or in in/day;

Um = maximum monthly crop consumptive use in mm or in, and

I = crop consumptive use between irrigations in mm or in.

With 193 mm per month and a 7 day irrigation interval, Up would be:

$$Up = 0.034\ (193)^{1.09}\ (193 \times 7/31)^{-0.09} = 7.50\ mm/day$$

Water Requirements, Technical Publication No. 21, Soil Conservation Service, USDA, 1971.'

This depth will require a continuous net peak use flow of 1.05 l/s/ha for 23 hours per day for 6 days during every 7-day period.

For a farm irrigation application efficiency of 75%, the design farm delivery rate is a continuous flow of 1.4 l/s/ha. This flow rate of 1.4 l/s/ha was used for the design of the farm sprinkler irrigation system.

Infiltration Rate. Soil infiltration tests, as reported in the Harza-Baker Report[3/], give the infiltration rate after 12 hours of water application. Sixty-eight percent of these tests recorded a rate exceeding 6.0 mm/hr. A safe maximum-application rate of 6.0 mm/hr was allowed in the design of the sprinkler system.

For areas where the infiltration rate is lower than 6.0 mm/hr, the farm sprinkler system will have to be designed according to the lower infiltration rate. Hence, all lands with restricted infiltration capacity will have to be delineated, their respective rates determined and treated individually during final design.

Sprinkler Lines and Sprinkler Spacing. One flyline is provided per farm and will be moved twelve times during the 7-day irrigation interval to cover the whole farm area. The flyline shall be set in a manner to minimize the differential pressures among sprinklers and obtain a satisfactory water distribution.

Sprinklers will be spaced at 12 m intervals on a sprinkler line to avoid loss of distribution efficiency due to wind, and to use medium sprinkler working pressures. This will

Yarmouk-Jordan Valley Project - Master Plan Report - Volume III, Land Resources - 1955, Table 3.1-8, By Harza/Baker.

result in an energy saving and will increase the area that can be commanded by gravity, ie. without pumping.

Time of Set and Spacing. Twelve-hour sets are required during the 7-day rotation (6-day operation + one day off) in order to make full use of the equipment and minimize the rate of flow required per farm. This assumes an 18 m spacing between consecutive sets on the mainline. The larger spacing between sets will reduce the cost of the portable and fixed farm equipment.

Pressure Losses. Losses in pressure due to friction were limited to 15% of the recommended sprinkler nozzle pressure in the farm mainline, and 10% in the sprinkler line. Other losses due to fittings etc., in the farm mainline were assumed to be 10% of the loss in the same pipe reach.

Valves and Hydrants. Every farm shall be equipped with four riser hydrants connecting the farm mainline to the sprinkler line. The risers shall be automatic and provided with a portable valve-opening elbow. Each hydrant shall serve the sprinkler line when positioned in three different locations.

Application Efficiency. A farm irrigation application efficiency of 75% was assumed. If such a level is not attained, two cushioning provisions are built into the design concept. One is the use of the seventh day during peak periods and the other is in the upward rounding of required pipe sizes to those available on the market. Thus the system can operate at a lower efficiency level and meet higher peak demands than those indicated previously.

Water Holding Capacity. The allowable moisture depletion of the average root zone for the soils of the Project Area

is estimated to be 60 mm. This provides adequate moisture for the weekly peak net irrigation requirement and defines the maximum depth of water to be applied per irrigation.

Previous field studies indicate that this depth of water can be stored in an average root zone of less than 70 cm. The Readily Available Moisture for medium-textured soils averages about 130 mm/m while for light sandy soils it is 77 mm/m. Hence, the 60 mm assumed above can be considered the minimum condition since the majority of the soils in the Project area are medium textured.

Alternative Farm Systems

Two of the several alternative farm systems evaluated in this study are worth special mention.

On-Going Projects. The farm system used on projects under construction in the Valley consists of a fixed-farm mainline and two 50 mm sprinkler lines. The system is designed with sprinkler and lateral spacings of 12 m and provides for only one being operated at a time. The design time of set is 8 hours and the peak water use is met by having three 8-hour sets each day for six days during a 7-day week. The rate of infiltration assumed obtainable is 6.8 mm/hr. The operating pressure is about 2.7 kgs/cm.

This system was not selected for the Stage II because of questions concerning the relatively higher infiltration rate required for this system. Furthermore, the 8-hour sets place a heavy burden on farmers. Although the above considerations were used for design of the system under construction, application rates can be reduced to about 1/2 the design application rate by simply changing to a smaller sprinkler and using both lines simultaneously. This would result in not exceeding an infiltration rate of 3.4 mm/hr.

Low-Pressure System. An alternative farm system consisting of three 50 mm sprinkler lines, with both sprinkler and laterals spaced at 12 m was studied. With a 22-hour set, this system would apply water at a very low rate and allow use of lower system pressure. The flexibility inherent in this system would also accommodate a higher peak water demand.

The initial capital cost for the farm system would be higher than that of the recommended system which uses one 75 mm sprinkler line. However, the lower pressure required would increase the area serviced by gravity without pumping and require less installed horsepower for areas requiring pumping. These changes would reduce the annual operating costs.

A detailed design and cost estimate was made for a sample area. The project capital cost for this low-pressure system was about the same as the costs for the recommended high-pressure system. It is recommended that a more detailed study of this alternative be made during the final design stage. It is also hoped that by the final design stage the demonstrational units being set up by the JVA in the Valley would have become operative and will furnish practical evidence for improving the quality of such study.

This final design study should consider such factors as:

- Meeting higher peak water requirements.
- Comparative labor requirements for operating alternative farm systems.
- Actual magnitude and extent of areas with low infiltration rates.
- Effect of wind on distribution uniformity for 12 x 12 vs 12 x 18 meter spacings.

Since both farm irrigation systems have comparable estimated costs, the 12 x 18 meter system was used as a basis for the feasibility level design and cost estimates for the Project.

Distribution Network

System Capacity. The capacity of the main distribution system (canal, carrier and distributary pipes, and headgate unit mains) shall be based on meeting the peak irrigation requirement of the average cropping pattern which is 85 mm per month. This requirement is augmented by the following percentages, depending on the delivery area considered:

Area less than 100 hectares,	add 60%
Area between 100 and 250 hectares	from 60-25%
Area more than 250 hectares,	add 25%

The allowance given above is for deviation from the peak requirement of the cropping pattern shown in the Appendix G, Agricultural Development.

Sizing of Specific Components. Headgate Unit Mains were sized on the basis of the area they serve and the criteria of the system capacity presented earlier. Distributaries, Carriers, the Main Canal Extension, and pumping plants were sized on the basis of the area they served and the criteria of the system capacity.

Velocity and Pressure Levels. The maximum allowable pipe flow velocity used was 2 meters per second. The pressure required at the beginning of a farm turnout was 3.5 kg/cm^2 or 35 meters of water head. Pressure regulators were incorporated in the system to reduce excessive pressures. Pressure-relief fixtures and hydraulic valves or similar devices for surge control were incorporated into the pipe network.

Main Canal Extension and Appurtenances

The design criteria applicable to the extension of the EGMC were the same as those used for the 18 km Extension now under construction. These criteria were applied to wadi crossings (whether flumes or siphons), cross-drainage structures, spillways, wasteways, bridges and turnout structures for both gravity carriers and pumping stations. If automation is adopted, several of the criteria presented will be modified as detailed in a subsequent section.

Canal. The proposed 14.5 km extension of the EGMC runs through land with a smooth topography. A reasonable slope of 28 cm per kilometer was adopted for the entire length of the extension.

The typical cross-section used for the canal was a concrete-lined trapezoidal section with side slopes 1-1/2 horizontal to 1 vertical. On both sides of the Canal, the earth embankment continues above the top of the lining, with a slope of 2-1/2 horizontal to 1 vertical for a vertical depth of about 30 cm. The free board from the design water surface to the top of the concrete lining is 30 cm.

To prevent infiltration of water into the earth embankments, their tops are designed to slope away from the canal.

In areas with transverse slopes an interceptor ditch is designed on the uphill side of the canal. This interceptor ditch will drain the runoff from the upper watersheds and prevent eroded material from entering in the canal.

Wadi Crossings. Wherever the canal crosses a major wadi, and the use of a cross-drainage culvert was ruled out because of the excessive compacted embankment and related cost or other complications, a choice was made between a flume and an inverted siphon. Comparative costs and struc-

tural considerations were analyzed to determine the appropriate solution.

Non-economic factors considered were mainly in relation to safety from enemy open attack or sabotage where it is generally agreed that flumes are easier targets than siphons.

Problems of calcium deposits have occurred in low pressure pipelines in the Jordan Valley. The causes and possible effects on the proposed sprinkler pipelines should be investigated.

Two inverted siphons are recommended at the following locations:

Beginning of Siphon (Station)	End of Siphon (Station)
99 + 741	100 + 151
106 + 956	107 + 171

Cross Drainage Structures. Where the canal crosses minor surface runoff channels or relatively large flat sloping areas that do not have visible runoff channels, cross-drainage structures are recommended to carry the runoff to the lower side of the canal. For small surface channels, box culverts are recommended while overchutes are used for flat areas.

1. Surface Runoff Considerations. The design of the cross-drainage structures was based on the peak runoff of the watersheds as determined by the Rational approach for a precipitation recurrence period of 50 years.

2. Box Culverts. The minimum size box culvert recommended is 1 m x 1 m and the subsequent sizes are multiple culverts with dimensions of 1.5 m x 1.5 m or 2 m x 2 m for each box. The design flow capacity was based on an entrance head of one meter.

3. Overchutes. Overchutes carry runoff water over the canal and are recommended where the canal does not cross a depression, but where considerable sheet flow may accumulate above it and require relief.

Control Structures. Structures are required for controlling flow in and out of the canal. These are the lateral turnouts, checks to control the water level in the canal, spillways and wasteways.

1. Lateral Turnouts. The proposed irrigation network requires construction of turnouts on the canal to permit water distribution under both gravity head and pumping. Each turnout was designed with adequate capacity to discharge the peak water requirement for the corresponding service area. A system of filters is required at each turnout to permit delivery of only clean water into the pipelines and sprinklers. Gates are provided to control the flow delivered into the system.

2. Check Structures. Check structures are provided to maintain normal water levels when the flow is less than maximum. The check structure will consist of an enlarged rectangular canal section with radial gates in the central part and openings controlled by stop planks on both sides.

3. Wasteways. Wasteways have been provided to allow complete emptying of the canal flow into side wadis and are placed either before inverted siphons or at 8- to 10-km intervals. Wasteway provisions include a check structure across the canal or a vertical leaf gate at a canal siphon entrance and a conveyance channel from the canal. Flow into the conveyance channel is controlled by a radial

gate wasteway structure placed on the right hand side of the canal. The service road crosses the wasteway via a small bridge.

Protective Structures. Two types of canal protective structures have been provided. These are 1) interceptor surface drain channels placed on the uphill side of the canal to intercept and prevent any overland flow that develops from entering the canal and 2) spillways to maintain the water level in the canal at prescribed elevations and prevent any flooding of the banks and the service road. No silt traps or sediment basins have been provided.

1. Interceptor Drains. A drain has been provided to intercept surface flow that is likely to reach and erode the uphill slope where the canal is in cut. This drain, in the form of a trapezoidal unlined ditch, conveys the intercepted flow to a culvert or an overchute.

2. Spillways. An overflow weir type spillway is provided at approximately 4 km intervals. The weir crest elevation is set to permit water to overflow the spillway whenever the water level in the canal rises 10 cm above the design level (20 cm below the top of the concrete). Rises in water level may be caused by slides of loose material in the winter, surface runoff entering the canal or by faulty operation of the facilities. The spillways are designed to discharge through culverts into waste channels.

Pumping Plants

The design criteria used for the various pumping plants was the same as used for the pumping stations of the East Ghor Canal Extension Project presently being constructed.

Centrifugal pumps set at elevations to provide a positive pressure on the intake and driven by electric motors are provided. A standby pumping capacity of 33%, an operator's residence block, and basic maintenance and repair facilities are provided for each pump station. The pumping station is an indoor type with pumps and motors located in concrete houses.

For some areas the difference in elevation of lands being served is as much as 120 meters. Consequently, the system must be designed to provide the desired pressure for each delivery. For systems using one stage pumping, the delivery to farms requires a pressure reduction of up to 12 kg/cm^2. An alternative would be to provide a multiple stage pumping plant with two or three separate distributary and/or carrier pipes. Another alternative would be to provide booster pumps in the distributary and/or carrier pipes. For this feasibility design, a one stage pumping system was deemed more economical and therefore used.

No stand-by generators were provided for the pumping stations. It was assumed that the proposed electrical network for the Valley will be adequate to eliminate the need for separate stand-by generators.

A typical layout of a pumping station is shown in Exhibit K-3.

Overall Layout of System

Summary of Net Irrigable Areas

Based on the land reclassification described in Appendix F and the published figures of on-going projects, the following net irrigable areas are identified in the Jordan Valley.

I. On-Going Projects	Area (ha)
Under Construction	
1. East Ghor Main Canal (EGMC) Extension (18 km Ext.)	3,550
2. Zarqa Triangle Irrigation	1,527
3. North East Ghor (NEG) Irrigation	
- New Lands	1,760
- Conversion Lands	1,000
4. Hisban - Kafrein Irrigation	1,560
Sub-Total	9,397
Under Study	
1. Wadi Arab Irrigation	
- New Lands	420
- Conversion Lands	830
Sub-Total	1,250
Total on-going projects	10,647

II. Project Areas Included in this Feasibility Study (Stage II)

Conversion Lands - Group C	Area (ha)
1. Balance of lands forming part of original EGMC Project	10,470
2. Lands to be upgraded within the EGMC Project	915
3. Lands commanded by the 8 km extension	1,457
Total Conversion Lands	12,842

	Area (ha)
New Lands	
1. Land Group B (between Zarqa Triangle and N.E.G. irrigation projects)	1,081
2. Land Group A (between 18 km extension and Dead Sea)	9,483
Total New Lands	10,564
Potentially Irrigable Lands - Group D	
1. Yarmouk Gorge	331
2. Ziglab Gorge	50
3. Inland Group B	432
4. Kufrinja Gorge	100
5. Zarqa Gorge	216
6. South of Zarqa Triangle Project	293
7. Along the 18 km Extension Project	525
Total Potential Lands	1,947
Summary	
- Conversion Lands	12,842
- New Lands	10,564
- Potential Lands	1,947
Total Area included in this Feasibility Study	25,353

III. Total Areas

Projects under construction	9,397
Project under study	1,250
Lands covered by this Study	25,353
Grand Total of Net Irrigated Stage II Lands	36,000

Irrigation System Layout

An irrigation network layout for the converted and new areas has been prepared on available 1:10,000 scale topographic maps (total area 23,406 hectares). However, no layout was prepared for the Potential Lands (area 1,947 hectares) because these lands are not yet definitely delineated.

Exhibits K-4 (eight sheets) show the proposed layout for the sprinkler system for Land Groups A, B and C on a 1:50,000 scale map. The layout sizes and lengths of carriers and distributary pipes, also are shown on 1:10,000 scale maps in Annex K-1.

From these exhibits, it can be seen that the existing EGMC is extended an additional 14.5 km and serves as the main water conveyor. Along its path are located gravity turnouts and the pumping stations. The proposed carrier pipes will convey water from the various turnouts to the distributaries. The distributaries supply the headgate unit mains which in turn supply the individual farms through the farm mains. The farm sprinkler laterals (flylines) with sprinkler heads are connected to the farm mains.

Table K-7 gives the designations, net irrigable area and number of farms for each separate area covered by the layout. This table shows there are 3,353 farms with a total area of 12,212 hectares supplied by gravity, 2,224 farms with an area of 7,894 hectares supplied by low head pumping, and 603 farms with an area of 2,385 hectares supplied by high head pumping diversions from EGMC. Low head pumping refers to pump stations which act as booster pressure stations for areas adjacent and below the EGMC. These are areas which would not have adequate pressure to operate sprinklers if served by gravity diversions. High head pumping refers

Table K-7

LAYOUT COMPONENTS
NET AREA SERVED & DESIGN TURNOUT FLOW

Area Designation	Net Area ha	No. of Farms No.	Turnout Flow l/s
1. New Lands			
1.1 High Head Pumping			
HP 43	336.5	85	200
HP 48	744.6	186	440
HP 99	258.0	66	160
HP 103	478.5	122	280
HP 107	200.0	51	130
HP 110	367.3	93	150
Sub-Total	2,384.9	603	
1.2 Low Head Pumping			
LP 98	371.0	92	220
LP 104	2,030.0	517	1,220
LP 109	875.3	215	660
Sub-Total	3,276.3	824	
1.3 Gravity			
Z 78	438.0	112	260
Z 82	56.0	15	45
Z 92	280.0	71	170
G 98	296.0	69	180
Z 104	530.0	140	315
G 106	1,319.0	338	770
G 110	1,984.0	506	1,150
Sub-Total	4,903.0	1,251	
Summary New Lands			
High Head Pumping	2,384.9	603	
Low Head Pumping	3,276.3	824	
Gravity	4,903.0	1,251	
Total New Lands	10,564.2	2,678	

Table K-7 (Cont'd)

LAYOUT COMPONENTS
NET AREA SERVED & DESIGN TURNOUT FLOW

Area Designation	Net Area ha	No. of Farms No.	Turnout Flow l/s
2. Conversion Lands			
2.1 Low Head Pumping			
CLP 14	620.0	187	375
CLP 25	550.0	171	340
CLP 29	660.0	200	400
CLP 34	630.0	191	375
CLP 38	650.0	197	390
CLP 44	26.0	8	25
CLP 46	28.0	9	25
CLP 51	600.0	182	365
CLP 55	853.3	255	510
Sub-Total	4,617.3	1,400	
2.2 Gravity			
Gravity Carrier	4,123.7	1,142	2,370
CG 14	310.0	96	200
CG 23	350.0	111	220
CG 28	200.0	60	140
CG 33	320,0	99	200
CG 36	230.0	72	150
CG 46	70.0	21	60
CG 50	120.0	39	100
CG 53	110.0	33	90
CG 56	480.0	147	295
CG 65_1	250.0	75	160
CG 65_2	420.0	126	260
CG 78	325.0	81	
Sub-Total	7,308.7	2,102	

Serving Rajib - Arda Area.

Table K-7 (Cont'd)

LAYOUT COMPONENTS
NET AREA SERVED & DESIGN TURNOUT FLOW

Area Designation	Net Area ha	No. of Farms No.	Turnout Flow l/s
Summary Conversion Lands			
High Head Pumping	4,617.3	1,400	
Gravity	7,308.7	2,102	
Upgraded Land in both above	915.0	-	
Total Conversion Lands	12,841.0	3,502	
3. Total Design Area			
3.1 New Lands	10,564	2,678	
3.2 Conversion Lands	12,841	3,502	
Total Design Area	23,406	6,180	
4. Total Project Area			
4.1 Design Area			
High Head Pumping	2,385	603	
Low Head Pumping	7,894	2,224	
Gravity	12,212	3,353	
Upgraded	915	-	
Total	23,406	6,180	
4.2 Potential Lands	1,947	500 (assumed)	
Total Project Area	25,353	6,680	

to pump stations supplying water to areas lying above the EGMC. These pump stations must lift the water to areas with elevations higher than the EGMC and supply the required pressure for sprinkler operation.

Design of Distribution and Sprinkler System

The design of the sprinkler system is based on the criteria discussed previously. The layout drawings give the location and size of the major system components.

Extension of the EGMC

The existing EGMC is extended 14.5 km with a slope of 28 cm per kilometer. A trapezoidal section similar to the one used in the existing EGMC is used for most of the area but with a diminishing depth and bottom width. However, if an automatic control system, as presented later is adopted, both the proposed slope and depth will be changed, and the check structures will be modified.

Table K-8 gives the detailed characteristics of the 14.5 km EGMC extension, and the location and sizes of the main appurtenances. The proposed layout follows the one previously submitted for surface irrigation of the East Bank by Dar Al-Handasah/Nedeco in 1971.

Pumping Stations

Table K-9 shows the main features of the proposed pumping plants. The recommendations for pump sizes are based on topographic considerations and preliminary comparisons of estimated costs for pipe and pumping to command a specific area. Evaluations also considered the use of one large pump versus several small pumps to command the same

Table K-8

MAIN CANAL EXTENSION
CHARACTERISTICS & APPURTENANCES

Station	Area Served Partial	Area Served Total	Design Flow	Size B/H	Remarks
	ha	ha	m^3/s	cm	
110+332					Wasteway
110+150					2-1.0x1.0 Culvert
110+100	367.3	367.3			HP 110 T.O & Check
110+000	1,984.0	2,351.3	2.0	180/110	G 110 T.O.
109+700	875.3	3,226.6			LP 109 T.O.
109+400					1-1.0x1.0 Culvert
109+000					2-2.0x2.0 Culvert
107+950					3-2.0x2.0 Culvert
107+495	200	3,426.6			HP 1.07
107+171			3.0	220/110	End Siphon
106+956					Begin Siphon & Wasteway
106+200					Overchute
106+080	1,319.0	4,745.6			G106 T.O. Culvert
105+900					2-1.0x1.0 Culvert
105+700					2-1.0x1.0 Culvert
105+100			4.6	300/110	1-1.0x1.0 Culvert
104+146	2,560	7,305.6			LP 104 & ZG 104 T.O. & Check
103+900					2-1.5x1.5 Culvert
103+300			5.0	300/140	2-1.5x1.5 Culvert
103+000	478.5	7,784.1			HP 103 T.O.
102+700					Overchute
102+100					Overchute
101+300					2-1.5x1.5 Culvert
100+500					2-1.0x1.0 Culvert
100+151					End Siphon
99+741					Begin Siphon & Wasteway
99+446	258.0	8,042.1			HP99 T.O. & Check
99+230			5.8	300/170	1-1.0x1.0 Culvert
98+600					1-1.0x1.0 Culvert
98+827	667	8,709.1			LP98xG98 T.O.
98+200					1-1.0x1.0 Culvert
98+000					1-1.0x1.0 Culvert
97+600			5.8	300/170	1-1.0x1.0 Culvert
97+150					2-1.5x1.5 Culvert
96+700					2-1.5x1.5 Culvert
96+000					1-1.0x1.0 Culvert
95+955					2-1.5x1.5 Culvert

Table K-9

CHARACTERISTICS OF PUMPING PLANTS

Designation		Area Served	Design Flow	Total Head	Total Horse Power
High Head Pumping					
HP	43	336.5	200	140	630
HP	48	744.6	400	160	1,570
HP	99	258.0	160	110	400
HP	103	478.5	280	110	690
HP	107	200.0	130	130	380
HP	110	367.3	150	160	540
Sub-Total		2,384.9			
Low Head Pumping					
CLP	14	620.0	375	45	375
CLP	25	550.0	340	45	340
CLP	29	660.0	400	45	400
CLP	34	630.0	375	45	375
CLP	38	650.0	390	45	390
CLP	44	26.0	25	40	20
CLP	46	28.0	25	40	20
CLP	51	600.0	365	45	365
CLP	55	853.3	510	45	510
LP	98	371.0	220	45	220
LP	104	2,030.0	1,220	45	1,220
LP	109	875.3	660	45	660
Sub-Total		7,893.6			
Grand Total		10,278.5			

area. The cost comparison included the expenses incurred for operation and maintenance. All pumps will be horizontal centrifugal pumps supplied with a positive intake pressure. A stand-by potential of one-third of the required capacity is included for emergencies. The high head pumping plants will be equipped with hydraulic valve surge controls.

Pressure Pipe Network

The 1:10,000 layout plans show the diameters and lengths of the carrier and distributary pipes. The pipe diameters were based on delivering the peak irrigation requirement at the desired pressure. Selection of pipe diameters was based on an economical study of pipe cost versus power cost. The section presented later on Pipe Size Selection gives a detailed discussion of procedures used for pipe diameter selection.

Design criteria for the gravity system limited the maximum velocity to 2 meters per second. Also, pressure reduction for farm deliveries was held to a minimum to prevent power wastage. Gravity delivery was adopted wherever feasible for areas located downhill of the EGMC such that adequate pressure is obtained by gravity means to operate the corresponding pipe network and sprinklers.

A critical area where an economic comparison was undertaken to select the type of system required to develop design pressure was the area lying between Wadi Rajib and the northern limit of the East Ghor Canal Extension Project (18 km Ext.). This area is referred to as the Rajib-Arda area with a net irrigable area of 3,950 hectares. For this area two sources of water and two methods of providing pressure were considered as detailed in the following:

1. Water obtained from releases at King Talal Dam, and diverted downstream from the Zarqa River.

2. Pumping from the EGMC to supply pressure.

Pipe Size Selection. After establishing the limiting pipe velocity (maximum of 2 m/s) and obtaining the available pipe diameters, the only variables left for selection of a pipe diameter were the estimated costs of the installed pipe and the power required for pumping.

For velocities below 2 m/s several pipe diameters with different friction losses can be considered. Given a flow requirement and two different pipe diameters, the smaller diameter pipe will cost less, but have a higher power cost due to greater friction loss. Conversely, the pipe cost is greater and the power cost lower for the larger diameter pipe. Trial selections of pipe diameters were carried out to determine the recommended pipe diameter. Table K-10 gives the results of the trials to select the most economical pipe diameter for each flow. The nomograph shown on Exhibit K-5 shows the friction loss, velocity, pipe diameter and annual cost based on a 6% interest rate and 40 years estimated life, for flows between 3 and 3,000 l/s.

The pipe diameter selection study was based on variations in power requirements which did not alter pumping capacity. The variation in the power required is a function of the increase in friction loss for different pipe diameters.

A sample calculation is presented in this section to show the computations used to arrive at a selected pipe diameter. The assumptions used are presented below:

1. The comparison was based on the annual costs of pipe and power for pipe length of one kilometer.

2. No change in cost for pumping equipment was considered for a given flow.

3. A power cost of JD 0.0125/KWH, inclusive of all taxes and fees was used.

4. Only the change in power costs resulting from the change in friction loss caused by the change in pipe diameter was considered.

5. The annual capital cost of pipe (asbestos cement) includes all operations required to purchase and install the pipe, and is computed at a 6% interest rate for an estimated life of 40 years.

6. The total working days per year was estimated at 255.3 days.

7. The Prandtl - Colebrook equation was used in computing a nomograph for pipe size selection (Exhibit K-5). It is presented below for reference:

$$\frac{H_f}{L} = \lambda \frac{V^2}{2gD} \delta$$

Where

H_f = Head loss due to friction in meters

L = Length of pipeline in meters

V = Velocity of flow in m/sec.

g = Gravitational acceleration = 9.81 m/sec^2.

D = Internal pipe diameter in mm

δ = Volume weight of the fluid in kg/m^3

and λ = Prandtl-Colebrook friction coefficient expressed by

$$\frac{1}{\sqrt{\lambda}} = -2 \log \frac{2.51}{R\sqrt{\lambda}} + \frac{K}{3.71\ D}$$

Where

R = Reynolds number

K = Absolute surface roughness of pipewall in mm.

Sample Calculations

1. Determination of the daily cost to pump a flow of one-l/s by one meter.

$$0.0125 \times 24 \times \frac{75}{100} \times \frac{100}{75} \times \frac{100}{87} \times \frac{1x1}{75} = \text{JD } 0.004598/\text{day}$$

Where

Cost of Power	= 0.0125 JD/kWh
Hours per day	= 24
Conversion from HP to KW	= 75/100
Pump and motor efficiency respectively	= 75/100;87/100
Flow of one l/s multiplied by one m lift and divided by the conversion of kg-meters to horsepower	= 1x1/75

Using 255.3 working days per year, the cost of power to lift one-l/s one meter would be JD 1.17387 per year.

2. Determination of power cost caused by friction head loss.

To obtain the annual power cost caused by the friction loss for a given pipe size and flow, the rate obtained above is multiplied by the friction head in the pipe and then by the pipe flow.

Example: Consider a five-l/s flow in two different pipe diameters of 100 mm and 125 mm.

From Exhibit K-5 the following is obtained:

Ø 100 at 5 l/s loses 4.488 m/km and capital costs JD 167.600/km/year

Ø 125 at 5 l/s loses 1.519 m/km and capital costs JD 212.500/km/year

The annual saving in power, by shifting from Ø 100 to Ø 125 mm, is: (4.488-1.519) x 5 x 1.17387 = 17.430 JD/km/yr while the incremental annual cost of pipe is: 212.5-167.6 = 44.900 JD/km/yr.

Since the saving in power is lower than the cost incurred in shifting to the next larger pipe diameter, the smaller pipe is selected.

The economical pipe diameters for different flows shown by Table K-10 was developed by applying the above procedures to the different flows required for the project.

Table K-10

MOST ECONOMICAL PIPE SIZE

Pipe Diameter mm	Flow Range l/s
100	5
125	10
150	15
200	20-35
250	40-45
300	50-85
350	90-110
400	120-150
450	160-180
500	200-250
600	300-450
700	500-650
800	700-850

The Rajib-Arda Area

As mentioned previously, the Rajib-Arda area can be irrigated by pumping from the EGMC or by gravity diversion from the Zarqa River. A schematic diagram of the two schemes is shown on Exhibit K-6.

Gravity Diversion. This alternative uses the diversion weir presently under construction for the Zarqa Triangle Irrigation Project. By use of the optimal pipe diameters given in Table K-10 the required diversion elevation for the Carrier was determined to be -137 m to service irrigable lands below an elevation of -227 m.

The Zarqa River diversion weir location was selected because of its low rehabilitation cost to accommodate this new carrier pipe and its appropriate elevation to ensure gravity command of the service area. The elevation of the pipe intake of the weir and desilting basin is -120.9 m, hence an additional head of 16 m may be used to reduce the optimal pipe diameter selected. This location increases the length of the carrier pipe by about 1,200 m more than the length required for pump diversions from the EGMC. However, since the Zarqa River diversion weir is located upstream of a large bend in the river this additional length of pipe will be needed to reach any new diversion weir designed and constructed for the new carrier. The lack of good diversion sites in the vicinity of the required elevation favors the adoption of the existing Zarqa weir. An additional desilting basin will be required adjacent to the existing one being constructed for Zarqa Triangle Irrigation Project.

The proposed carrier pipe follows the alignment of the Zarqa Triangle carrier pipe for the first 4,700 m and the last 2,500 m follows the layout of the proposed road which

128

will join the King Talal Dam to the Yarmouk Dead Sea Road. The layout maps attached to this report show the proposed alignment of the carrier. The capacity of the carrier pipe is 2,370 l/sec.

Pump Diversion. For this alternative five pumping plants were considered along the EGMC. Their characteristics are shown in Table K-11, and the layout of these pumping plants, along with their distributaries, are shown on Exhibit K-4, sheets 4A and 5A.

Table K-11

Pumping Characteristics

	Area Served ha	Design Flow l/sec.	Total Head m	Total BHP Required BHP
CLP 59	1,010.1	610	45	610
CLP 63	801.7	480	45	480
CLP 65	998.1	575	45	575
CLP 72	641.9	245	45	245
CLP 78	500.8	405	45	405

Complete designs and quantity estimates of the above alternatives are summarized in Tables K-12 and K-13 while Table K-14 provides a summary of the overall cost for each alternative where the annual capital recovery cost was based on an interest rate of 6% and the corresponding estimated life of each item.

The Tables show that the initial investment for the gravity alternative is JD 3,285,000 while that for pumping is only JD 1,570,000. However, when the costs to own and operate are estimated, the annual cost of the pumping diver-

Table K-12

GRAVITY ALTERNATIVE
RAJIB ARDA AREA
(Quantities & Costs)

Description of Item	Quantity & Unit (meters)	Unit Cost (JD/Unit)	Amount (JD)
A- Distributaries			
Pipe Diameter (mm)			
200	100	7	700
300	300	12	3,600
350	550	17	9,350
400	150	22	3,300
450	450	26	11,700
500	3,700	30	111,000
600	1,000	45	45,000
700	3,290	60	197,400
800	5,845	75	438,375
900	3,275	105	343,875
1,000	865	120	103,800
1,100	600	150	90,000
Sub-Total Distributaries			1,358,100
Fittings 11%			149,391
Thrust Blocks 6%			81,486
Sub-Total Distributaries			1,588,977
		Say	1,590,000
B- Carrier Pipe	7,200	190	1,368,000
Fitting 5%			68,400
Thrust Block 6%			82,080
Sub-Total Carrier			1,518,480
		Say	1,520,000
C- Diversion Headworks	L.S.		185,000
Sub-Total Distributaries			1,358,100
Sub-Total Carrier			1,520,000
Sub-Total Diversion Headworks			185,000
Grand Total Gravity Alternative			3,295,000

Table K-13

PUMPING ALTERNATIVE
RAJIB ARDA AREA
(Quantities & Costs)

Description of Item	Quantity & Unit (meters)	Unit Price (JD/Unit)	Amount (JD)
A- Distributaries			
PIpe Diameter (mm)			
200	100	7	700
250	820	10	8,200
300 mm	3,015	12	36,180
350	2,030	17	34,510
400	4,620	22	101,640
450	950	26	24,700
500	1,945	30	58,350
600	2,725	45	122,625
700	200	60	12,000
Sub-Total Pipes			398,905
Fittings 11%			43,680
Thrust Blocks 6%			23,934
Sub-Total Distributaries			466,719
		Say	470,000
B- Pumping Stations			
CLP 59	L.S.		300,000
CLP 63	L.S.		250,000
CLP 65	L.S.		300,000
CLP 72	L.S.		125,000
CLP 78	L.S.		125,000
Sub-Total Pumping Stations			1,100,000
Sub-Total Distributaries			470,000
Sub-Total Pumping Stations			1,100,000
Grand Total Pumping Alternative			1,570,000

Table K-14

GRAVITY VS PUMPING
RAJIB ARDA AREA

Annual Cost Comparison

	Capital Investment (JD)	Expected Life (Years)	Capital Recovery (factor)	Annual Cost (JD)
Gravity Alternative				
Diversion Headworks	185,000	40	0.06646	13,292
Carrier Pipe	1,520,000	40	0.06646	101,192
Distributaries	1,590,000	40	0.06646	105,671
Grand Total Gravity Alternative	3,295,000			221,135
Pumping Alternative				
Pumping Stations	1,100,000	15	0.10296	113,256
Maintenance				
Spareparts				11,970
Operators				
Mechanics				25,000
Power Cost				58,000
Distributaries	470,000	40	0.06646	31,236
Grand Total Pumping Alternative	1,570,000			240,000

Power Cost = 1,740HP x 0.75 x 250 days x 15 hrs. x 0.012 fils.

sion becomes about JD 20,000 higher than for the gravity diversion. Therefore, particularly since energy costs are likely to increase in the future, the gravity diversion alternative is recommended.

Farm Irrigation System

The feasibility design for the farm irrigation system is based on supplying the peak water use demand for alfalfa of 7.50 mm/day. This peak demand occurs during July. When a crop with a higher water demand is grown, such as bananas, only part of the farm can be served unless the seventh day is used for irrigation. If a crop with lower water demand is grown, the water delivery duration can be reduced. These adjustments will be required since a constant flow rate per farm is delivered by the distribution system.

Based on a farm application efficiency of 75 percent, the peak farm water delivery requirement is 10.0 mm/day. For a seven-day irrigation interval, the depth of water to be applied by each irrigation is 70 mm. Considering six working days per week and two sprinkler lateral (flyline) settings per day the farmer can irrigate 0.648 ha per day on an average 3.888 ha farm. Each sprinkler setting will be operated effectively for 11-1/2 hours. The amount of water delivered during each sprinkler setting of 11-1/2 hours of operation is 227 m^3 when using a flow rate of 5.47 l/sec. A design flow rate of 5.5 l/sec was used for each 3.888 ha farm unit.

Farm Layout. The majority of the project farms were planned with dimensions of 216 x 180 meters to obtain an area of 3.888 ha. These dimensions were selected on a sprinkler spacing of 12 x 18 meters for an average farm area of 4 ha. Based on two sprinkler settings per day, the full

length of the farm will be covered in 6 days during the peak month. This corresponds to the general criteria presented above.

The required width of the farm would be 185 meters to give an area of 4 ha. However, since this length is not a multiple of 12, the nearest length that is a multiple of 12 was chosen. This was 180 meters which requires a farm sprinkler line (flyline) that is 174 meters long.

The 180 x 216 meter dimensions result in an average farm size of 3.888 ha. A variation in farm sizes may occur at the beginning and end of the headgate units and for areas with uneven irrigable land boundaries.

The 216 m boundaries of the farms have been chosen to lie along contour lines as much as possible. The farm main line will be buried asbestos-cement pipe located along the 216 m dimension at the higher edge of the farm, with 4 risers spaced 54 meters apart. The total farm mainline will be 189 meters in length for the standard farm. This length does not include the pipe section to be placed under the service road from the farm turnout assembly.

The sprinkler flyline have been located perpendicular to the contour lines as much as practicable to utilize slope as effectively as possible and wherever possible reduce the pipe diameter requirement. A typical layout of the pipe network is shown on Exhibit K-7.

Portable Farm Systems

Sprinklers

The sprinklers were selected on the basis of 11-1/2 hour application to an area 12 x 18 meters. The design flow capacity of each sprinkler is 0.365 l/sec. and each sprinkler line requires 15 sprinklers.

A 100 percent overlap between adjacent sprinklers is recommended to ensure good distribution uniformity under variable windy conditions. An operating nozzle pressure of 2.7 kg/cm^2 is required to supply the required flow rate. The sprinklers will be located one meter above the ground surface.

The net head loss for the entire length of the 75 mm (3 inch) diameter sprinkler line for land with a one percent slope is 0.26 m. Assuming a design nozzle pressure of 2.7 kg/cm^2, the pressure at the first sprinkler would be 2.713 kg/cm^3 and 2.687 kg/cm^2 on the last sprinkler. This pressure distribution results in a four percent pressure variation along the sprinkler line. The pressure at the last hydrant on the farm mainline would be 2.751 kg/cm^2.

Each farm hydrant serves three sprinkler line positions. One position is aligned with the hydrant, and the two side positions are at 18 meters from the hydrant. The two side positions are connected to the hydrant by an additional 18 meter length of 75 mm portable pipe.

An alternative portable farm system consists of three 2-inch diameter aluminum pipe flylines with 12 m x 12 m sprinkler-lateral spacings. With 0.139 l/sec sprinklers operating for 22-hour sets this alternative reduces the application to about one-fourth of that of the 12 x 18 m system. There is also a reduction in the energy requirements. Although the cost estimate was prepared using the 12 x 18 system, design studies are expected to establish that the 12 x 12 system is preferable for the Project.

Farm Main Line. An asbestos cement pressure pipe of adequate diameter with respect to the pressure loss criteria, was selected for the farm mainline. A 100 mm diameter pipe

was selected since the pressure drop along its 189 meter length with a 5.5 l/s flow is 0.085 kg/cm^2 (4.5 m/km) which is less than 10 percent of the sprinkler operating pressure. The pressure required at the beginning of the farm mainline is 2.863 kg/cm^2. This will result in a pressure of 2.824 kg/cm^2 at the first hydrant.

The nearest sprinkler to the farm turnout operates at a pressure of 2.786 kg/cm^2 while the one farthest away from it operates at 2.687 kg/cm^2. The difference in operating pressure is about 3.67 percent which ensures an equal uniform water spray distribution over the farm.

Cast-iron 75 mm (3 inch) diameter risers were located at 54 meter intervals along the 100 mm diameter asbestos-cement farm mainline. These risers were fitted with hydrants which reach above the ground surface. These risers will be attached to the sprinkler laterals by means of portable valve-opening elbows with a 75 mm (inch) diameter male inlet and female outlet. One valve-opening elbow will be supplied for each sprinkler line. The valve at the top of the riser will be protected at the ground level by a 400 mm diameter asbestos-cement collar.

Drainage System

A drainage system is recommended as an intergral part of the irrigation development. The drainage system should provide for runoff from surface drainage and water table level control with sub-surface drainage.

Surface Drainage System

New Surface Drains. For the "New Lands", a surface drainage system consisting of interceptor drains aligned parallel to the lower boundary of each standard farm is

planned. This drain discharges into a proposed main drain located parallel to the headgate unit main. The main drains will convey the water to the Katar which will eventually return to the Jordan River.

The size of the interceptor drains was based on determination of the capacity required to convey runoff generated by high intensity rainfall on the contributing area. The required capacity of the main drains was determined by using a coefficient of 40 to 70 percent of the total interceptor design flow.

The design of the surface drainage system was based on criteria developed and used for previous projects. These criteria, detailed in the Dar-Nedeco Report of 1966 Annex C, recommends that one-third of the peak 24 hour rainfall having a 5-year recurrence interval be used for computing the surface run-off from natural rainfall. This criteria accounts for the retention capability of irrigated lands. The recurrence interval also reflects a compromise between the cost of a higher capacity system and the damage caused by low frequency, high intensity rainfall. Based on the above, run-off coefficients due to rainfall were set at one-l/sec/ha for the South zone and two l/sec/ha for the North Zone of the Jordan Valley.

All surface drains will be unlined earth channels with 1.5 horizontal to one vertical side slopes and will follow the natural slope of the land. When steep slopes are likely to cause excessive erosion, control outfall structures will be constructed at their discharge points into the Katar. These will prevent erosion from moving upstream and eroding the drains. In specific cases of steep slopes, more than one control structure may be required along the course of the drain.

Upgrading of Existing Surface Drains. For the "Conversion Lands", a surface drainage system has already been constructed to provide for runoff from both rainfall and surface irrigation. Although a surface drainage system exists in the conversion area, improvements will be required. These recommended improvements are:

1. Reshape the drain cross-sections to avoid spilling of water onto adjacent farms.
2. Construct control structures to prevent further erosion.
3. Route interceptor drains into larger collector drains to convey the water to natural wadis or the Katar.
4. Clean rocks, weeds and other obstructing material from all drains.

Sub-Surface Drainage System

Based on the findings of previous field studies, which led to the preparation of reports by Dar Al-Handasah/Nedeco, Harza/Baker and others, some areas of the Valley are considered to require sub-surface drainage. General areas requiring immediate installation of sub-surface drains were identified during preliminary field investigations. The total area for which sub-surface drains are recommended covers about 500 hectares, in addition to a nearly equal area which the JVA is presently planning sub-surface drains.

These previous field studies have identified three types of drainage problems: (1) areas where, high water tables are caused by upward flow from artesian aquifers, (2) areas where there is lateral seepage from upstream areas, and (3) areas that need artificial drainage to leach salts from the soil profile. The areas with upward artesian flow

will require pumping to relieve the pressure as well as tile drainage. Water tables caused by lateral seepage can be lowered with widely spaced (250 m or more) interceptor drains. Areas with high salts will need tiles spaced at 90 to 125 meters depending on the soil permeability and leaching requirement. Most of the soils in the area are drainable but, extreme care must be exercised in draining the soils high in salt content.

Subsurface tile is recommended over open ditches to reduce maintenance costs and reduce land loss. Sulfate resistant concrete pipe or plastic pipe, will be used depending on availability of materials and installation equipment. The maximum length of each field relief drain will be limited to 250 meters for cleaning purposes and have a minimum slope of 0.1 percent to reduce siltation. The minimum size of tile will be 10 centimeters to allow for siltation and misalignment. A tile size of 15 cm would be even more desirable. These field relief drains will discharge into collector drains, which in turn will discharge either directly into a conveyor or into a natural drain. The conveyors will also discharge the flow of several collectors into a natural drain. The subsurface drainage system, including the manholes, will be buried and will not interfere with farming operations.

It does not seem justified, on the basis of the available data, to design subsurface drains for all of the areas suggested by various observers and previous reports.

Careful management of sprinkler irrigation will assist in controlling the behaviour of the water table. For project cost estimates and economic evaluations it is estimated that an additional area of 200 to 300 hectares will require drainage annually.

Observation Wells and Piezometers. A grid of observations wells is recommended in the areas likely to have a drainage problem to observe the behaviour of the water table. A minimum number of observation wells should be distributed as shown on the 1:50,000 Layout Plans. Monitoring of the water level in these wells will provide information to assess the development of drainage problems in time for design and construction of needed drains before crop production is impaired.

Once a problem area is identified, piezometers should be installed to determine if the water is moving laterally or upward under artesian pressure. The specification of the piezometers will be the same as those detailed in the Dar Al-Handasah/Nedeco Report of 1969 Annex C. A typical layout for a piezometer is shown in Exhibit K-8. The observation wells will be similarly constructed except the plastic pipe will be perforated and backfilled with coarse sand only. Both the piezometers and observation wells will be pumped to determine conductivities for final system design.

Operational Characteristics of System

Operation of the Farm System

Each farm turnout from a HUM is equipped with a pressure regulator to be set at 3.5 kg/cm^2. Under this pressure condition a 15 sprinkler lateral line can withdraw 5.5-l/sec, which is the calculated required flow per farm. During the peak season farmers may operate 2 settings per day of 11-1/2 hours each for 6 days during a week. At the end of each setting, the water is turned off at the valve-opening elbow and the lateral is moved 18 meters to its next position. Then, it is operated for the next setting.

Farm Management Support

To achieve the Jordan Valley Project's expressed goals and objectives there are some important operational requirements for support of the on-farm irrigation. These operational requirements will necessitate an organizational infrastructure to support and supply these services.

The operational services are basically a technical education program for the farm operators. This requires an organization that would be similar to an agricultural extension service and utilize farm extension agents. The service will advise and provide continued support of the irrigators on an intimate and intensive basis. It should be staffed with an experienced and knowledgeable technician staff composed of agronomists, irrigation engineers, plant and soil scientists. This organization will also work with the research and demonstration farm system that has been discussed in these studies.

The project cropping plans and farm production levels are dependent on a level of technology that is not currently available in the area. Water supplies and the irrigation system operation will likewise require effective management to develop the economic success that this project is predicated on. System efficiencies, while real and obtainable, are high because of supply limitations of the water resources and a desire to be as effective in development of the land resource as possible. All of these goals can be obtained readily by developing a strong technical base to support this irrigation enterprise.

The objective of this service organization is to develop and provide the technical support required for sprinkler irrigation technology at the irrigation operator level.

It should be noted at this point that, since the whole irrigation system will be operated continuously during the peak season, farmers cannot all take the same day off every week. This day should be rotated among farmers in a way so that only about one-seventh of the farmers do not irrigate on any one day.

A water meter will be installed at every farm turnout for control and billing purposes. Farmers should be charged for water withdrawn to encourage water conservation. It is further proposed that farmers on each headgate unit administer and operate their own system. They will thus be able to establish schedules and work plans among themselves. Foreseeably, for the first few years of operation, the JVA may be required to supervise farmer allocations within headgate units. Since every farm is equipped with a measuring device and the system is confined, it is expected that with good management the distribution and water use efficiencies can be high.

At times, other than the peak use season, farmers will continue to use the 5-l/sec flows to satisfy sprinkler lateral design criteria whenever they irrigate. However, during these periods, the volume of water depleted weekly from the soil would be less than the 60 mm applied during an 11-1/2 hour setting. Thus, either a shorter setting time or a longer interval between irrigations is required. This means that a farmer may either cover all his farm in a fewer number of days, compared to the six required at periods of peak demand or delete a weekly irrigation. These conditions will require modification in the project operations to meet the varying demand for water which will occur each year.

This extension service will function in depth in the activity of irrigation scheduling and fertility management. The irrigation scheduling will assist the water user in developing an irrigation strategy for the specific crops and soils, while considering climatic demands and irrigation system criteria. Irrigation scheduling is capable of dealing with water supply limitations which can occur as well as maintaining soil moisture levels under normal conditions suitable for optimum production. This on-farm water management service will also play an important role in the overall operation and effective management of project storage and distribution facilities.

Fertility management will introduce soil and plant tissue analysis as production tools for Jordan Valley agriculture. This aspect of service will assist farmers in evaluating their individual fertility programs and cropping patterns and also assist the Jordan Valley Authority to administer project seasonal cropping plans.

These proposed support services will be effective in helping the farmer in maintaining a long-term salt balance on project soils, evaluating irrigation system performance and assuring minimum subsurface drainage problems. The most important aspect of these services are that with good water and fertility management the farmer will have control of principal factors which influence agricultural productivity.

Flows into Pipes

Gravity flows into the carrier pipes will be controlled by the rate of water use of farmers. The pipe inlets will always be open and the pipes filled with water. The gate valves controlling the HUM's will be either open or closed. The period during which the valves will be open will depend

on the anticipated rate of water use. Since the flows turned into these mains are constant, periods of flow will be modified during the periods of lower water use.

For the carriers pipes supplied water by pumping the flow will be controlled by the number of pumps being operated, and only the appropriate distributary and HUMs will be flowing full at any one time. This means that the JVA should predetermine the approximate rate of water demand and operate the pumps accordingly. The manner of doing this will be described in the following section dealing with water supplies.

Water supply Allocations

If all the distribution network were a closed one (that is if the EGMC were replaced by a closed conduit) and all or most of the irrigation water came from storage, then by controlling the farmers rate of use, the water supply allocation would be automatically operated at optimum efficiency. However, since water diverted into the canal will be wasted if not used, it becomes imperative to have advance information about the rate of water demand so that only the correct amount of water is diverted into EGMC for eventual distribution by the pipe network. This can be assisted by adopting a system of automatic control.

Therefore, by mid-March of every year, an inventory of stored water and expected flows should be prepared. Field surveys should check the area reported to be planted by farmers. A water budget should be prepared for each area of the Project and the stored water allocated. Priorities for allocations should be given to perennials, although variable governing policies may be adopted depending on the particular situation. These policies should be communicated and ex-

plained to users, so that they may plan their planting and farm operations accordingly.

It should be stressed that, in general, farmers will be given less water than they would like to receive and will obtain it according to a pre-established rotation. This will allow the JVA to operate at a relatively high efficiency level, even without the automatic control measures discussed in the following section.

Automatic Control of Water in The EGMC

General. Automated irrigation is utilized as the result of high labor costs, scarce water supplies, and a desire to assure farmers of the reliability of their water delivery. Automation is usually practiced in either or both of the activities of field irrigation and the operation of conveyance structures.

In field irrigation automation is used to determine when irrigation is required and the amount of water to be applied. This replaces the traditional decision making of the farmer and usually results in saving considerable amounts of water. It is hoped that this aspect may eventually be developed through the Farm Management Support Services, described earlier.

Objective of Automatic Control. The objective of automation of the operational controls for conveyance structures is to match the demand with the supply of irrigation water while minimizing labor requirements and waste of water. For the Jordan Irrigation Project, the automatic control of structures in the EGMC will assure that volumes of water released into the canal are retained for irrigation with minimal losses. The following basic facts about the water conveyance and distribution systems describes the system for which automatic controls will be provided.

a. The EGMC, about 110 kms long, serves as the main conveyor of water along the length of the Project. It supplies about 23,000 hectares, while the remaining 13,000 hectares are supplied by a pipe network, which obtains water from storage or diversion dams on the natural wadis. Flows of water from these wadis in excess of pipe network diversion requirements enters the EGMC.

b. The principal source of water for the 23,000 ha commanded by the EGMC is the Yarmouk River which supplies an average of 255 MCM of the total 285 MCM annual demand.

c. The amount of water a farmer may obtain for irrigation is limited, by the JVA. This amount is generally less than many farmers would like to obtain. This limiting of water provides an incentive for efficient water distribution.

d. The irrigation network is designed on the basis of delivering water to headgate units and farmers on a modified demand basis.

e. Except for the main canal, the distribution system is a closed pipe system.

f. It is proposed that the JVA release from storage only those volumes required to meet water use demands and power production requirements. These volumes, when added to the available uncontrolled flows entering the EGMC, should equal the volumes demanded for irrigation by the farmers as closely as practicable. Because releases for peaking power production will at times exceed irrigation demands, the utilization of the short-term storage

capabilities of the EGMC is important to prevent wastage of water.

The release of water from the Maqarin reservoir will be made daily during 4 or 5 hours of the early evening for power generation. This release must be distributed uniformly throughout a 24-hour day to meet irrigation demands.

Basic Facts About Main Canal. The canal length is 110 km and the slope of canal is 18 cms/km for first 70 kms and 28 cms/km for the balance. Area served by the canal is 23,000 hectares.

Canal Section:	Trapezoidal in shape.
Bottom width :	3 meters, except for the last 4 km where the width = 1.8-2.2 meters.
Side slopes :	1-1/2 horizontal to 1 vertical
Water depth :	0.8 to 2.47 meters.
Free board :	30 cms.
Capacity :	20 m^3/sec.

The volume of water that can be stored in top 40 cms of EGMC over its entire length is 380,000 m^3. There are about 37 checks along the length of the canal that control the water level. The control of water level is obtained by radial gates with open bays on each side of the check.

Because the EGMC was originally designed to serve lands on both the East and West banks of the Jordan River and planned for application of surface irrigation (with lower efficiency), there is a surplus conveyance capacity ranging from zero to 7 m^3/sec.

Equalizing Storage Requirements. The average monthly water demand and supply is shown on Table K-15. The assumed release for hydrolectric power development is 5 hours of 20 m^3/sec. or 72,000 m^3/hr, from Maqarin Reservoir. The releases

Table K-15

ANNUAL AVERAGE WATER DEMAND AND SUPPLY

Month	Irrigation Demand of Area Commanded by Main Canal		Inflows into Main Canal From: Uncontrolled Side Wadis		Inflows into Main Canal From: Maqarin Reservoir and Yarmouk River	
	MCM	m^3/sec.	MCM	m^3/sec.	MCM	m^3/sec.
Oct.	25	9.63	1.6	0.62	23.1	9.01
Nov.	22	8.59	1.7	0.65	21.1	7.84
Dec.	15	5.79	1.9	0.74	13.1	5.05
Jan.	16	6.22	3.0	1.17	13.1	5.05
Feb.	21	7.96	3.9	1.30	17.1	6.66
Mar.	26	10.13	4.3	1.67	22.1	8.46
Apr.	34	13.19	2.8	1.08	32.1	12.11
May	32	12.16	2.3	0.86	29.1	11.30
June	24	9.26	1.7	0.65	22.1	8.61
July	21	7.93	1.5	0.59	19.1	7.34
Aug.	21	8.09	1.5	0.59	20.1	7.50
Sept.	25	9.05	1.5	0.56	23.1	8.94
Total	285		30		255	

from Maqarin Reservoir will reach the canal after flowing in a natural river bed for a considerable distance. The following calculations identify the daily volumes of water to be managed for the peak irrigation demand month.

The average irrigation demand is 13.2 m^3/sec., which after adding 20% for peak demand, results in a flow of 15.8 m^3/sec., or 57,000 m^3/hr., or 1,368,000 m^3/day. For such days, the reservoir release pattern will be:

Maqarin release - 5 hours of 20 m^3/sec.	=	360,000 m^3/day
Uncontrolled flows (1 m^3/sec.)	=	86,400 m^3/day
Maqarin release - 19 hours of 13.5 m^3/sec.	=	921,600 m^3/day
Total		1,368,000 m^3/day

This means that during the five hours for power release, the volume to be stored in canal can be up to 93,600 m^3. Assuming adequate attenuation of this flow, this volume can be stored in the top 9 cms of depth in canal.

During the month of the lowest water requirement the average demand is 7 m^3/sec., add 20% which gives 8.4 m^3/sec or 30,000 m^3/hr, or 720,000 m^3/day. For such days, the release pattern will be:

Maqarin releases -	5 hours (20 m^3/sec)	360,000 m^3/day
	Uncontrolled flows (1 m^3/sec)	86,400 m^3/day
Maqarin release	-19 hours of 4.00 m^3/sec	273,600 m^3/day
	Total	720,000 m^3/day

This means, that during 5 hours of power release the volume to be stored in canal is 226,800 m^3. This volume of water can be stored in the top 25 cms of depth in canal again assuming proper attenuation and distribution of the flow wave.

Alternative Automation Concepts. Two alternative automatic control systems which could be utilized to control water releases were evaluated during this study. One is a combination of hydraulically operated automatic gates along the EGMC, with water level sensors to control the releases from the Maqarin Reservoir. The other alternative is a dynamic regulation system which utilizes water level sensors to control by computer actuation the opening and closing of electrically operated gates along the canal and at Maqarin Reservoir. Both alternatives can also provide a control system for releases from storage and the distribution of inflows along the length of the EGMC.

Automatically Operated Gates. This first alternative will utilize two components to provide for control.

a. Automatic Gates. Downstream from every turnout, but at spacings not greater than 3.6 kms in the lower stretches of the EGMC and not greater than 5 kms in the upper 70 kms, a hydraulic or electric automatic control gates will be placed. This will include a downstream constant level gate (which will close the gate when farmers demand less water and open it when they demand more), and an upstream constant level control that will open the gate as the water levels exceed a given limit, although the down stream level does not require that. The limits of water levels can be set such that the volumes released during power generation will be distributed along the entire length of the EGMC.

b. Water Level Sensors. At strategic locations along the EGMC, approximately 15 kms apart, water level sensors will be installed. These will sense the water level and transit data to the operator of release gates at the reservoirs. This data will enable the operator to reduce or increase the discharge as required by demand. The sensors can, if desired activate automatic release gates at the Maqarin Reservoir. The levels at which sensors activate the gates that release storage water can be set to take into consideration the time required for the releases to reach the various turnouts.

The main disadvantage of this system is the problem of installing the upstream/downstream constant water level hydraulic gates into the sections of the canal that have already been built. This may disrupt normal irrigation deliveries and pose additional structural and engineering problems. Furthermore, the hydraulically operated gates

require constant adjustment and inspection to assure their proper operation.

Dynamic Regulation. This second alternative will make use of the existing checks for distributing the water supply uniformly along the length of the canal. Water level limit switches will be installed at each check structure to accuate electric motors which will open and close the radial gates. The present manually operated gates will be converted to a system permitting manual operation for emergencies and automatically operated electric motors for normal conditions. The electric motors will furnished power from the planned electrical grid system.

Water level sensors will be installed at strategic locations along the canal. Their readings are relayed to a central control room where the operator will open or close the storage release gates. If desired the water sensor data can be transmitted to a central location, digitized and printed out to provide operational records for analysis. These data could be used to actuate opening and closing of strategic gates in the EGMC and for control of releases from storage. Actual control of these strategic gates could be carried out by either a central operator or by a programmed computer.

Recommendation

It is recommended that an automatic electrically operated gate system be installed in the EGMC to regulate water surface levels throughout the entire length of the EGMC.

Components of Recommended Automatic System. A computer operated system is not recommended for the first stage of operation. The main components of the recommended system for the automatic control of water level in the EGMC are the following:

a. Install electric motors to automatically operate all existing radial check gates.

b. Design and construct the proposed 14 kilometer extension of the EGMC with a 0.0005 slope (5 cm per kilometer) with no check gates and with dimensions that would allow the design flow to be conveyed with a water surface that will have a slope greater than 5 cm per kilometer. Additional EGMC volume will be used for additional canal storage.

c. Water level sensors can be installed at a future date at strategic locations including gaging stations on all uncontrolled wadis, and transmitted to the central control room.

d. At a future date, data for all water level sensors on the EGMC, Maqarin, wadi storage, and those on the diversion at the entrance to tunnel can be transmitted to the central control room.

e. A central computer for record keeping, and other operational needs should eventually be installed, although for the start manual operation would suffice.

Cost Estimate. The estimated cost for the initial recommended automatic control system to provide for regulation of the EGMC and provide data for reservoir operation is JD 361,500. The various items leading to this total cost are given in the development of cost estimates contained in Appendix L.

Economic Consideration. Based on an annual interest rate of 6 percent and an average useful life of 15 years, the annual investment would be about JD 37,000 for the automatic control system.

It is estimated that automation will improve management and conveyance efficiency by an attainable 5 percent (from 89 to 94 percent) and the estimated volume of water saved will be 10 MCM. This water savings would cost an estimated JD 0.004 per cubic meter per year.

Future Development for Communications

As the Project develops the need for voice and data communications will increase. The following proposal describes a system which could accomplish this requirement. The proposed system for future installation, if desired, would provide voice communications between; Amman, which is considered to be the operating headquarters; the proposed hydroelectric plants, Maqarin and King Talal; and the operational offices in the Jordan Valley.

This system would consist of a microwave radio backbone with VHF transmission spurs for direct communications with field operators. Selective call using digital encoding would be utilized for radio communications. This would provide high degree of security and prevent unauthorized use.

Dynamic water regulation for optimization of water resource use would be achieved by providing VHF radio extensions to gate controllers and data transmission channels back to the operating headquarters. In addition hydrological and meteorological data could be transferred directly to headquarter for automatic analysis.

To implement the proposed communication and control system would require a detailed microwave field survey to determine specific sites and communication paths. Therefore,

the following cost estimates are based on an essentially flat surface:

I.	Estimated acquisition and Installation Cost:		
	A. Communication System	JD	667,000
	B. Expanded System for Automatic Controls	JD	375,000
	C. Maintenance Equipment	JD	33,000
	Total	JD	1,075,000
II.	Operation and Maintenance Cost		
	Energy	JD	3,000/year
	Maintenance and Repairs	JD	33,000/year
	Total	JD	36,000/year

The maintenance cost is based on including a resident engineer for the purpose of maintenance and training of JVA personnel.

Irrigation Project Operation and Maintenance

The operation and maintenance group is responsible for all irrigation conveyances, ancillary structures and drainage systems which are part of the Project. The area of services discussed here considers irrigation of 36,000 hectares in the Jordan Valley.

The system operation includes control of water diversions from the Yarmouk River and side wadis, and their delivery to the Project farms. The 36,000 hectare area which will be divided into three watermaster areas will be supported by a main project operation and maintenance headquarters.

Operation and Maintenance Headquarters

The main operation and maintenance headquarters for the Project will be charged with overall management, developing policy and guidelines, conducting engineering studies, and carrying out project maintenance.

The Project Manager will be charged with the overall responsibility of project operation and maintenance and be the chief responsible project officer. He will be directly assisted by two assistant managers one for implementation of operations and one for implementation of project maintenance.

The main project office will be staffed by three engineers. These engineers will be responsible for developing solutions as required for maintenance activities, carrying out continuing water supply and allocation studies, conducting a continuing drainage observation program, carrying out required drainage investigations and design of necessary drainage facilities along with other project facility requirements as they develop. The headquarters will include a workshop for maintenance and repair of equipment.

Operation

The purpose of the irrigation project, including on-farm irrigation facilities, is to supply water as needed by the crops being grown on individual farms and to remove excess waters from Project lands. The average monthly continuous flow required to supply the project is shown on Exhibit K-9. Actual daily demands will vary from these average figures depending on climatic variations, crop selections, and planting dates.

On-farm irrigation. The on-farm sprinkler systems have been designed with a flow capacity to meet the peak requirement of intensive cropping. Throughout much of the season, the system capacity will be greater than the requirement. The majority of the irrigations for a fully cropped farm will normally require five to seven days of continuous flow to the individual farm. When crop demand is less than the peak flow capacity of the on-farm system the sprinkler irrigation

system will be shut off for a period of time before the next irrigation is made.

Watermaster Areas. Each watermaster will be responsible for the operation and delivery of water to the irrigable lands within the area. His responsibility will be to supervise the ditchriders, pump operators, office staff, miscellaneous laborers and guards assigned to his watermaster area. Approximately 18 ditchriders, 12 pump operators, three clerical personnel, six laborers, five drivers and five guards will be required for each watermaster area.

The ditchriders will be responsible for the opening and closing of valves and regulating the flow from the pumping stations to the farms. It is recommended that farmers be required to order water two days in advance of actual need. This will provide lead time to regulate the major system supply. Each ditchrider will be responsible for an area of approximately 1,000 hectares which would mean regulating flow to about 250 farms. Generally, this will require adjustments of deliveries on only 20 to 30 farms on any given day.

The water will be delivered to farms through individual turnouts with flow meters and charges for water will be made for actual on-farm use. The ditchrider will be responsible for recording the water use on each farm and for the continual surveillance of the project system for which he is responsible. He will note and report any repair or maintenance requirements to his supervisor. Because the system will operate on a 7-day per week basis, four additional ditchriders will be required for each watermaster area for relief work.

In addition, seven ditchriders and gate tenders will be required to operate the main canal system (two for each

watermaster area plus a relief rider. Although automatic water level controls will be installed, twenty-four hour surveillance of the main canal is recommended. These ditch-riders will be responsible for operational control of flows from the side wadis as well as being responsible for patrolling the main canal.

Approximately twenty-five pumping plants are planned for providing pressure for the sprinkler operations. Each pumping plant will be operated by a pump operator who will live at the station. Relief pump operators will be required to provide for continuous operation and surveillance of each pump station.

The clerical staff for each watermaster area will be responsible for record keeping and for providing necessary documentation for the main office to bill farmers for water used.

Sequence of Project Water Control Events. The irrigation requirements will be derived from the farmers water orders. Day-to-day adjustments throughout the system will be required to provide the needed water on schedule and prevent wastage.

The sequence of communications for Project operation will begin with the ditchrider collecting the water orders from the individual farmers. It is recommended that groups of farmers place their orders on cards and put them in a collection box centrally located for daily pickup by the ditchriders.

In turn, the ditchriders will submit the orders to the watermaster staff who will identify areas supplied independently from sources other than the main canal. All orders for water supplied from the main canal will be

tabulated and submitted to the main office which will correlate orders and request that the appropriate discharges be released from Maqarin or other storage reservoirs. Operating personnel at Maqarin and other reservoirs will make the required reservoir releases. Control of regulated side wadis will be done by operators at the side-wadi storage facilities.

Watermaster staff will inform pump operators within their area to make appropriate adjustments in pumping at each station, while main-canal ditchriders will make adjustments in gravity flow main-canal turnouts.

An essential element for operations is an adequate communication system. A two-way radio system linking all Project elements is preferred for rapid communications, although an independent telephone system could be used.

Maintenance

Maintenance should be carried out on project facilities on a regular continuing basis. An annual inspection of all Project facilities should be conducted by a qualified team which would identify maintenance and repair needs. This team should include an engineer, wastermaster and selected members from the maintenance staff.

Maintenance facilities will include a workshop with capabilities to repair Project equipment, vehicles, pumps, sprinkler equipment and other mechanical items. Equipment, in addition to normal workshop equipment, will include a mobile shop to make minor field repairs of equipment and facilities. The Project should maintain an inventory of commonly used spare parts and supplies for continued project maintenance. These would include vehicle parts, pump parts, and supplies for maintenance of other Project equipment and facilities.

The maintenance staff also should be competent to perform drainage maintenance (surface and subsurface), concrete repairs, electrical repairs, mechanical repairs, welding etc.

Project Operation and Maintenance Organization

The operation and maintenance organization for the irrigation system will be directed by the Jordan Valley Authority. To enhance coordination with on-farm needs, it is recommended that a local advisory board of representative farmers from different Project areas be elected or selected from the water users. Such an advisory group would increase cooperation between the farmers and the governmental operating agency. In addition, it would enhance the responsiveness of the operating agency to farmer needs within the project. An organizational chart is shown on Exhibit K-10.

Construction Program

Preconstruction Activities

The initial steps for project implementation will require decisions by the Government of Jordan with respect to project size, development plans, and financing negotiations. The proposed program of construction assumes an early committment for design funds. Based on information presented in this report, the Government of Jordan can enter negotiations with international financing institutions to assure that the necessary funds can be secured when construction contracts are to be awarded. By proceeding in this manner, the Government can continue with project implementation expeditiously without encountering delays due to investment needs.

The design phase of the preconstruction activities for the sprinkler system will include necessary surveys and investigations for all project areas, and detailed studies of the method for irrigation supply and final design. On the basis of the detailed field surveys and investigations the final detailed designs of the project can be completed and the contract documents consisting of the bid drawings and specifications can then be prepared. The Government will then be able to advertise for tenders, negotiate the construction contracts, and enter into the construction phase for the project.

Areas to be Developed Annually

The total net irrigable area to be developed by this project is approximately 25,000 hectares. Based on the present rate of installing such systems in Jordan this may take a considerably period of time to achieve. However, it is believed that an average of 6,000 hectares, may be developed annually if the following recommendations are implemented. This will allow the total area to be developed by the end of the year 1983.

The total project area may be divided into two geographic regions, and each will be let to one international contractor.

The first contract will cover installation of sprinkler facilities for about 13,379 ha of land in the northern part of the Valley. The area will include all of Land Groups B and part of C and D. The geographic breakpoint is at the end of the original EGCP, or at the beginning of the 8 km extension area. Basically this will cover the conversion of the presently surface irrigated area and the installation of new systems for those new land and potential areas falling north of the Zarqa River.

The second contract will provide for the installation of a sprinkler system on an additional 11,974 ha and will include the rest of Land Groups C and D and all of Land Group A. Basically this will cover the development of new and potential lands, and the conversion of the 8 km extension area to sprinklers.

Is is assumed that with proper logistics and the favorable consideration of the recommendations made in the following section, each contractor will be able to install sprinkler systems with their appurtenances at the rate of 3,000 hectares per year. A critical analysis of the rate of progress of the projects presently under construction in the Valley supports this assumption.

Four separate contracts were given to one Contractor for the "on going" projects in the Valley. Based on on the present state of affairs it is believed that the following schedule of completion will be possible.

By the end of	Total Area Equipped
39 months	3500 hectares
42	5000 hectares
54	6500 hectares
57	9400 hectares

The above rate was achieved although the Contractor did not know from the start that he was to be given all four contracts. Furthermore, this is his first experience with both sprinkler irrigation and working in Jordan. There was a serious delay due to administrative complications related to his letter of credit. The war in Lebanon, disrupted plans for obtaining certain supplies. Even with these delaying factors the contractor was able to average approximately 1600 hectares per year. Therefore, with better

organization and more favorable conditions, the development of 3000 hectares per year seems attainable.

Allowing about a year for field surveys, design, and the preparation of Tender Documents, the contracts may be initiated in 1979 and completed by 1983. The actual construction program can be planned so that water delivery can be made to farmers at the rate of 6,000 hectares per year.

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

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

Construction Considerations

Assuming there are no financial constraints, the following three considerations could assist in executing the proposed project in a period of 4 years:

a. Pipe Manufacturing in Jordan.

b. Long term contractual arrangments with price escalation.

c. Stream lining adminstrative procedures.

Pipe Manufacture. One of the bottlenecks facing executing the proposed Project may be the availability of pipe. At present neither, asbestos-cement or aluminum pipe is manufactured in Jordan. Presently, there are plans for production of PVC pipe at a moderate level in the near future.

For the success of the construction program and to be able to equip about 6,000 hectares per year, requiring approximately one thousand two hundred (1,200 km) kilometers of pipes of various diameters, it is imperative that a pipe manufacturing factory be set up in Joran. Once the pipe material is agreed upon, such a plant should be encouraged and given a firm order for the production of the required pipe sizes and lengths with all couplings. Even fittings should be manufactured locally. Without this assured supply the construction program may not be adhered to. Details of pipe manufacturing arrangements fall beyond the scope of the present report, but the concept must be stressed.

The pipe factory can be a completely privately owned enterprise or can be an enterprise with ownership divided between the government and private sector. The annual production rate should be at least 1,500 km of pipe for this and other proposed irrigation developments in Jordan and another 1000 km for export. The required capital investment would be in the range of JD 5 to 7 million.

If this undertaking is assured of a market for at least the first 10 years of its operation, there seems to be little doubt that such a factory will find many willing financers and will be economically justified.

Contractual Concepts. It is proposed that each sub-project be given to one contractor, thus allowing a long term contractual arrangement that will spread over 4 years. It is further recommended that each contract include a fair and realistic escalation clause that will remove the uncertainties stemming from world and local market price variations.

Other contractual considerations pertain to encouraging the contractor to assure an ample supply of all fittings and

material, required for the Project. One consideration might be to assure him that the Government will purchase all items remaining in his stores at the termination of the works. Another would be to include in the conditions of contract a provision allowing the Government to influence the planning and procurement of his supplies.

Proper project management and adequate machinery that will be kept in good operating condition are other factors that should be seriously studied while preparing the contract documents.

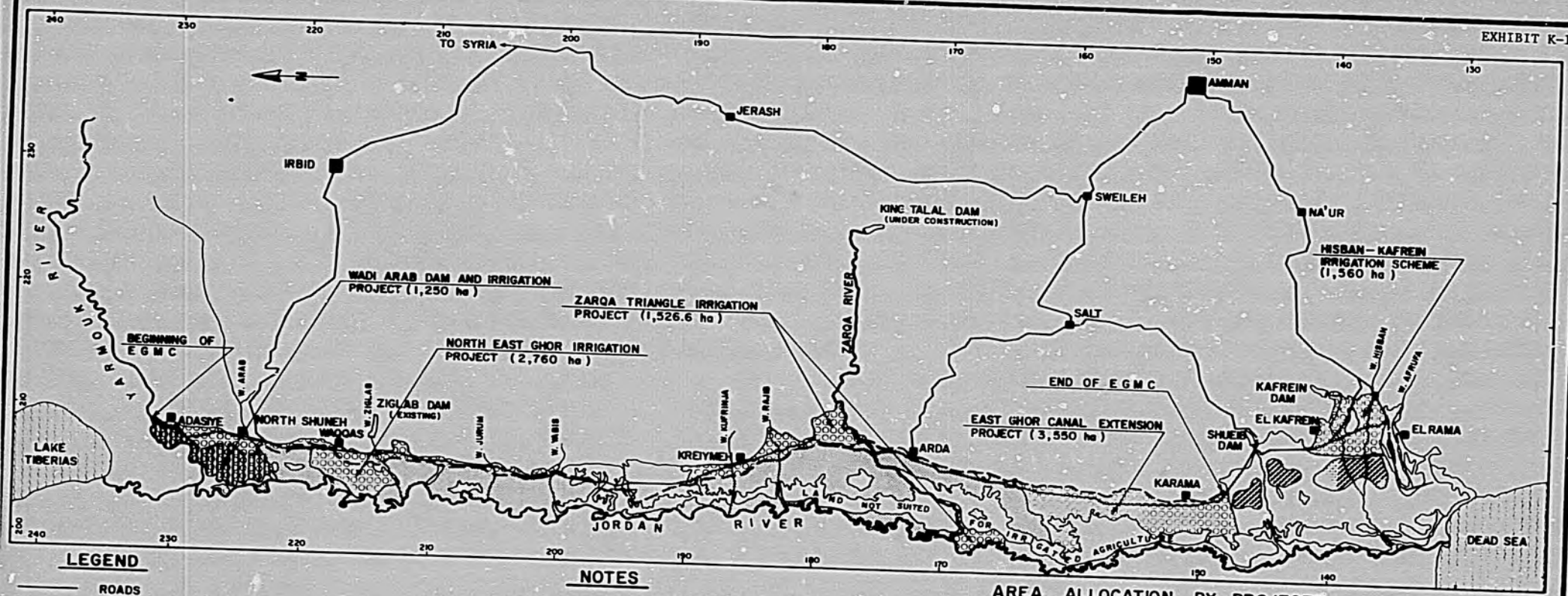
Stream Lining Administrative Procedures. Based on previous experience in the Valley, it is conceivable that adminstrative bottlenecks may delay the rate of progress of the Project considerably. The main aspects that should be considered include the following:

- Import License
- Customs Clearances
- Letter of Credit Formalities
- Work Permits
- Expropriation of Rights-of-Way
- Evaluation of Improvements Falling Within the Rights-of-Way
- Coordination With Other Ministries for Integration With Other Projects.

It is recommended that the impact of each of the above aspects on the execution of the Project be studied in detail and resolved before the contracts are signed. Appropriate Ministerial decrees and related exemptions, formation of committees, public and private announcements and declarations, should all be prepared and executed before the Contractor is given the order to proceed. Otherwise, the work plan will be disrupted and progress delayed.

Conclusion. The above considerations will favor the selection of good contractors, and will allow them to gain on-the-job experience, train workers to execute good work, and minimize delays imposed by administrative bottlenecks. It will also allow Jordan to become a trade school and export pipe layers for the Arab world, which is badly in need of such skills.

EXHIBIT K-1



LEGEND

- ROADS
- EAST GHOR MAIN CANAL
- RIVERS
- SPRINKLER IRRIGATION PROJECTS UNDER CONSTRUCTION OR STUDY
- EAST GHOR CANAL PROJECT SURFACE IRRIGATION
- IRRIGABLE LANDS NOT INCLUDED IN PRESENT DEVELOPMENT
- AREAS IRRIGATED BY INDIVIDUAL WELLS

NOTES

1 – AREAS ARE NET IRRIGABLE
2 – GRID FIGURES ARE KILOMETERS

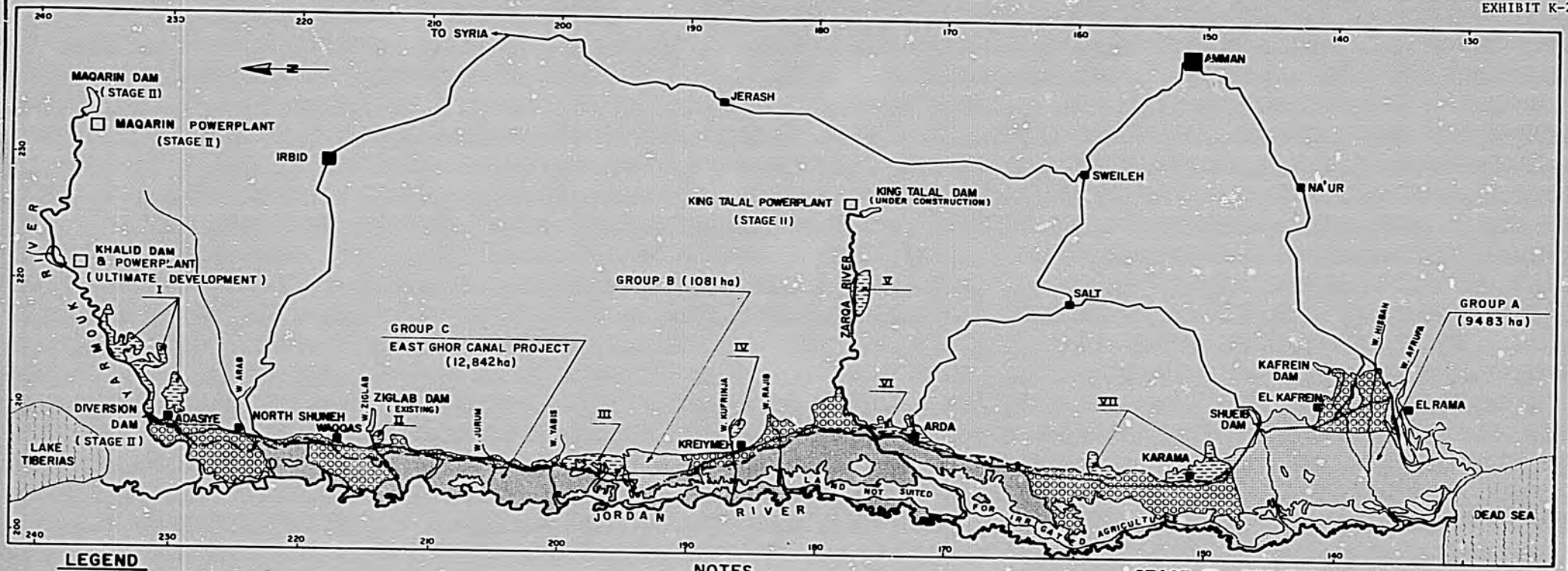
AREA ALLOCATION BY PROJECTS

	HECTARES
1 - EAST GHOR CANAL EXTENSION	3,550
2 - ZARQA TRIANGLE & ZOR	1,527
3 - NORTH EAST GHOR - NEW AREA	1,760
- CONVERSION	1,000
4 - HISBAN-KAFREIN	1,560
5 - WADI ARAB	1,250
TOTAL PROJECTS UNDER CONSTRUCTION OR STUDY	10,647

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

PRESENT DEVELOPMENT
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

EXHIBIT K-2



LEGEND

- ROADS
- EAST GHOR MAIN CANAL
- RIVERS
- STAGE I PROJECTS
- STAGE II - NEW LANDS - GROUPS A & B
- STAGE II - CONVERSION LANDS - GROUP C
- STAGE II - POTENTIALLY IRRIGABLE LANDS - GROUP D

NOTES

1 - GRID FIGURES ARE KILOMETERS
2 - POTENTIAL AREAS INCLUDE

	HECTARES
I - YARMOUK GORGE	331
II - ZIGLAB GORGE	50
III - BETWEEN KUFRINJA & YABIS	432
IV - KUFRINJA GORGE	100
V - ZARQA GORGE	216
VI - SOUTH OF ZARQA	293
VII - ABOVE 18 Km EXTENSION	525
TOTAL	1947

STAGE II PROJECT AREA

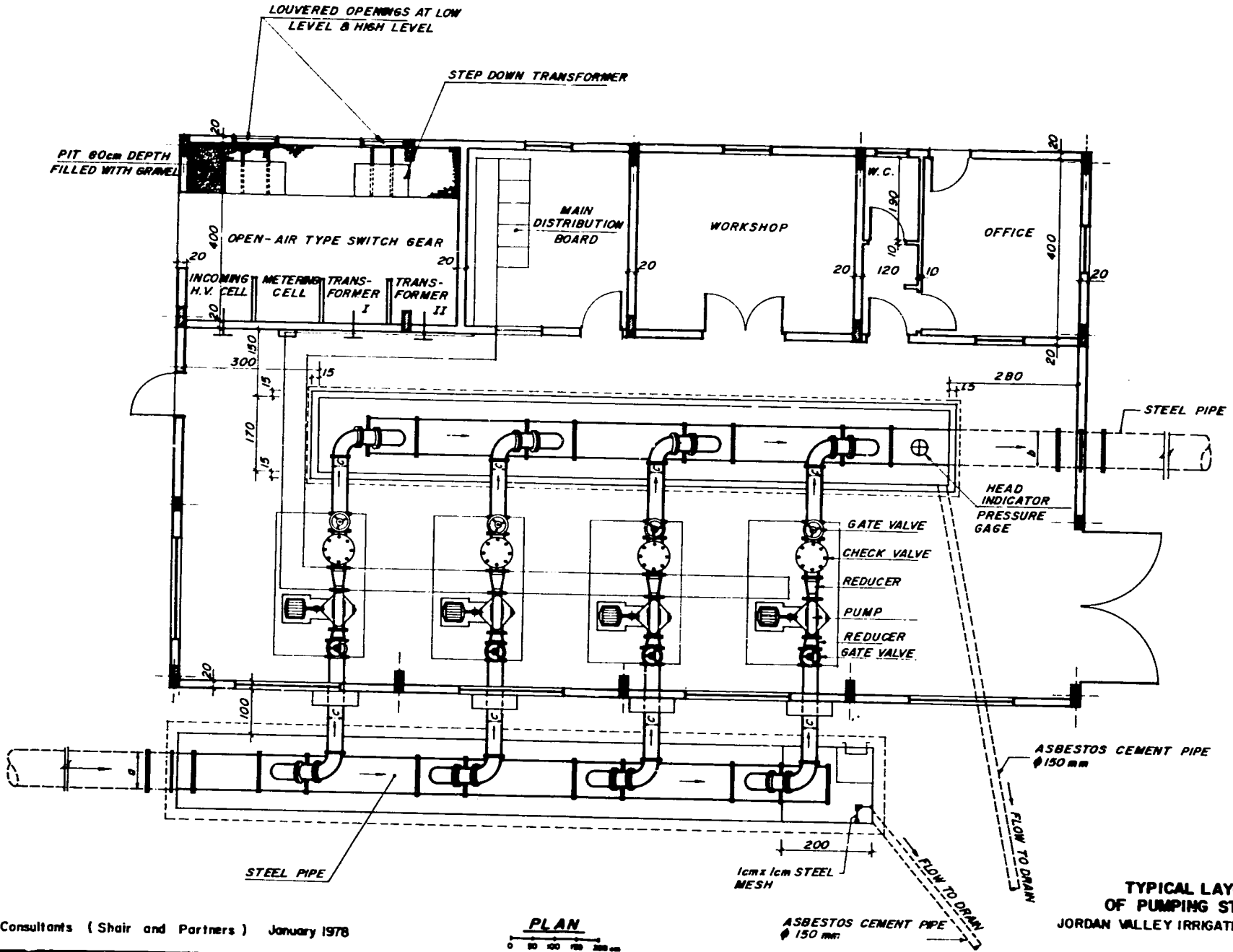
	HECTARES
CONVERSION LANDS (INCLUDES UPGRADED AREAS)	12,842
NEW LANDS	10,564
POTENTIALLY IRRIGABLE LANDS	1,947
TOTAL	25,353

TOTAL AREA

ON GOING PROJECTS	9,397
JAPANESE PROJECT ON WADI ARAB	1,250
STAGE II LANDS	25,353
TOTAL	36,000

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

GENERAL PLAN OF DEVELOPMENT
JORDAN VALLEY IRRIGATION PROJECT
STAGE II



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

PLAN

0 50 100 150 200 cm

TYPICAL LAYOUT OF PUMPING STATION

JORDAN VALLEY IRRIGATION PROJECT

STAGE II

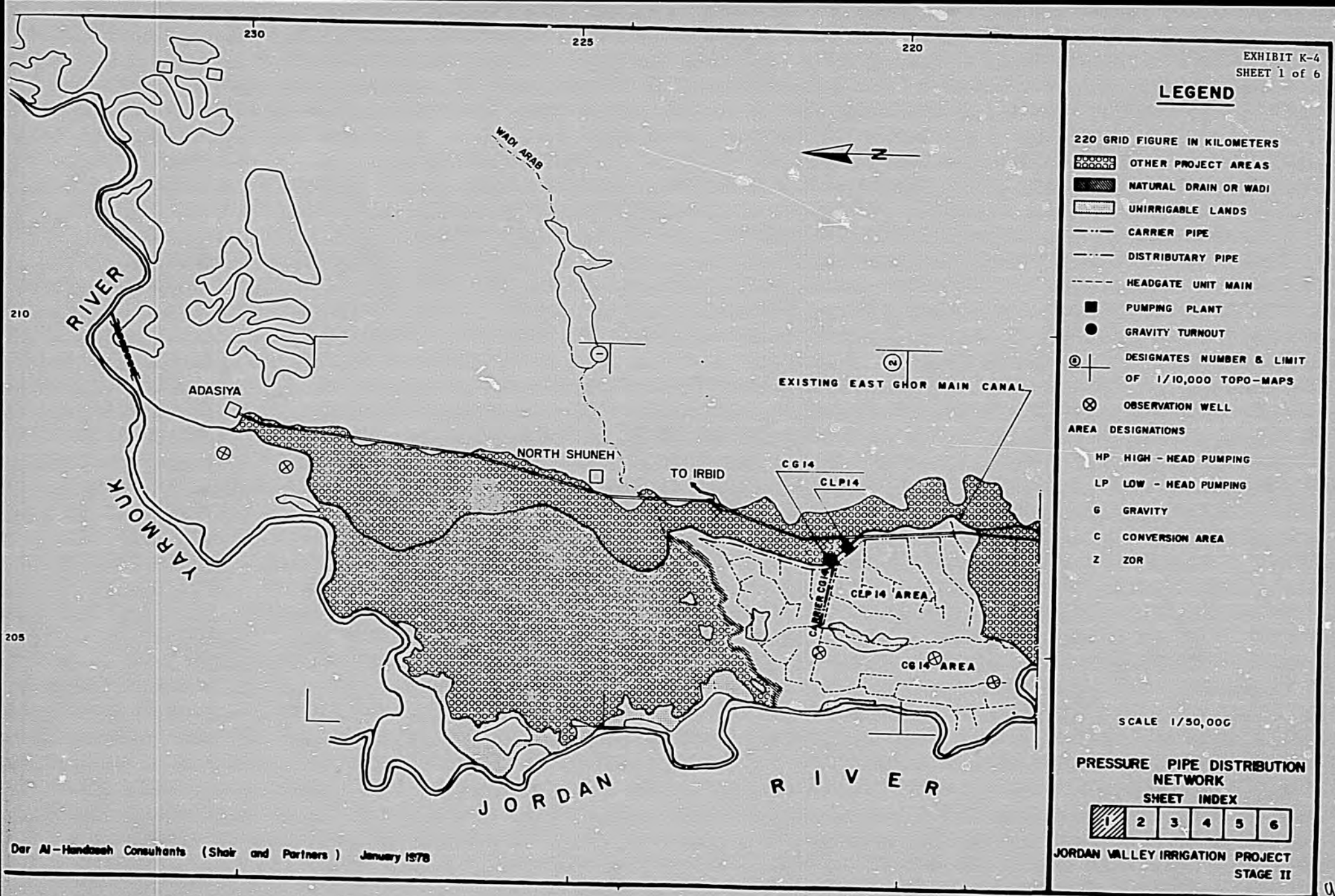
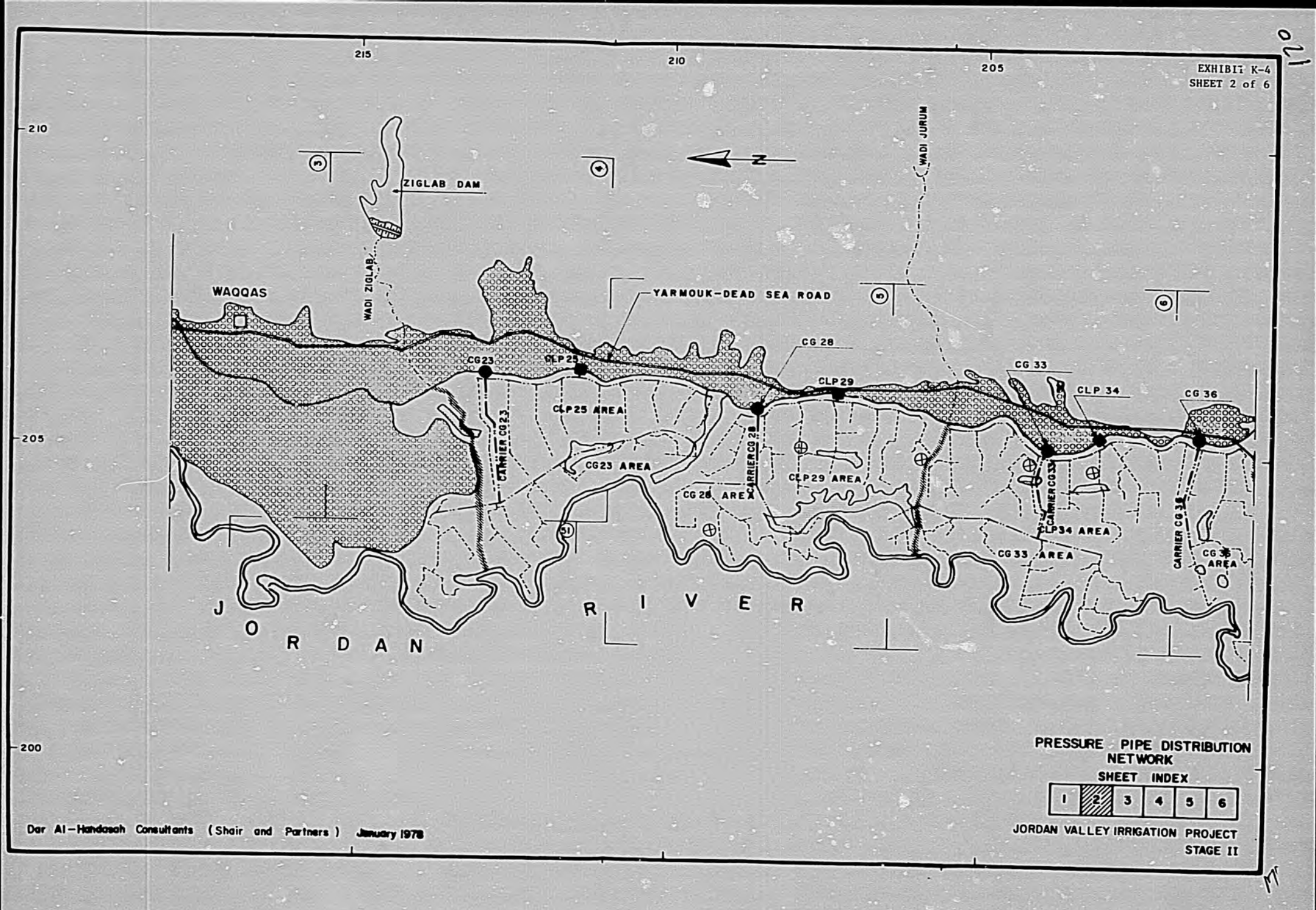
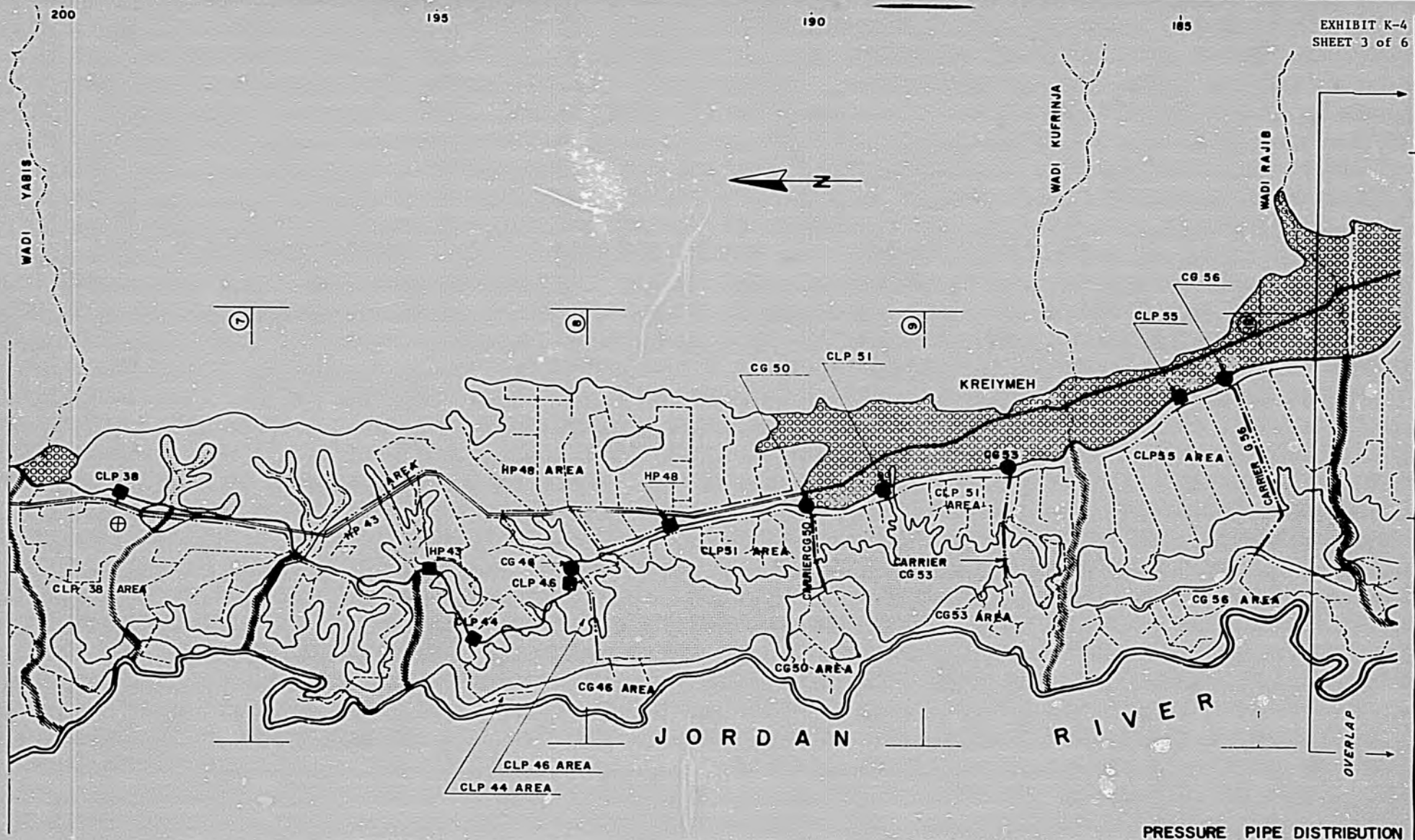


EXHIBIT K-4
SHEET 1 of 6
LEGEND
220 GRID FIGURE IN KILOMETERS
OTHER PROJECT AREAS
NATURAL DRAIN OR WADI
UNIRRIGABLE LANDS
CARRIER PIPE
DISTRIBUTARY PIPE
HEADGATE UNIT MAIN
PUMPING PLANT
GRAVITY TURNOUT
DESIGNATES NUMBER & LIMIT OF 1/10,000 TOPO-MAPS
OBSERVATION WELL
AREA DESIGNATIONS
HP HIGH - HEAD PUMPING
LP LOW - HEAD PUMPING
G GRAVITY
C CONVERSION AREA
Z ZOR
SCALE 1/50,000
PRESSURE PIPE DISTRIBUTION NETWORK
SHEET INDEX
1 2 3 4 5 6
JORDAN VALLEY IRRIGATION PROJECT
STAGE II
230
225
220
210
205
N
WADI ARAB
RIVER
YARMOUK
ADASIYA
NORTH SHUNEH
TO IRBID
EXISTING EAST GHOR MAIN CANAL
CG14
CLP14
CARRIER CG14
CLP14 AREA
CG14 AREA
JORDAN RIVER
Der Al-Handasah Consultants (Shair and Partners) January 1978

59

169


215
210
205
210
205
200
ZIGLAB DAM
WADI ZIGLAB
WADI JURUM
WAQQAS
YARMOUK-DEAD SEA ROAD
CG23
CLP25
CG 28
CLP29
CG 33
CLP 34
CG 36
CLP25 AREA
CG23 AREA
CARRIER CG23
CARRIER CG28
CG 28 AREA
CLP29 AREA
CARRIER CG33
CLP34 AREA
CG 33 AREA
CARRIER CG36
CG 36 AREA
51
J O R D A N R I V E R
PRESSURE PIPE DISTRIBUTION NETWORK
SHEET INDEX
1 2 3 4 5 6
JORDAN VALLEY IRRIGATION PROJECT
STAGE II
Dar Al-Handasah Consultants (Shair and Partners) January 1978



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

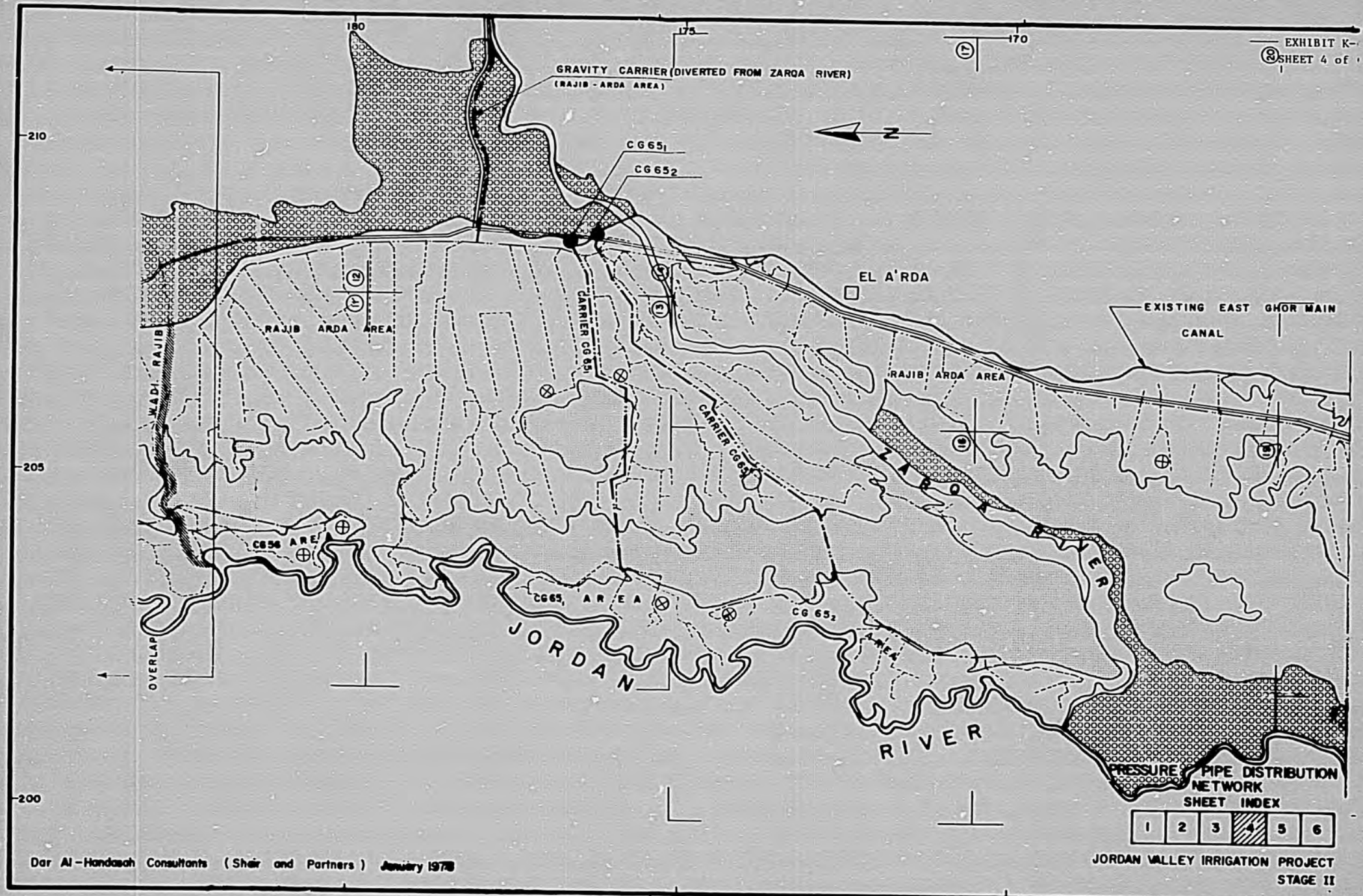


EXHIBIT K-
SHEET 4 of
GRAVITY CARRIER (DIVERTED FROM ZARQA RIVER)
(RAJIB - ARDA AREA)
CG65₁
CG65₂
EL A'RDA
EXISTING EAST GHOR MAIN CANAL
RAJIB ARDA AREA
RAJIB ARDA AREA
CARRIER CG65₁
CARRIER CG65₂
WADI RAJIB
ZARQA RIVER
CG56 AREA
CG65₁ AREA
CG65₂ AREA
JORDAN RIVER
OVERLAP
PRESSURE PIPE DISTRIBUTION NETWORK
SHEET INDEX
1 2 3 4 5 6
JORDAN VALLEY IRRIGATION PROJECT
STAGE II
Dar Al-Handasah Consultants (Shair and Partners) January 1978

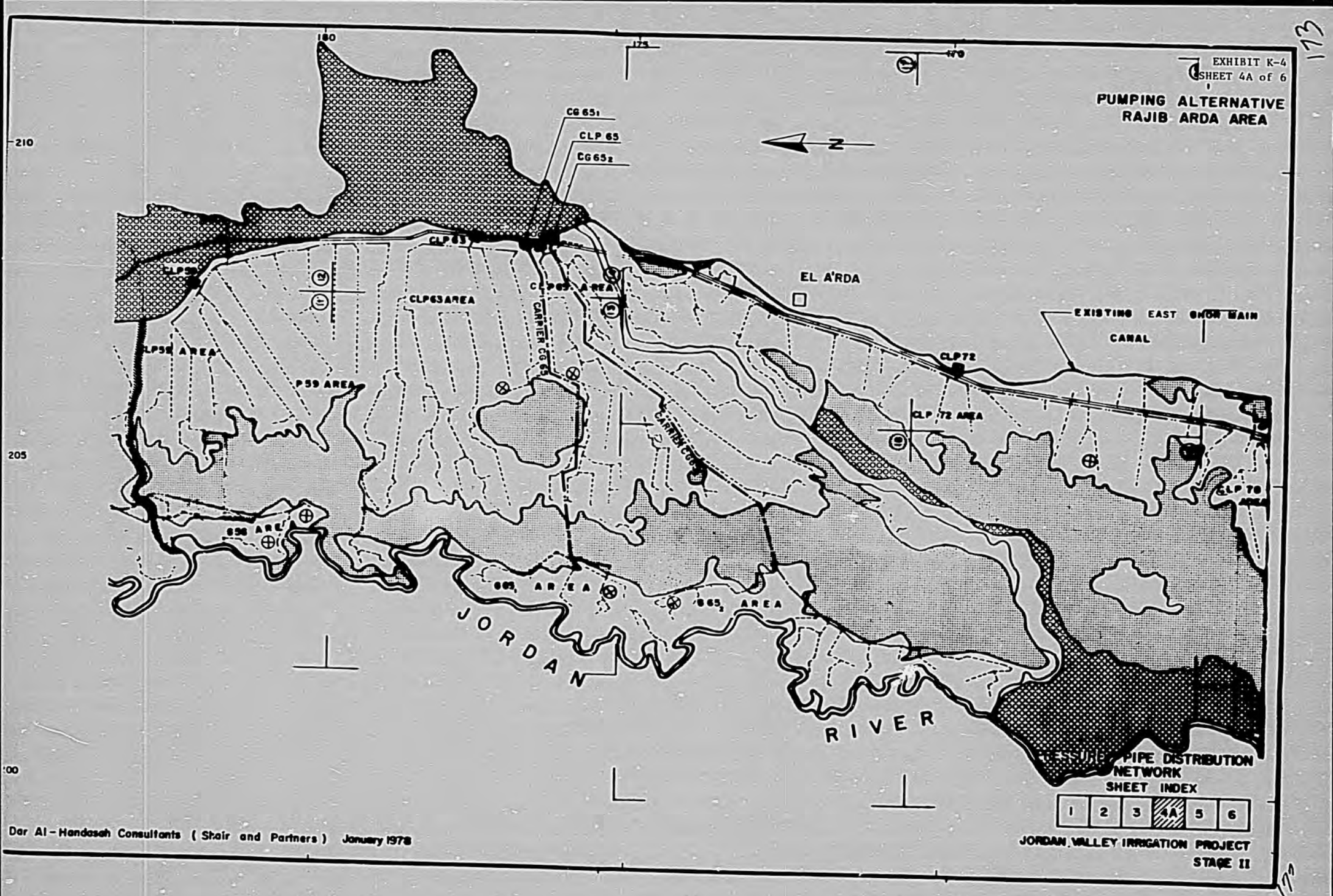
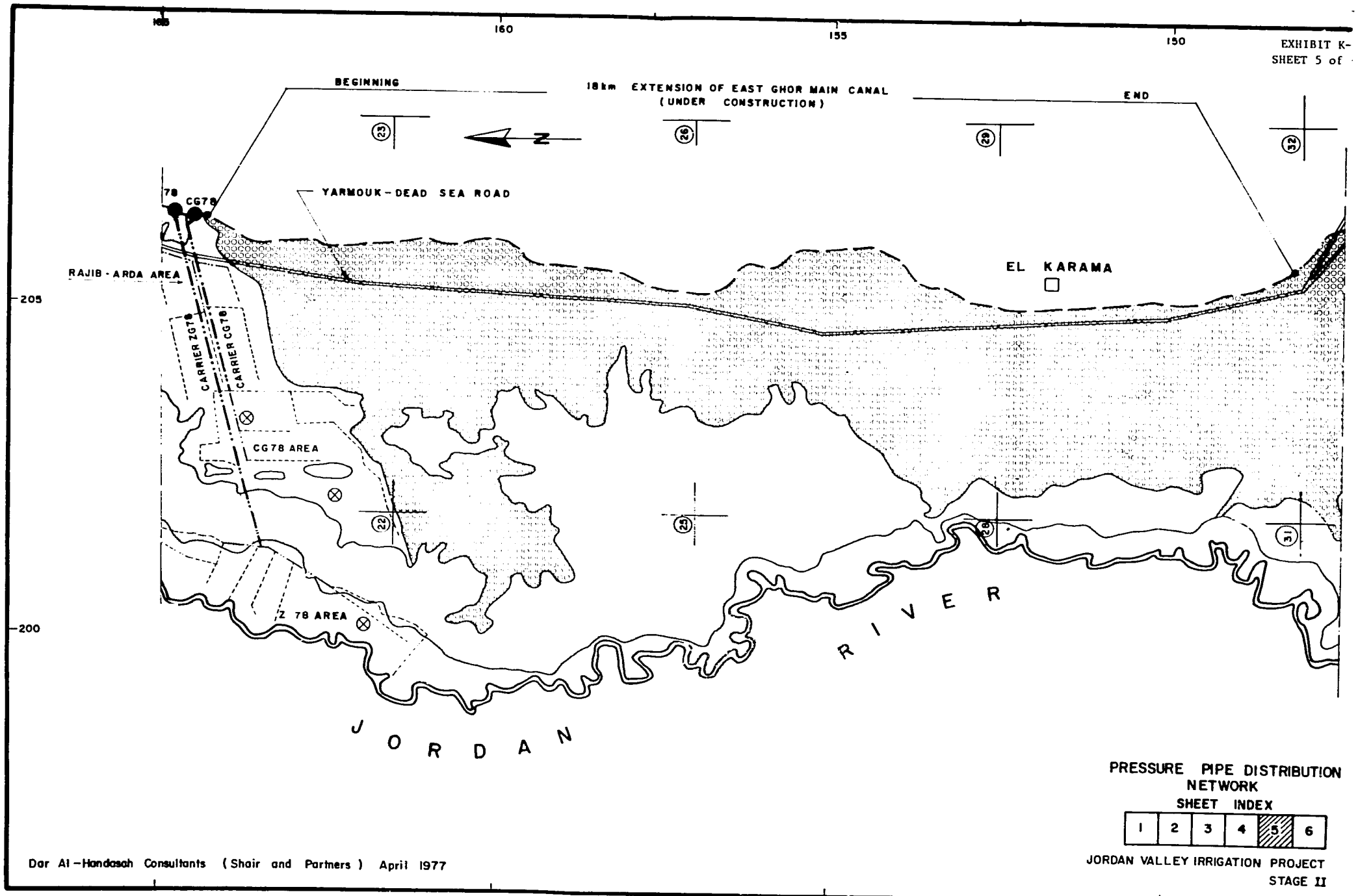
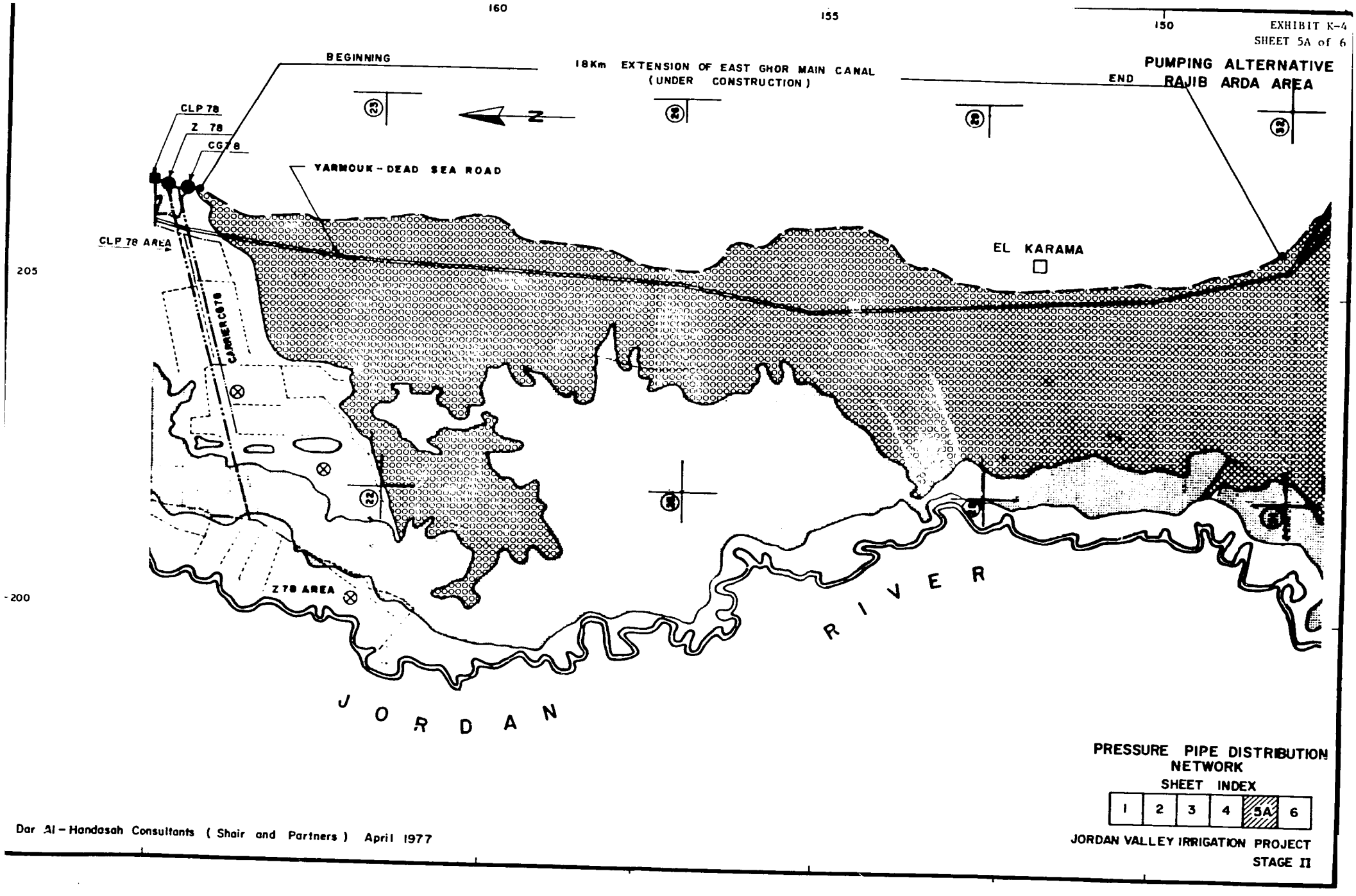


EXHIBIT K-4
SHEET 4A of 6
PUMPING ALTERNATIVE
RAJIB ARDA AREA
N
CG 65₁
CLP 65
CG 65₂
CLP 63
CLP 58
CLP63 AREA
CLP 65 AREA
CARRIER CG 65
EL A'RDA
EXISTING EAST GHOR MAIN CANAL
CLP 72
CLP 72 AREA
CLP 58 AREA
P 59 AREA
CARRIER CG 65
CLP 70 AREA
65₁ AREA
65₂ AREA
JORDAN RIVER
PIPE DISTRIBUTION NETWORK
SHEET INDEX
1 2 3 4A 5 6
JORDAN VALLEY IRRIGATION PROJECT
STAGE II
Dar Al-Handasah Consultants (Shair and Partners) January 1978

EXHIBIT K-
SHEET 5 of

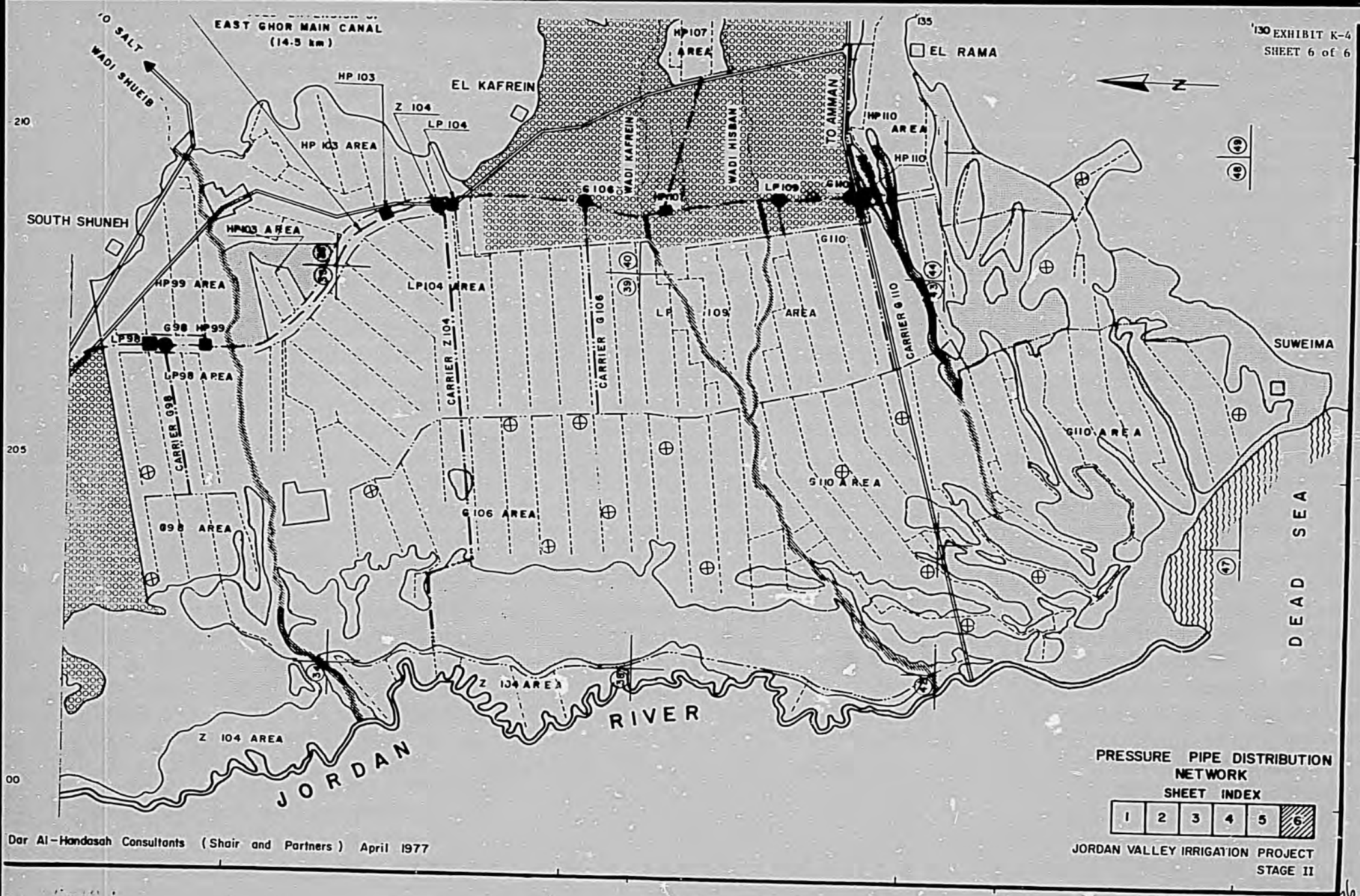


Dar Al-Handasah Consultants (Shair and Partners) April 1977

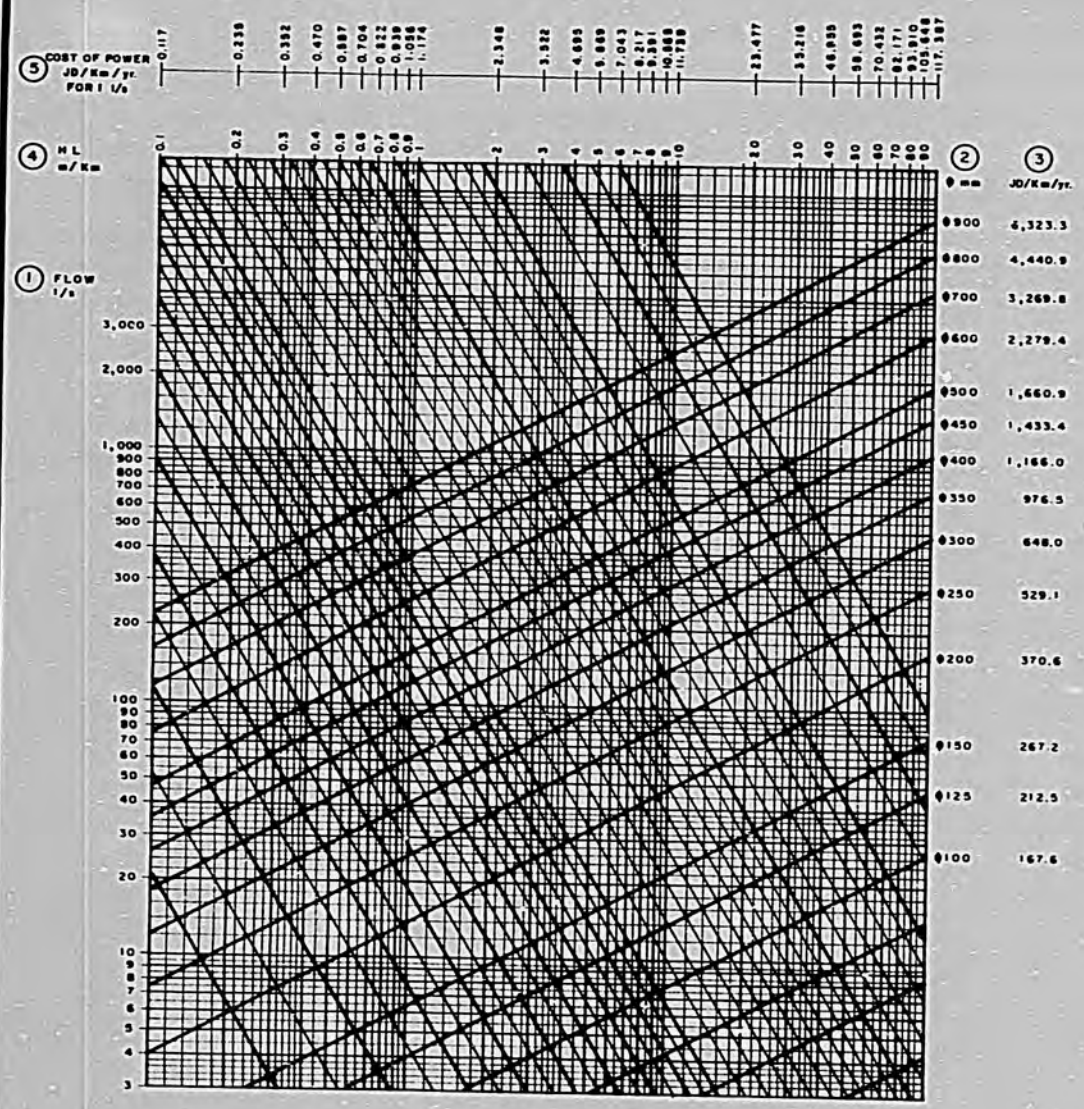


Dar Al-Handasah Consultants (Shair and Partners) April 1977

EXHIBIT K-4
SHEET 6 of 6



Dar Al-Handasah Consultants (Shair and Partners) April 1977



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

INSTRUCTION FOR USE OF THE NOMOGRAPH

1) ENTER FLOW AT 5 l/s IN ①

2) READ FRICTION HEAD LOSS, IN ④ FOR THE PIPE DIAMETERS IN (AS FOLLOWS

①	②	④
5 l/s	Φ_1 100 mm	4.488 m/km
5 l/s	Φ_2 125 mm	1.519 m/km

3) THE HL OBTAINED FROM ④ IS MULTIPLIED BY JD 1.17387/l/s/YEAR TO OBTAIN ⑤ IN JD/Km/yr FOR 1 l/s FLOW. THE RESULTS OF ⑤ AR THEN MULTIPLIED BY THE CONSIDERED FLOW TO OBTAIN THE AN NUAL COST OF PUMPING THE HEAD LOSS, EXPRESSED IN JD/Km/yr

	⑤	POWER COST - JD/km/yr
Φ_1	5.268	26.343
Φ_2	1.783	8.916

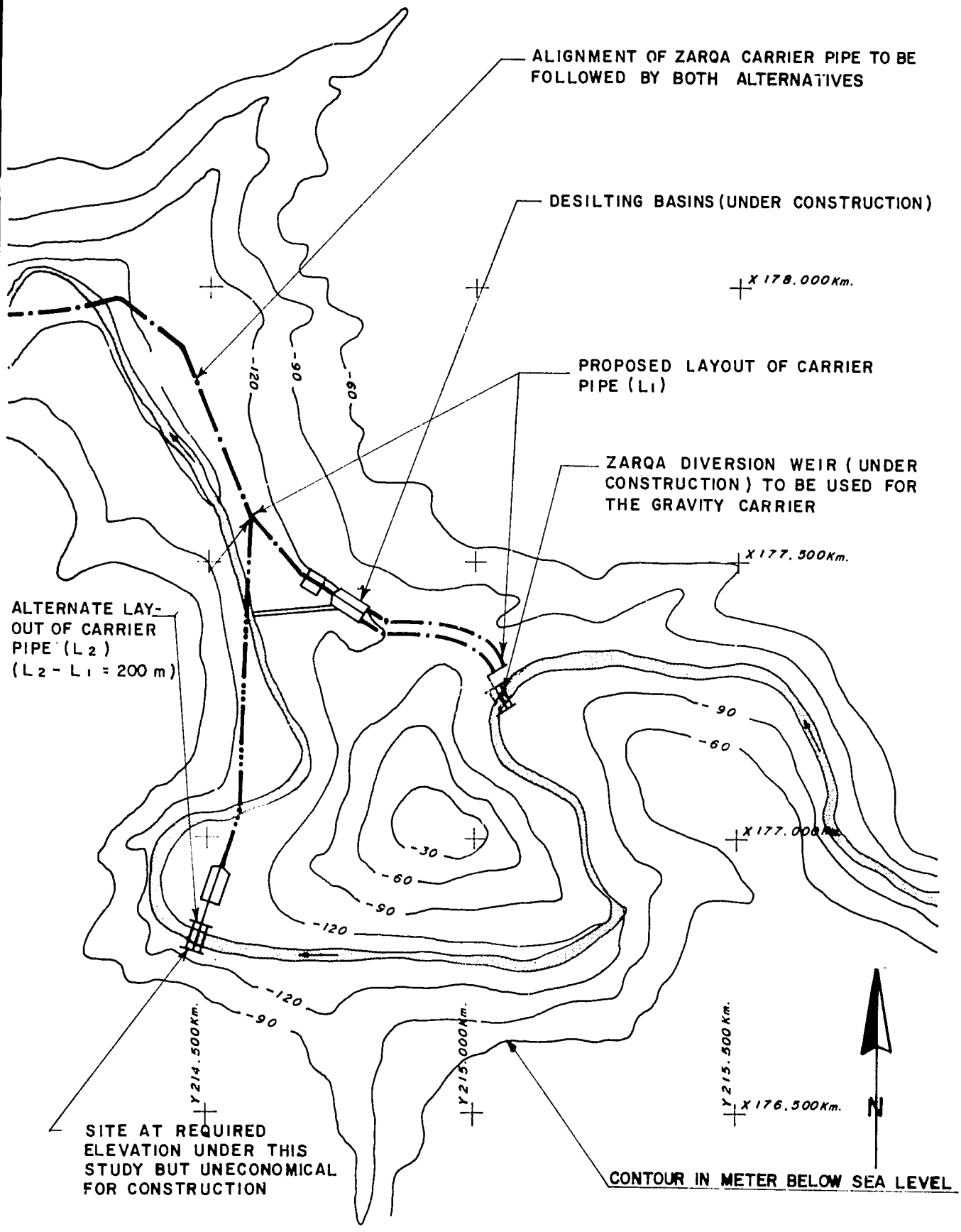
4) THE ANNUAL COSTS OF POWER FOR THE TWO PIPE SIZES ARE THEN COMPARED WITH THE CORRESPONDING ANNUAL COST OF EACH PIPE IN ③

	POWER COST JD/km/yr		PIPE COST JD/km/yr	
Φ_1	26.343	17.427	167.600	-44.900
Φ_2	8.916		212.500	

Φ_1 IS SELECTED BECAUSE THE POWER SAVING IN SHIFTING TO Φ_2 IS LOWER THAN THE INCREMENTAL COST IN PIPE INCURRED IN SUCH A SHIFT

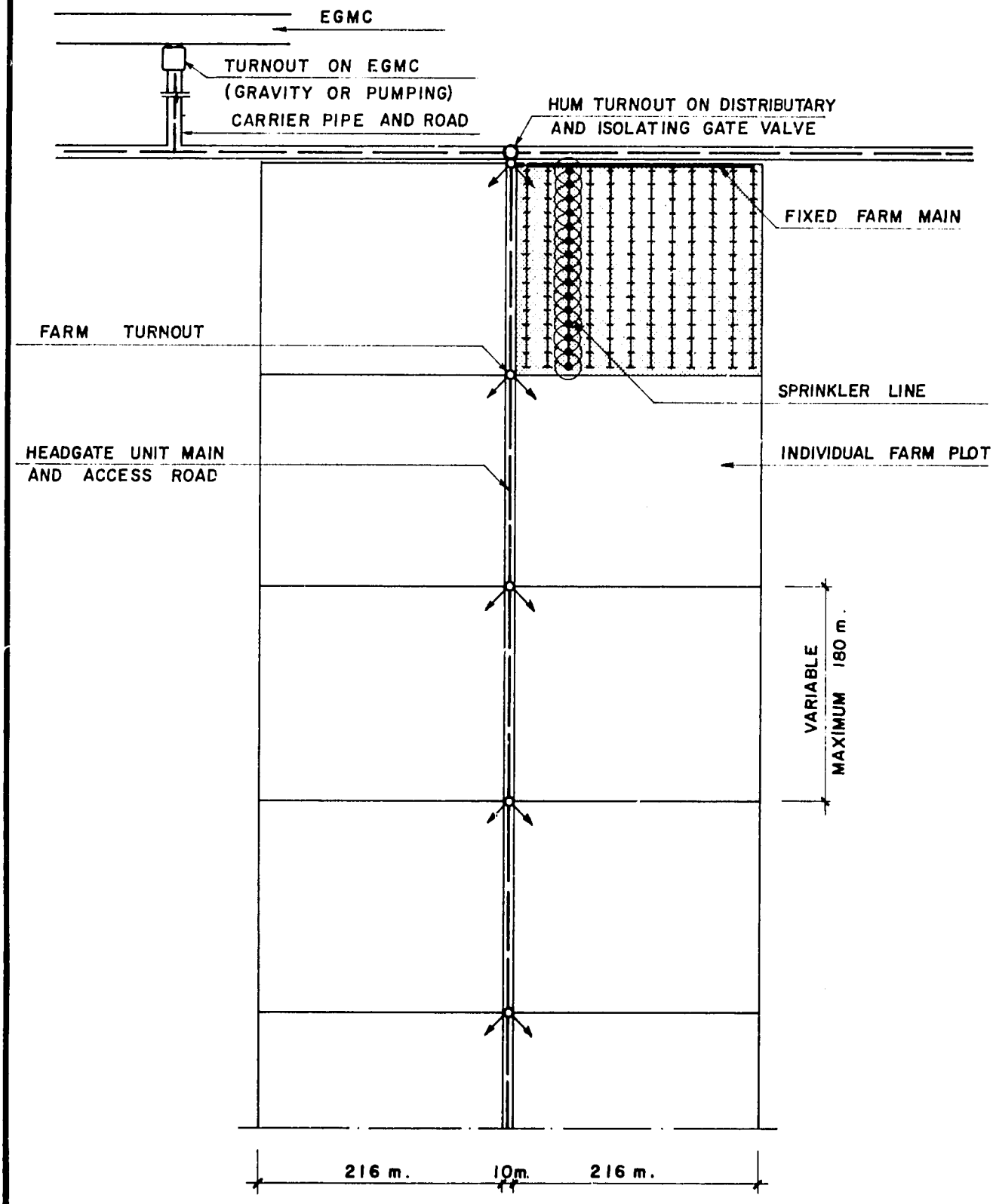
5) THE LARGER PIPE DIAMETER IS SELECTED AS LONG AS ITS INCREMENTAL COST IS LESS THAN THE COST OF POWER SAVED

NOMOGRAPH FOR PIPE SIZE SELECTION
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

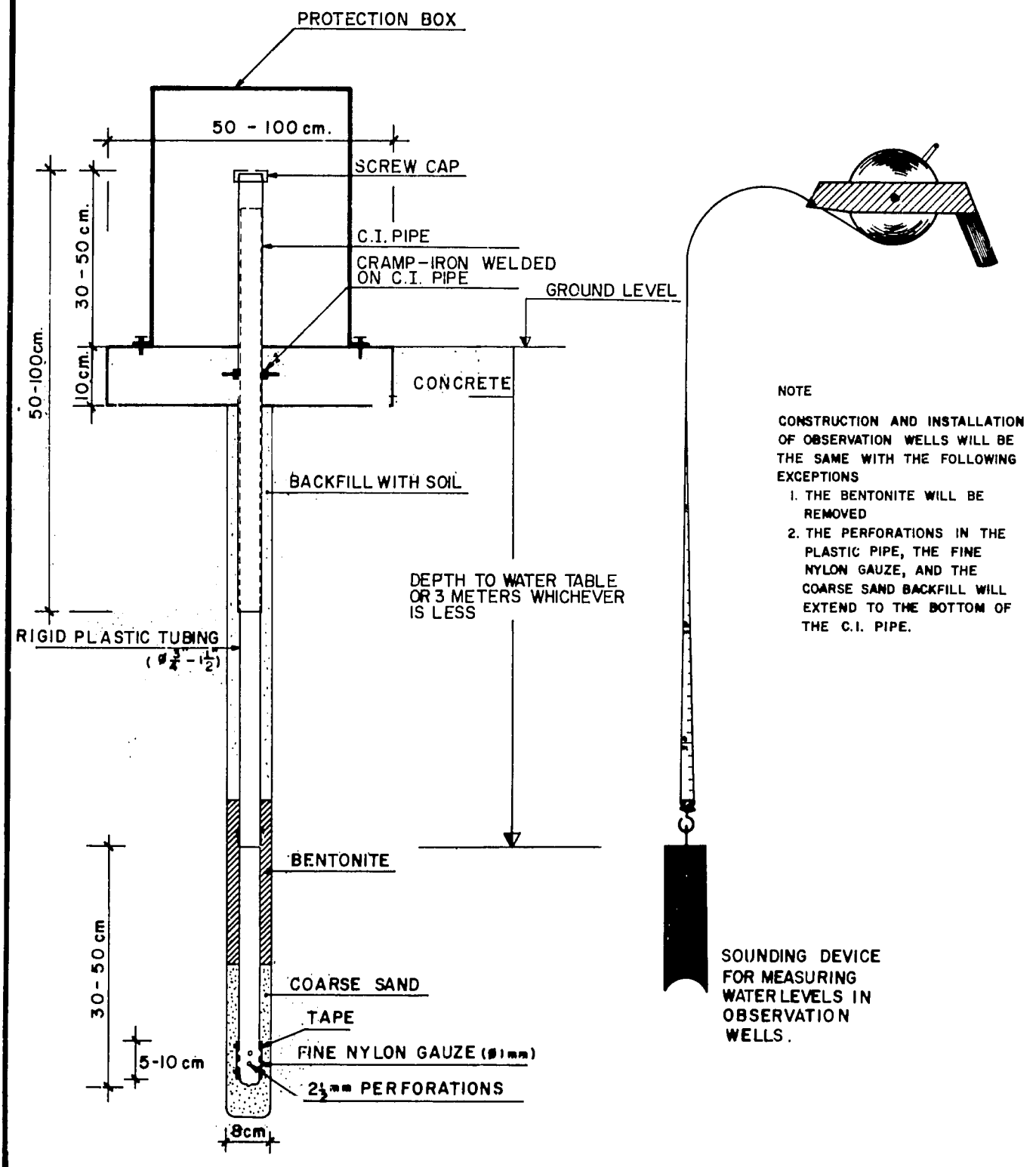


GRAVITY CARRIER PIPE & DIVERSION ALTERNATIVE

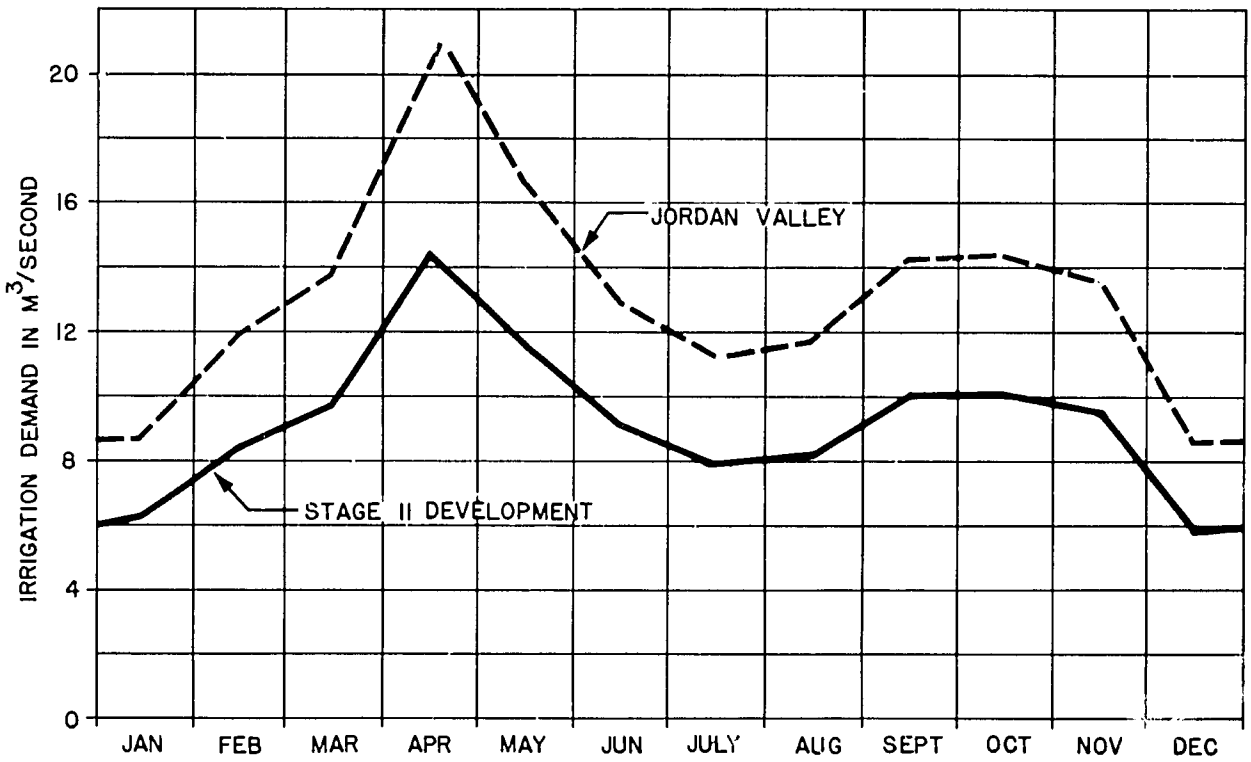
RAJIB - ARDA AREA



TYPICAL LAYOUT OF THE PIPE NETWORK



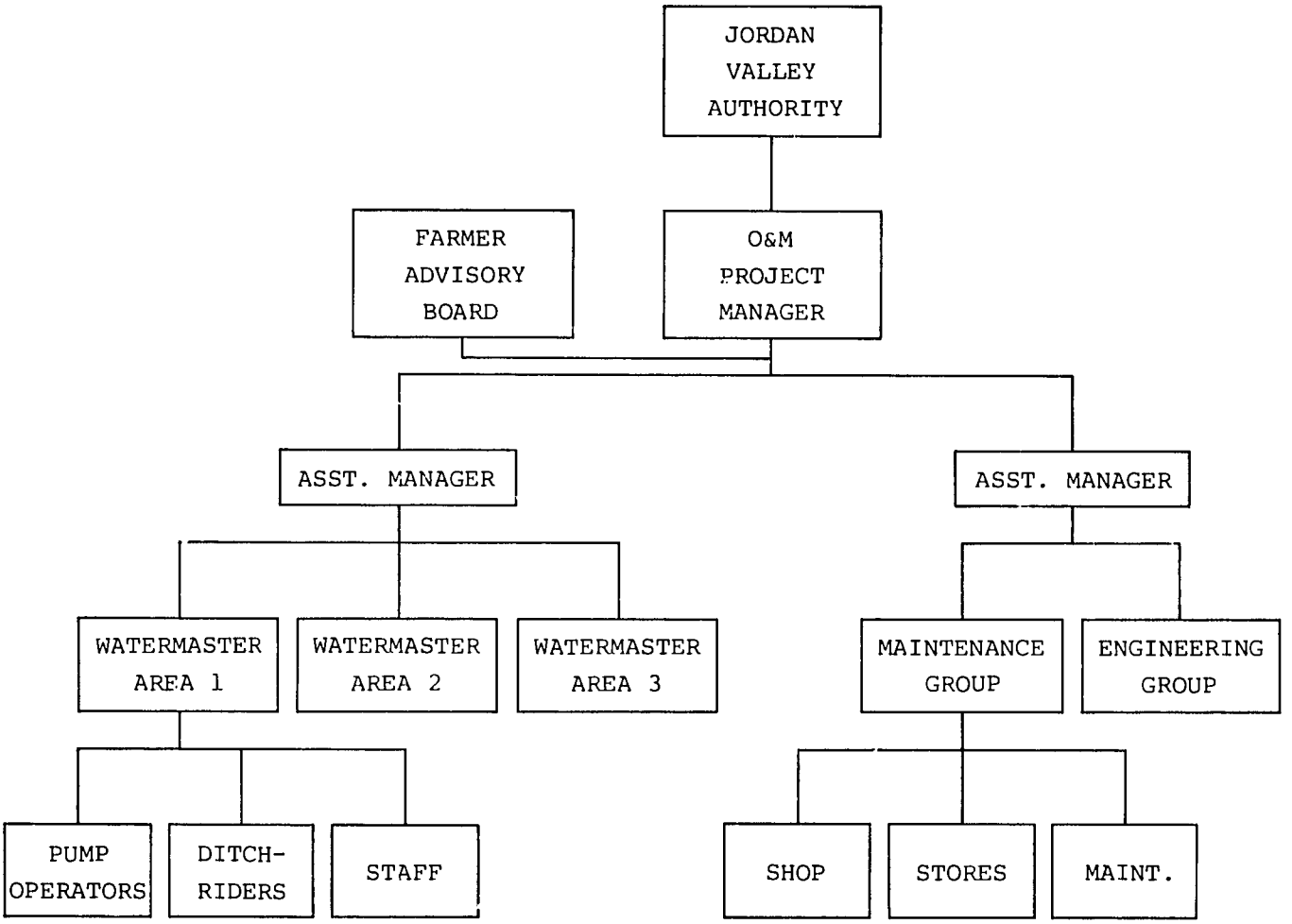
CONSTRUCTION & INSTALLATION OF PIEZOMETERS



IRRIGATION DEMAND

JORDAN VALLEY IRRIGATION PROJECT

STAGE II

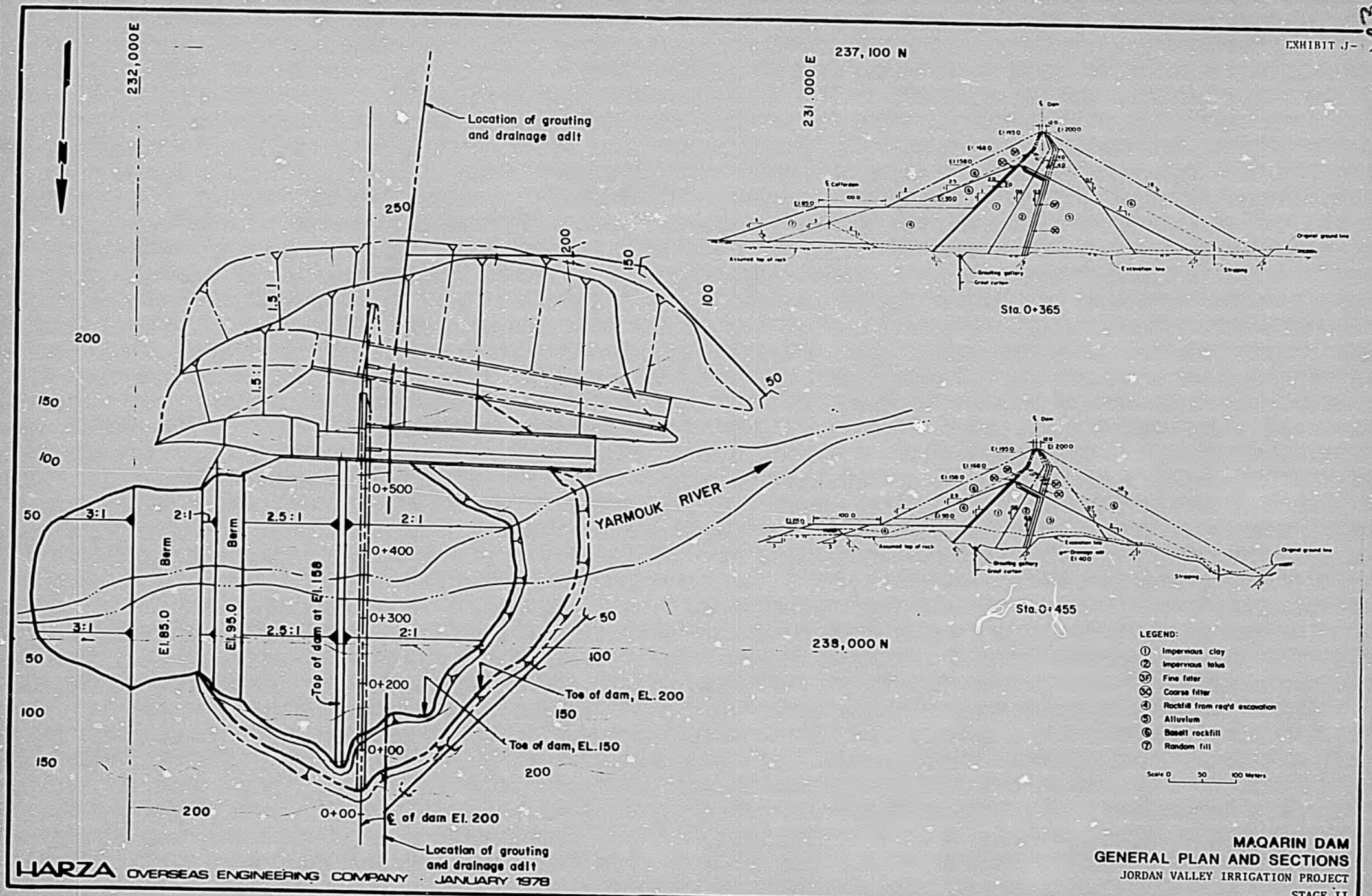


OPERATION AND MAINTENANCE ORGANIZATION

JORDAN VALLEY IRRIGATION PROJECT

STAGE II

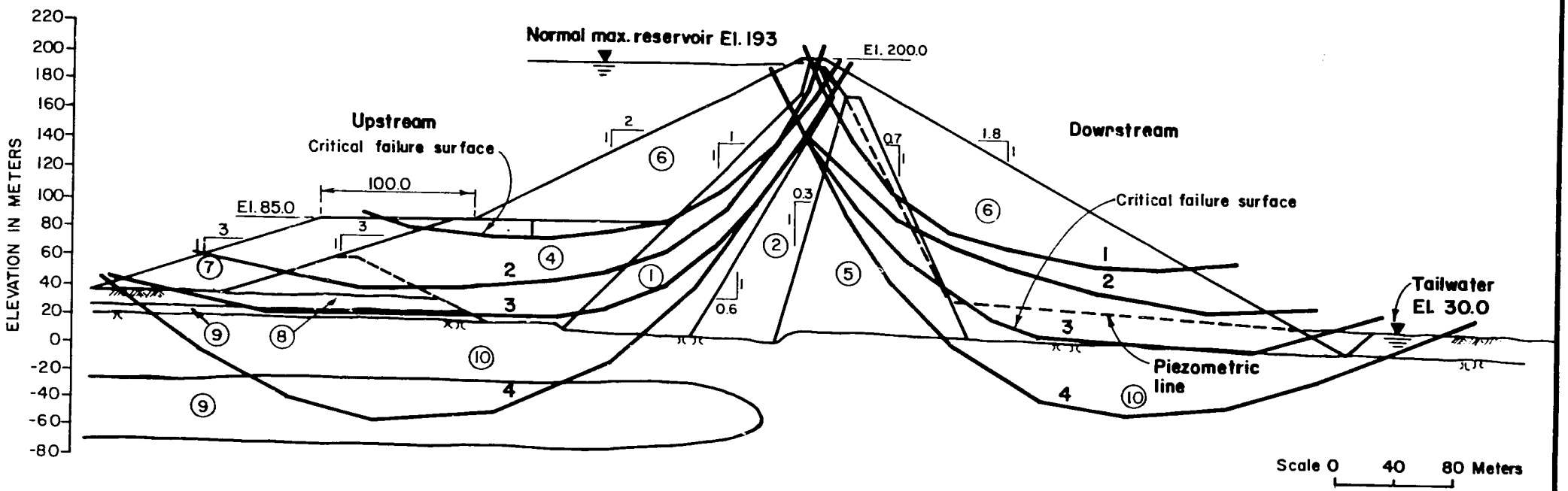
EXHIBIT J-3

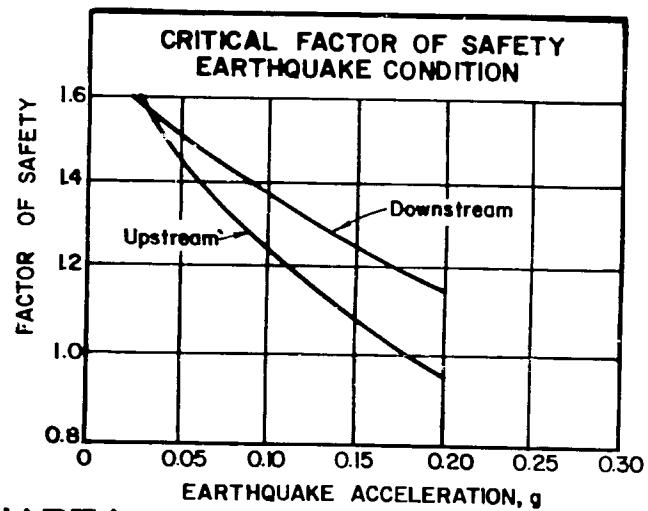


HARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

MAQARIN DAM
GENERAL PLAN AND SECTIONS
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

18



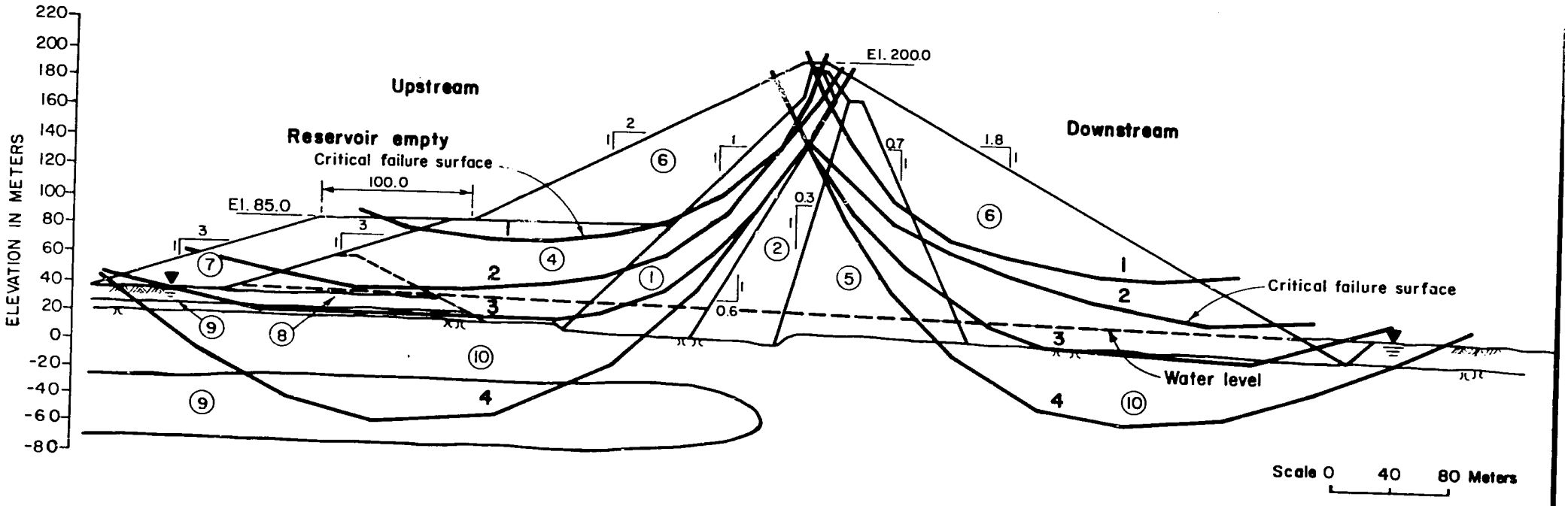


FACTORS OF SAFETY									
ANALYSIS		REPRESENTATIVE FAILURE SURFACE							
		UPSTREAM				DOWNSTREAM			
		1	2	3	4	1	2	3	4
STEADY STATE	STATIC	1.77	2.14	2.07	3.58	1.89	1.69	1.68	2.30
	EARTHQUAKE 0.10g	1.24	1.41	1.37	2.31	1.56	1.38	1.37	1.90
	EARTHQUAKE 0.15g	1.08	1.21	1.17	1.98	1.43	1.26	1.25	1.74
	EARTHQUAKE 0.20g	0.95	1.06	1.02	1.75	1.31	1.16	1.15	1.61

HARZA ENGINEERING COMPANY · JANUARY 1978

MAQARIN DAM - CREST ELEVATION 200.0
SLOPE STABILITY - STEADY SEEPAGE
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

184



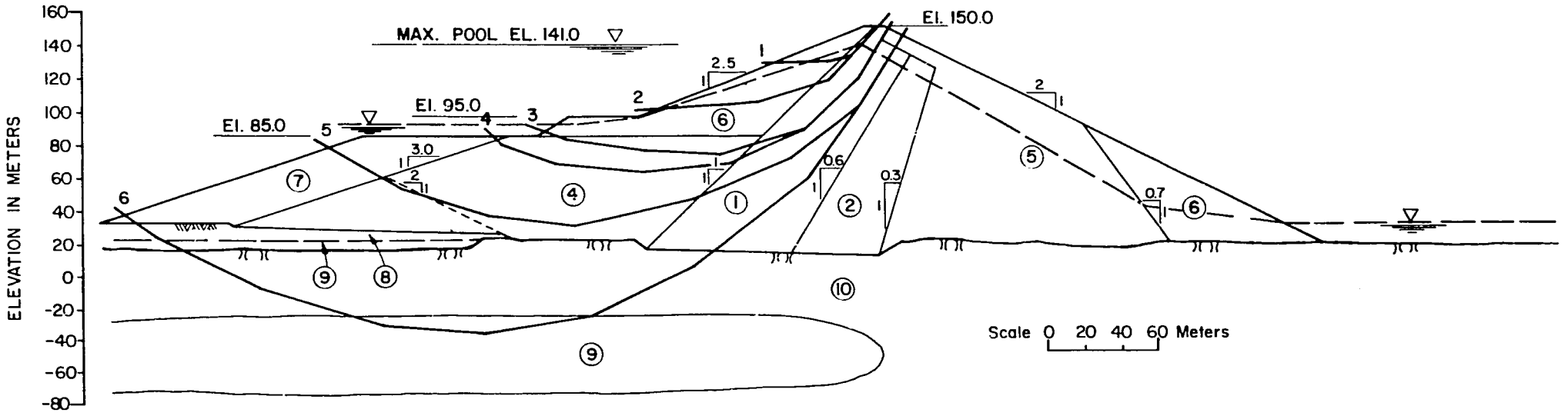
FACTORS OF SAFETY									
ANALYSIS		REPRESENTATIVE FAILURE SURFACE							
		UPSTREAM				DOWNSTREAM			
		1	2	3	4	1	2	3	4
CONSTRUCTION*	Zone 1 Ru = 0.8	1.24	1.57	1.25	2.43	1.86	1.70	1.79	2.56
	Zone 1 Ru = 0.7	1.29	1.64	1.33	2.48	1.86	1.71	1.80	2.56
	Zone 1 Ru = 0.6	1.35	1.70	1.41	2.52	1.86	1.72	1.80	2.56

*Zone 2 Ru = 0.5 for all construction analyses

MAQARIN DAM - CREST ELEVATION 200.0
SLOPE STABILITY - END OF CONSTRUCTION

JARZA ENGINEERING COMPANY · JANUARY 1978

JORDAN VALLEY IRRIGATION PROJECT
STAGE II



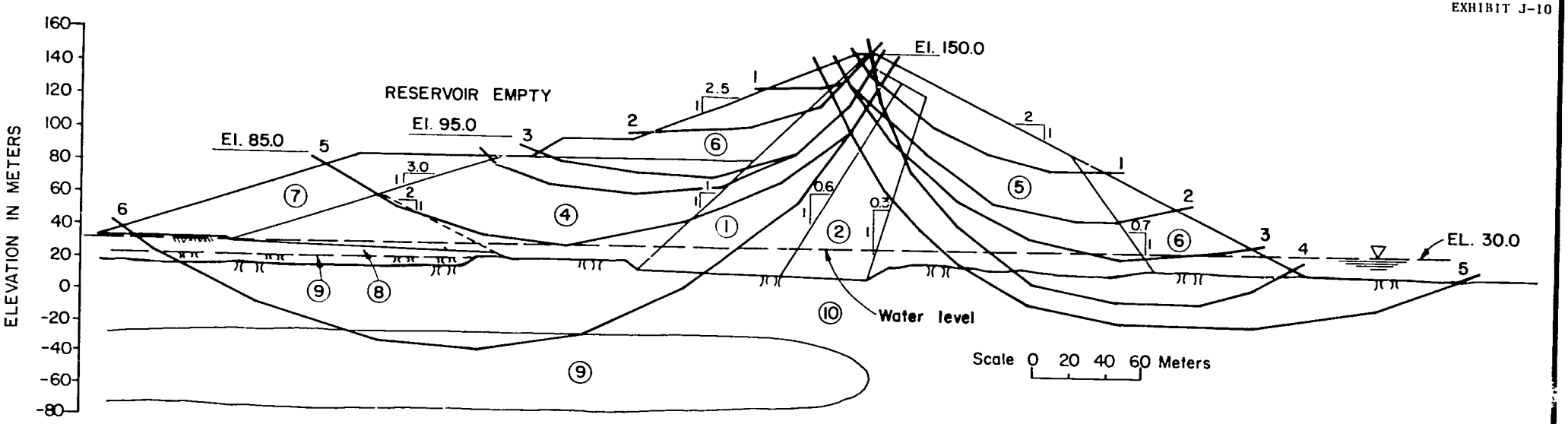
DRAWDOWN FROM EL. 141.0 to EL. 90.0

FACTORS OF SAFETY													
ANALYSIS		REPRESENTATIVE FAILURE SURFACE											
		UPSTREAM						DOWNSTREAM					
		1	2	3	4	5	6	1	2	3	4	5	6
RAPID DRAWDOWN	STATIC	2.43	2.18	1.58	1.61	2.29	3.43	—	—	—	—	—	—

MAQARIN DAM - CREST ELEVATION 150.0
SLOPE STABILITY - RAPID DRAWDOWN
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

HARZA ENGINEERING COMPANY · JANUARY 1978

EXHIBIT J-10

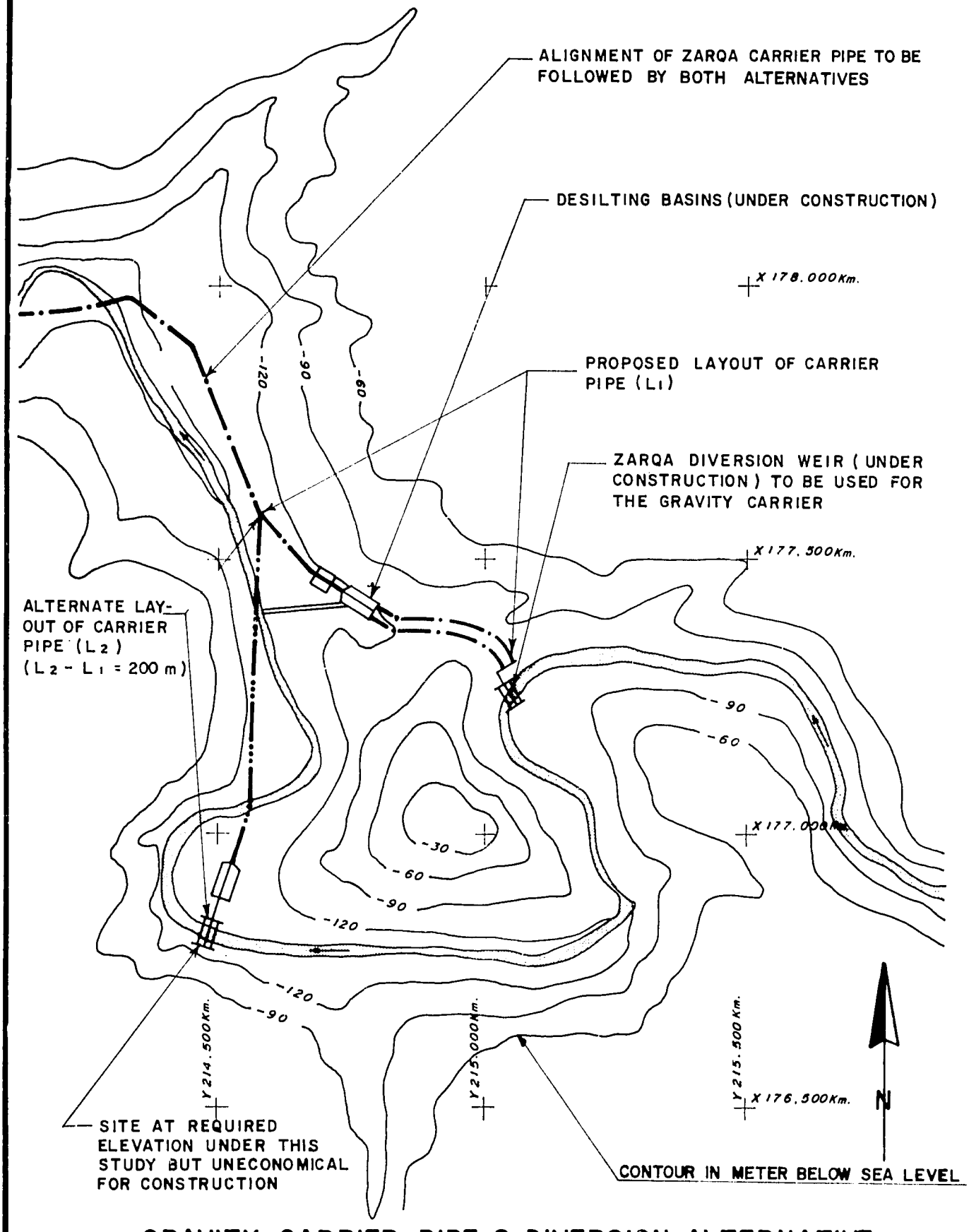


FACTORS OF SAFETY													
ANALYSIS		REPRESENTATIVE FAILURE SURFACE											
		UPSTREAM						DOWNSTREAM					
		1	2	3	4	5	6	1	2	3	4	5	6
END OF CONSTRUCTION	Zone 1 R_u = 0.6	2.06	2.00	1.99	2.25	3.06	3.48	1.60	2.04	2.05	2.91	2.80	—
	Zone 1 R_u = 0.7	1.99	1.96	1.91	2.18	2.96	3.41	1.59	2.03	2.04	2.90	2.79	—
	Zone 1 R_u = 0.8	1.93	1.92	1.83	2.12	2.85	3.35	1.57	2.02	2.03	2.90	2.78	—
	Zone 2 R_u = 0.5	For all end of construction analysis											

MAQARIN DAM - CREST ELEVATION 150.0
SLOPE STABILITY - END OF CONSTRUCTION
JORDAN VALLEY IRRIGATION PROJECT
STAGE II

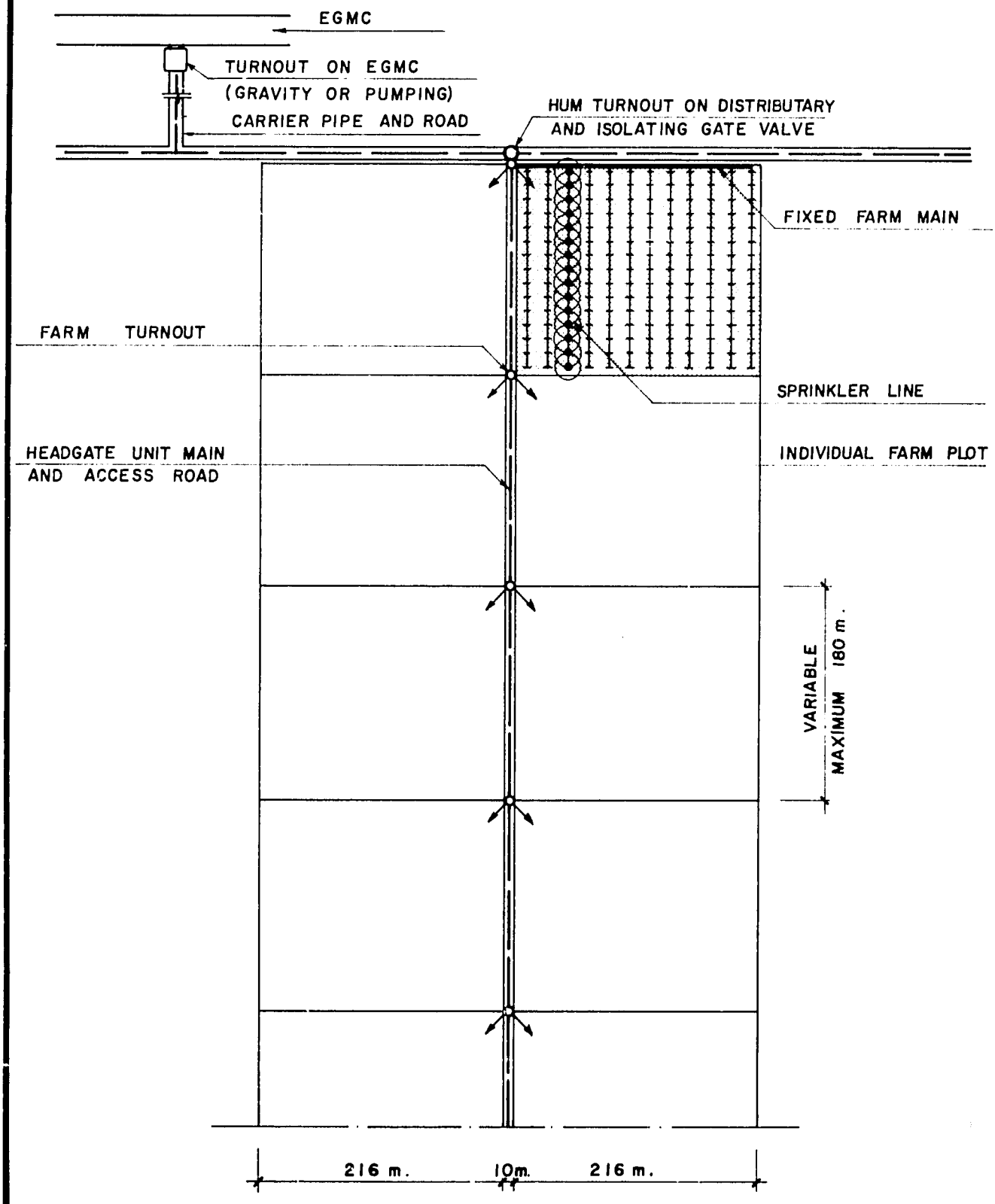
LARZA OVERSEAS ENGINEERING COMPANY · JANUARY 1978

187

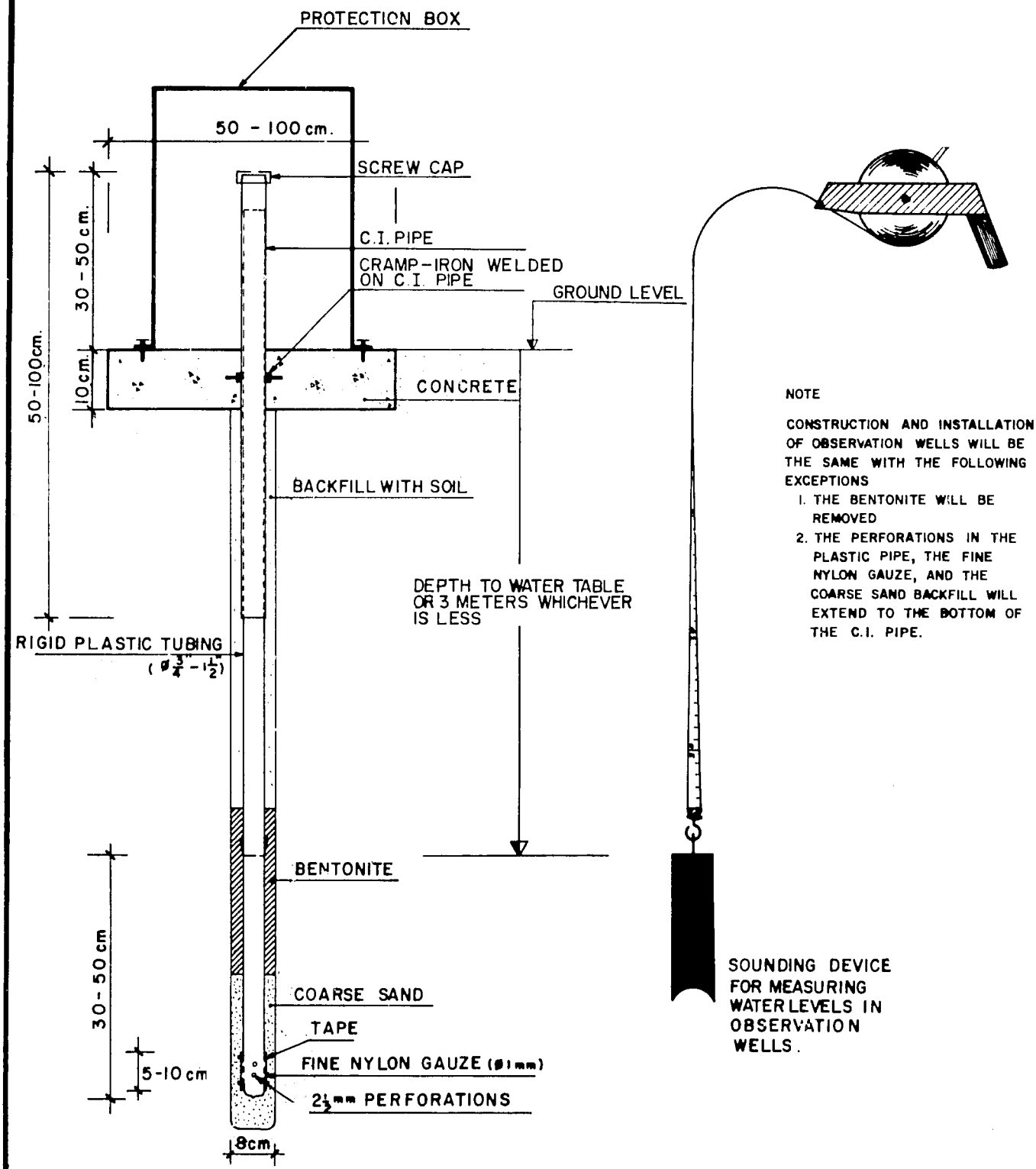


GRAVITY CARRIER PIPE & DIVERSION ALTERNATIVE

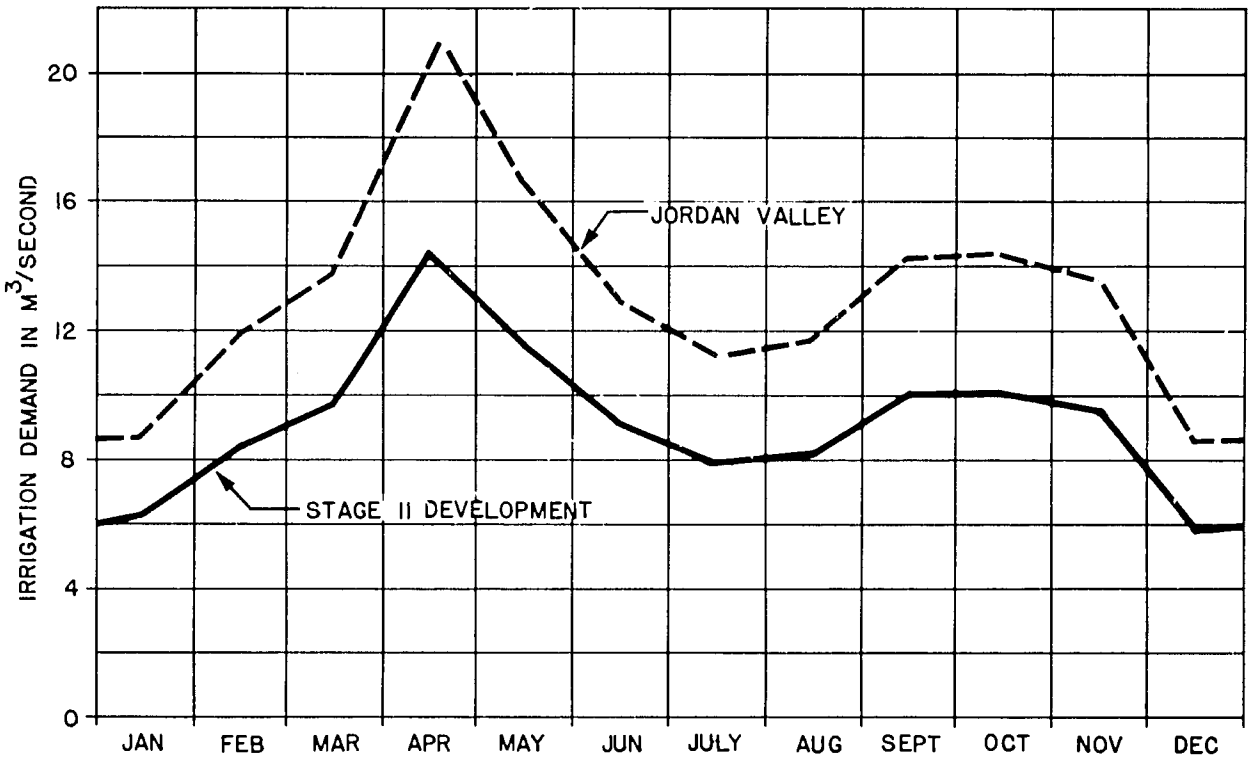
RAJIB - ARDA AREA



TYPICAL LAYOUT OF THE PIPE NETWORK



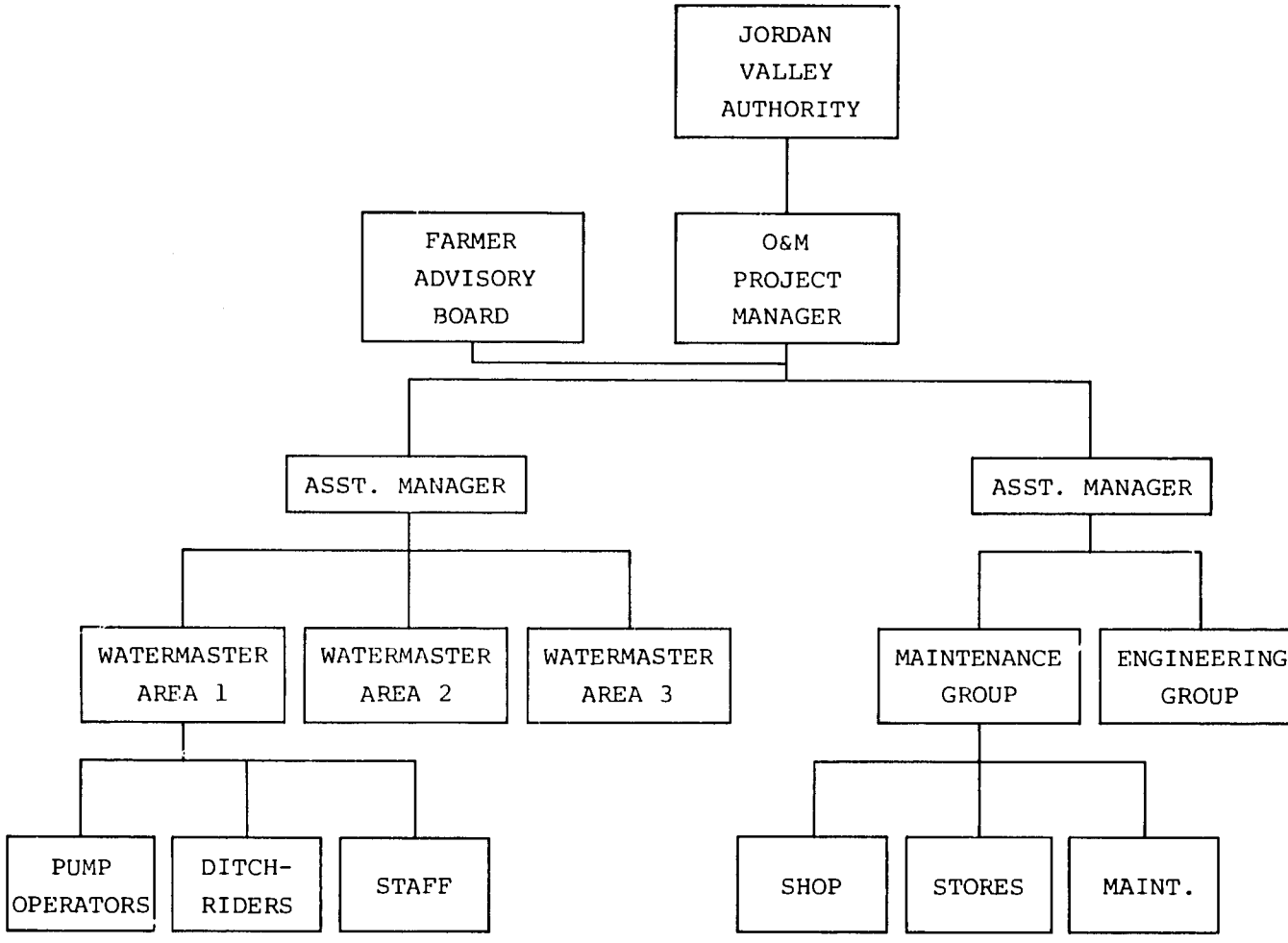
CONSTRUCTION & INSTALLATION OF PIEZOMETERS



IRRIGATION DEMAND

JORDAN VALLEY IRRIGATION PROJECT

STAGE II



OPERATION AND MAINTENANCE ORGANIZATION

JORDAN VALLEY IRRIGATION PROJECT

STAGE II

Appendix L

COST ESTIMATE

Table of Contents

	Page No.
Introduction	L-1
Project Construction Costs	L-1
Access	L-2
Land Acquisition	L-2
Railroad Relocation	L-4
Storage and Power Facilities	L-4
Irrigation Facilities	L-5
Excavation and Compaction	L-5
Concrete	L-5
Metal Work	L-5
Asbestos Cement Pipes	L-6
Pipelines Appurtenances	L-6
Farm Turnout Assemblies	L-7
Farm Equipment	L-7
Pumping Stations	L-7
Drainage Works	L-9
Gravel Surfacing of Roads	L-9
Operators Housing	L-10
Main Canal Turnouts and Rehabilitiation	L-10
Zarqa Diversion Weir	L-10
Potential Lands	L-11
Automatic Water Surface Control	L-13
Permanent Equipment	L-13
Operators Village	L-13
Contingencies	L-14
Engineering and Administration	L-14
Escalation During Construction	L-14
Costs for Stage II Development	L-15
Recommended Scheme	L-15
Alternative 1	L-15
Alternative 2	L-18
Costs of Stage III (Ultimate) Development	L-18
Single Stage Project at Maqarin	L-22
Annual Operating Costs	L-23
Storage and Power Facilities	L-23

Operation and Maintenance L-24
Interim Replacement L-24
Insurance L-25
Administration and General Expenses L-25
Summary L-25
Irrigation Facilties L-26
Personnel for Operation and Maintenance L-26
Equipment for Operation and Maintenance L-28
O&M of Service Equipment L-28
Energy L-28
Spare Parts for Pumping Stations L-31
Office Supplies L-31
Maintenance Materials L-31
General Property Maintenance L-31
Subsurface Drainage L-32
Summary L-32

LIST OF TABLES

Table No.		Page No.
L-1	Land Acquistion	L-3
L-2	Stage II Development - Recommended Scheme Summary of Construction Cost	L-16
L-3	Stage II Development - Alternative 1 Summary of Construction Cost	L-17
L-4	Stage II Development - Alternative 2 Maqarin - Wadi Arab Project Summary of Construction Cost	L-19
L-5	Stage III Storage and Power Facilities Construction Costs	L-21
L-6	Single Stage Storage and Power Facilites Construction Cost	L-22
L-7	Operation and Maintenace for Dam and Powerplant	L-24
L-8	Interim Replacement Costs for Dam and Powerplant	L-25
L-9	Operation Costs for Dam and Powerplant	L-26
L-10	Personnel Required for Operation and Maintenance of Irrigation Facilities	L-27
L-11	Equipment for Operation and Maintenance	L-29
L-12	Summary of Annual O&M Costs	L-33

LIST OF EXHIBITS

Exhibit No.	
L-1	Cost Estimate - Recommended Scheme
L-2	Cost Estimate Alternative 1

Appendix L

COST ESTIMATES

Introduction

Estimates have been made of the construction cost of Project facilities and the annual cost of operating the Project. The construction costs for the storage, power, diversion, and irrigation facilities, the main canal repair and extension and all associated operation costs are presented in detail in this Appendix. The costs used in the estimates represent the prevailing rates during January 1977. The estimates are based on the assumption that the Project will be constructed by international contractors without restrictions on sources of supplies and equipment. Cost estimates for all facilities included in the recommended Stage II development and the alternative which includes conveyance down the Yarmouk River have been prepared at the feasibility level. Estimated costs have been separated into national and foreign currency components. All costs are expressed in Jordan Dinars (JD); an exchange rate of JD 1.00 equals U.S. $3.00 has been used. The costs of other alternatives for Stage II development and the option for Stage III development have been prepared at appraisal level.

Project Construction Costs

The Project construction cost includes land acquisition, relocation and access, civil works, permanent equipment, Operators' Village, contingencies, engineering and administration, and escalation during construction.

The national component of the cost includes construction labor, fuel, lubricants, local transportation, and other

items that are available locally. The foreign component includes costs of supervisory personnel, construction equipment and spare parts, cement, reinforcing steel, piping and electrical materials, and permanent mechanical and electrical equipment.

Access

The existing access road to the damsite will be made unusable because of the spillway excavation. A new road will be constructed beginning from the existing road at about El. 300 on the left abutment. The new road will proceed west to the small wadi immediately downstream from the damsite, north to the Yarmouk River Valley floor, and east to the damsite. From this road to the valley floor, a second road will be constructed to provide access to the dam crest by way of a bridge across the spillway. A third road segment will be required to the powerhouse. The total length of access road will be 4.8 km.

Land Acquisition

The cost allocation for land acquisition for the Maqarin storage project includes all land in the reservoir plus lands for project structures, the relocation of the railroad, borrow areas, transmission lines, and temporary structures. The reservoir areas were taken from the reservoir area curve; the area for Project structures and borrow areas was estimated from 1:25,000 scale maps; the railroad relocation areas were based on the length and a 50 m right-of-way; and the transmission lines were based on the length and a 20 m right-of-way. The acquisition areas are shown in Table L-1. The value of these lands is based on an estimate for Maqarin Reservoir which was supplied by the JVA. The value of the reservoir lands was based on field inspections and discussions with appropriate local agencies.

Table L-1

LAND ACQUISITION

Dam	Reservoir Crest Elevation	Reservoir R/W Elevation	Reservoir Area (km^2)	Project[a] Structures (km^2)	Railroad Relocation (km^2)	Total Area (km^2)
Maqarin	158	170	8.7	3.2	1.1	13
Maqarin	168	190	10.4	3.2	1.2	15
Maqarin	200	220	13.1	3.6	1.3	18
Khalid	20	40	10.5	3.2	1.3	15

[a] Includes dam, powerplant, diversion structures, borrow areas, transmission lines, operators' village.

Railroad Relocation

The unit prices for earthwork, culverts, and rubble masonry walls were based on current expenditures for similar works in Jordan. The cost of tunnels and bridges was based on construction done in 1971 escalated to reflect 1977 prices. The cost of the tracks and sleepers was based on estimates for another line in Jordan prepared by Sofrerail, Paris France, in May 1976. The price for ballast was taken from a current ballast contract.

Storage and Power Facilities

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

Irrigation Facilities

The unit prices for the irrigation facilities are based on prices submitted in tenders for recent contract awards for construction of on-going sprinkler development projects in the Jordan Valley. Adjustments have been made to reflect updated quotations by manufacturers, wage indices, etc.

The unit prices for the irrigation facilities are for in-place finished products in full working order, and include contractor's overhead and profit.

Excavation and Compaction. Excavation covers the specified removal and placement of common and rock materials, while compaction includes excavation from borrow, supply of water, overhaul and specified placement of earth mterials. Excavation and compaction are associated with the canal.

Concrete. Prices cover labor, materials, additives, fillers, pads, formwork, etc. Class A concrete was used for all reinforced concrete structures (350 kg of cement per cubic meter). Class B concrete was used for canal lining and raising of existing Zarqa Weir (300 kg of cement per cubic meter). Price also covers trimming and finishing of surface underneath the canal lining. Class C cement was used for blinding (200 kg of concrete per cubic meter).

Metal Work. This item covers the steel reinforcing used for concrete structures, and other metal works required for construction of the canal and diversion structures, and the steel pipes for road crossings. The latter are measured by weight and priced accordingly.

The prices cover acquisition, fabrication, and installation of the reinforcing steel (considered as High Tensile) and for the other metal works, including the steel pipes required for the road crossings. Fabrication includes all

cutting, welding, assembling, and fitting into into place. The steel gates prices include the gates with all frames, hoists, emergency stop log grooves and other fixtures.

Asbestos Cement Pipes. The prices for asbestos-cement pipe include the purchase price of the pipe, its couplings, transport and handling, excavation, bedding, and backfilling of the trench and the pipe installation. The price of grading the surface of the service road and installing surface drains is also included.

For the Conversion Lands a differential price per kilometer of existing network is provided for irrigation carry overs and for keeping the existing surface irrigation systems operative during construction. The price of JD 500.00 per kilometer was arrived at for each of the foreign and local components.

Pipelines Appurtenances. This item includes all valves, pipe fittings and thrust blocks. The price of valves is for cast iron manufacture, and includes all flanges and bolts, flanged adaptors and mechanical couplers. The price of fittings includes all reducers, tee and cross-sections, elbows of different angles, angle branches, etc. The price of thrust blocks is for the blocks installed in place with dimensions according to the fitting they support.

Based on previous detailed inventories of similar sprinkler systems in the Jordan Valley, the following estimates - in percent of the price of pipes were made:

Item	Cost of Item in Percent of Cost of Pipes
Fittings	11%
Valves	5%
Thrust Blocks	6%

Farm Turnout Assemblies. These include gate valves, pressure regulators, flow regulators, flow meters and the required fittings to produce a unit. The price includes all labor, material, transport, and installation, as well as the guard rails for protection. The price is based on "on site" assembly of the turnouts, and a nominal diameter of the feeder and turnout branches of 100 mm.

Farm Equipment. This item includes both the fixed farm equipment i.e., the 100 mm buried main and 75 mm farm hydrants with their risers - and the portable farm equipment i.e. the valve opening elbow and the 174 m long 75 mm sprinkler line complete with couplers, sprinklers risers and stabilizing shoes. A provisional price of JD 150 per farm was added to the price of portable equipment in the Conversion Lands to make up for irregularities in farm shape and deviations from the standard farm. Although the cost estimates are based on this single 75-mm flyline system, it is expected that design studies will confirm that an alternate three 50-mm flyline system is preferable. The alternate system results in reduced application rates and energy requirements.

	Unit	National Currency (JD)	Foreign Currency (JD)
Fixed Farm Equipment	farm	120.000	680.000
Portable Farm Equipment (New Lands)	farm	35.000	315.000
Portable Farm Equipment (Conversion Lands)	farm	50.000	450.000

Pumping Stations. The unit price of every pumping station is a lump sum covering all mechanical, electrical, and civil components of the station.

The civil works include all concrete structures and buildings to house the pumps, motors and appurtenances, and provide enough space for handling and repair of the foregoing i.e. panel board room, workshop, etc.

The mechanical equipment inlcudes the intake and outlet mainfolds with all gates and fittings to ensure proper connection with the centrifugal pumps. It also includes all safety and emergency pressure reliefs, hydraulic valve controls and others.

The electrical equipment includes step-down transformers, motor-control centers, circuit breakers, starters, cooling fans, and all other lighting and earthing fixtures. No provision is made for stand-by diesel generators.

From on-going similar projects and recent quotations from different manufactuers, a unit price per brake horse power was established according to the following schedule. The unit price includes all works as described above, on-site assembled, and in full working order.

Overall BHP of Pumping Station	Unit	National Currency (JD)	Foreign Currency (JD)
Less than 100	BHP	650.000	1,400.000
100 - 200	BHP	350.000	800.000
200 - 300	BHP	190.000	450.000
300 - 500	BHP	150.000	370.000
500 - 800	BHP	120.000	280.000
800 - 1,500	BHP	100.000	230.000
More than 1,500	BHP	92.000	218.000

The above unit prices were applied to the specific pumping stations and the amount rounded up to the nearest JD 1,000.

Drainage Works. This item includes all drainage works required for surface runoff, shallow ground water table control and observation wells for recording the ground water table movement.

For surface drains, the unit prices are inclusive of 1) excavation of drain trunk, 2) dumping of excavated materials along the sides to form the berms, 3) any crossings of roads or pipelines, 3) construction of concrete control structures at discharge end of steep slopes to prevent erosion and 5) other miscellaneous works.

In the Conversion Lands, the surface drains are already existing. The price of upgrading these to a full working order is estimated at JD 40 per hectare. This unit price includes reshaping where necessary, installing control sections, culverts and pipe crossings.

For sub-surface drains, the unit price covers the price of the tile drains and all materials and labor required to open the trench, install the tiles, and backfill; as well as the price incurred to excavate the open-drain collectors/ evacuators.

The unit prices for surface and sub-surface drains are prorated by area from on-going similar projects in the Jordan Valley.

The unit price of observation wells includes the price of 1) drilling the well, 2) installing the casings and cap, 3) a concrete pad on the ground surface, 4) a sounding tape for measuring water levels, and 5) all other materials and labor.

Gravel Surfacing of Roads. The unit price includes the price of gravel - 15 cm thick - and rolling. The earthwork is included in the price of the pipe. The price is JD 0.70/m^3 of surface area.

Operator's Housing. The unit price includes all civil works to accommodate two operators with their families, sanitary and mechanical works i.e., indoor installations, percolating pits etc.., electrical fixtures and lighting, and furniture.

Main Canal Turnouts and Rehabilitation. This item covers both the construction of turnouts and rehabilitation of the existing 78 km of the EGMC.

The unit price of the turnouts includes construction of the concrete turnout on the existing canal, and installation of all gates, lifts, guard rails, manhole covers, screens, and other metal works. The turnout is composed of two chambers for alternative operation.

The lump sum price of the rehabilitation of the EGMC includes all earthwork, labor and materials necessary for reshaping of berms, resurfacing of service road, cleaning, repair cracking of the lining. etc.

Zarqa Diversion Weir. This item includes raising of the existing Zarqa weir commanding the on-going Zarqa Triangle Irrigation Project, to accommodate the 1,200 mm gravity carrier to the Rajib-Arda area.

The cost includes all materials and labor to modify the existing weir, for excavation of the neighboring hill to lay the connecting pipes to the desilting basins, and construction of the disilting basins proper; all with gates and miscellaneous work as required.

	Unit	National Currency (JD)	Foreign Currency (JD)
Concrete for Weir + Intake + Gates (600 m^3 of Concrete)	L.S.	7,100	25,900
Excavation			
Common 7,000	m^3	3,400	7,400
Rock 14,000	m^3	12,600	29,500
Desilting Basins + Gates (1000 m^3 of Concrete)	m^3	22,800	67,000
		45,700	129,800
Total (including about 5% for miscellaneous other items)		48,000	137,000

Potential Lands. A lump sum price per area was estimated for these lands based on their high elevation above the source of water, their scattered pattern in small lots, and the necessity of constructing diversion headworks and pumping plants for every few hundred hectares.

The price components are tabulated below:

	Unit	National Currency (JD)	Foreign Currency (JD)
Diversion Headworks	ha	60.00	130.00
Pressure Pipe Distribution Network	ha	200.00	860.00
Farm System	ha	55.00	310.00
Pumping Stations	ha	300.00	580.00
Drainage Works	ha	100.00	100.00
Automation of MC	ha	5.00	10.00
Miscellaneous	ha	100.00	100.00
Total		1,820.00	2,090.00
Use		1,000.00	2,400.00

Diversion Headworks. Three weirs with all appurtenances are required on the Yarmouk, Zarqa and Kufrinja wadis. For the other four areas of the potential lands, connection with the existing system is anticipated.

Pressure pipe network. Costs were prorated from the gravity area between wadi Rajib and Arda, and increased by 30 percent because of the parcellation of the areas.

The farm system. Cost is the same as that of the Conversion Lands.

Pumping Stations. Costs were taken from the costs per BHP presented earlier, for average pump sizes between 200 and 300 BHP with the national component increased to overcome hardship in construction.

Drainage Works were estimated at JD 200/ha for all surface and subsurface problems.

Miscellaneous costs were based on the cost of the New Lands, and increased slightly to allow for the inaccessibility of sites and additional clearing required.

Automatic Water Surface Control

The assumed cost of automation is arrived at in the following manner:

a) Motorizing radial gates, with DC operated motors and solar battery chargers.

34 at JD 6,000 = JD 204,000

b) Water level controls at 40 locations with housing.

40 at JD 250 = JD 10,000

c) The additional cost of building the Main Canal Extension with 5 cms/km and additional storage facility, reduced by the saving of not building check structures is JD 50,000.

d) Motorizing the storage release gates at Maqarin and the gates at EGMC intake, JD 97,500.

Total Cost = JD 361,500

Permanent Equipment

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

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

Operators Village

The operators' village will consist of about 12 houses, a warehouse, a shop, and the necessary roads and utilities. The cost included in the estimate will be used to rehabilitate the engineers' and owners' camp to provide the necessary facilities.

Contingencies

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

Engineering and Administration

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

Escalation During Construction

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

Costs for Stage II Development

Recommended Scheme. The cost for the recommended scheme for Stage II development is shown on Exhibit L-1 and is summarized in Table L-2. The total construction cost, which includes contingencies, engineering and administration, and escalation during construction is JD 208.8 million.

The costs are for the following major elements:

1. Maqarin Dam at Crest El. 158,
2. 20-MW powerplant at Maqarin Dam,
3. 2.0-MW powerplant at King Talal Dam,
4. Diversion dam at entrance to the EGMC,
5. Three side-wadi diversion structures,
6. 14.5 km extension to the EGMC and repair of the existing canal, and
7. Sprinkler irrigation facilities for 25,353 ha.

Alternative 1. If it is not possible to construct a diversion dam at Adasiye, diversion can be accomplished by constructing two intakes and two tunnels to the EGMC and constructing Maqarin Dam to Crest El. 168. Without a cross-river structure for water control at the irrigation intake, the regulated discharge from Maqarin Reservoir must be large enough to serve the irrigation requirements with some water passing the intake. A summary of the cost for Alternative 1 is shown in Table L-3; a detailed estimate is shown on Exhibit L-2. The total construction cost is JD 219 millions. The facilities different from those listed in the previous subsection are shown below.

1. Maqarin Dam at El. 168
2. Two intakes to the EGMC, and
3. 22-MW powerplant at Maqarin Dam.

Table L-2

STAGE II DEVELOPMENT-RECOMENDED SCHEME
SUMMARY OF CONSTRUCTION COST

(JD X 1000)

	Total Cost
Land, Relocation, & Access	6,597
Operators' Camp	500
Diversion and Control of Water	3,483
Dam	31,111
Spillway	16,364
Outlet	413
Subtotal	58,468
Power Facilities - Maqarin Dam	4,033
Power Facilities - King Talal Dam	465
Subtotal	4,497
Diversion Facilities - Adasiye, Wadis Yabis, Kufrinja and Rajib	263
Main Canal Repair and Extension	1,888
Irrigation Facilities - New Lands	15,699
Irrigation Facilities - Converted Land	20,565
Irrigation Facilities - Potentially Irrigable Land	6,425
Subtotal	44,577
Subtotal Direct Cost	107,806
Contingencies	16,720
Total Direct Cost	124,526
Engineering and Administration	19,174
Total Construction Cost - 1977	143,700
Escalation to end of Construction	65,050
Total Construction Cost	208,750
Total Construction Cost including portable farm system	213,536

Table L-3

STAGE II DEVELOPMENT - ALTERNATIVE 1
SUMMARY OF CONSTRUCTION COST
(JD x 1000)

	Total Cost
Land, Relocation and Access	7,169
Operators' Camp	500
Diversion and Control of Water	3,516
Dam	34,829
Spillway	16,460
Outlet	417
Subtotal	66,028
Power Facilities - Maqarin Dam	4,109
Power Facilities - King Talal Dam	465
Subtotal	4,574
Diversion Facilities - Adasiye, Wadis Rajib Kufrinja and Yabis	1,459
Main Canal Repair and Extension	1,888
Irrigation Facilities - New Lands	15,699
Irrigation Facilities - Coverted Land	20,565
Irrigation Facilities - Potentially Irrigable Lands	6,425
Subtotal	44,577
Subtotal Direct Cost	113,501
Contingencies	17,777
Total Direct Cost	131,278
Engineering and Administration	20,174
Total Construction Cost - 1977	151,452
Escalation to end of Construction	67,498
Total Construction Cost	218,950
Total Construction Cost including portable farm system	223,400

Alternative 2. The second alternative to the recommended Stage II development consists of a 25 km concrete-lined, 2.2 m diameter tunnel from Maqarin Reservoir to the Wadi Arab basin. A 40-MW powerplant would be located at the end of the tunnel.

This alternative would have no losses associated with the release of reservoir flows into the EGMC because of the control afforded by Wadi Arab Dam. Therefore, Maqarin dam at El. 158 will provide enough water to meet the needs of Stage II development. The storage facilties would be the same as those described for the recommended development.

The cost of a project which will serve the Stage II irrigation requirements by diverting water from the Maqarin reservoir directly to the Wadi Arab reservoir is shown on Table L-4. No cost is included for storage and conveyance facilities on the Wadi Arab because it is assumed these facilities will be constructed as part of the Stage I development.

Cost of Stage III (Ultimate) Development

Ultimate development of the Jordan Valley Project will make full use the water available from the Yarmouk River. Ultimate development will require construction of the following elements.

1. The Maqarin storage project raised to provide a reservoir at El. 193. (Crest El. 200)
2. New generating equipment with a rated capacity of 28 MW installed in the Maqarin Powerplant.
3. A storage project at the Khalid site with a reservoir at El. 12. (Crest El. 20).

Table L-4

STAGE II DEVELOPMENT - ALTERNATIVE 2
MAQARIN - WADI ARAB PROJECT
SUMMARY OF CONSTRUCTION COST

(JD 1,000)

	Total Cost
Land, Relocations, & Access	6,597
Diversion and Care of Water	3,483
Outlet Works	413
Dam and Diversion Facilities	31,374
Spillway	16,364
Water Conductor	22,427
Power Facilities[a/]	2,880
Operators Village	500
Irrigation System	44,577
Subtotal Direct Cost	128,615
Contingencies	21,265
Subtotal	149,880
Engineering & Administration	17,236
Total Construction Cost (1977)	167,116
Escalation to end of Construction	75,864
Total Construction Cost	242,800

At Wadi Arab and at King Talal Dam.

4. A 10-MW powerplant at Khalid Dam
5. Sprinkler irrigation facilities, including mainline conveyance for 5,147 ha.

Maqarin Dam, initially constructed for Stage II development, will be raised to El. 200. A new spillway, to be constructed farther up the abutment, will include three gates and a chute similar to the Stage II chute. The Stage II spillway gates and hoists will be moved to the new spillway. The low-level outlet, constructed in the diversion tunnel for the Stage II project, will be modified, for use as part of the ultimate development.

The Stage II powerplant will be modified to operate satisfactorily under the higher head conditions. The plant will contain two new generating units with an installed capacity of 28 MW. The Stage II transmission line from the powerplant to Irbid will serve the needs of the ultimate development.

Khalid Dam will be located on the Yarmouk River downstream from the mouth of Wadi Raqqad. A chute-type spillway with a discharge capacity of 5600 m^3/s will be located in the right abutment. A low-level outlet will be provided through the power intake and the diversion tunnel. A powerplant with an installed capacity of 10 MW will be located at the base of Khalid Dam on the right abutment. The plant will include two 5.0 MW generating units and will be connected to the national grid by a transmission line to the Maqarin substation. A sprinkler irrigation system will be provided for 5,147 ha.

The railroad, which was relocated during Stage II construction to El. 165, will be relocated around the raised Maqarin Reservoir and Khalid Reservoir. The total length of the Stage III relocation would be about 40 km. The construction cost of the Stage III storage and power facilities is shown in Table L-5.

Table L-5

STAGE III STORAGE AND POWER FACILITIES
CONSTRUCTION COSTS

(JD 1000)

	Total Cost
Maqarin Storage Project	
Dam	21,464
Spillway	15,532
Power Facilities (Incremental)	755
Subtotal	37,751
Contingencies	7,550
Engineering and Administration	6,299
Subtotal Maqarin Storage Project	52,100
Khalid Storage Project	
Land, Relocation, and Access	12,440
Diversion & Care of Water	2,041
Dam	31,369
Spillway	8,938
Outlet Works	686
Power Facilities	1,840
Operation Village	500
Subtotal	57,814
Contingencies	11,563
Engineering & Administration	10,406
Subtotal Khalid Storage Project	79,783
Total Construction Cost (1977)	131,883
Escalation During Construction	59,117
Total Construction Cost	191,000

The costs shown for Maqarin are for raising the dam and spillway from crest El. 158 to El. 200, plus the cost of modifying the powerplant. As shown on Table L-5, the 1977 cost of Stage III storage and power facilities is JD 131.9 million. The Stage II storage and power facilities are estimated to cost JD 86.9 million giving a total cost of JD 218.8 million for the ultimate development storage and power facilities.

Single Stage Project at Maqarin

A preliminary evaluation was made of the cost of constructing a project at Maqarin without provision for raising. The costs estimated for the single stage project give an indication of the portion of the initial project cost that is necessary for providing a raisable project at Maqarin.

The estimated costs of a single stage project at Maqarin are shown on Table L-6.

Table L-6

SINGLE STAGE STORAGE AND POWER FACILITIES
CONSTRUCTION COSTS

(JD 1000)

	Crest of Dam	
	El. 158	El. 200
Land, Relocations and Access	6,597	8,477
Diversion and Care of Water	3,483	3,525
Outlet Works	413	581
Dam	25,683	51,580
Spillway	16,364	18,182
Power Facilities	4,497	4,051
Operators Village	500	500
Irrigation System	44,577	44,577 a/
Subtotal Direct Costs	102,114	131,473
Contingencies	15,965	21,837
Subtotal	118,079	153,310
Engineering & Administration	17,711	22,990
Total	135,790	176,300

a/ Stage II irrigation facilities.

Annual Operation Costs

The annual operation costs were developed for the storage and power facilities, and for the irrigation system.

Experience data collected by the U.S. Federal Power Commission[1/] (FPC) was used as a basis for estimating operating costs for the storage and power facilities. The FPC data were used, with adjustments to current conditions, because data are not available for hydroelectric stations in Jordan. The operating cost for the irrigation facilities was based on an assessment of the cost of required personnel, equipment, spare parts, energy, materials and supplies, and general property maintenance. In addition, an allowance for installing a subsurface drainage system was included.

Storage and Power Facilities

The annual operation cost for the storage and power facilities includes an allowance for operation and maintenance (O&M), interim replacements, insurance, and administration and general expense. The operation cost was developed on the basis of a combined operation of the dam and powerplant and separated into component costs for storage and power. The storage component is for operation of the Project facilities for irrigation. The irrigation releases will be made through the powerplant and, therefore, part of the cost of operating the powerplant can be allocated to irrigation. The power component is an incremental cost which represents the additional operation cost allocable to power.

The operation cost of the King Talal powerplant also represents an incremental component wholly allocated to power. The operation cost for the King Talal storage facility is not included in the Project O&M cost because the dam is not a part of Stage II development.

Hydroelectric Power Evaluation, Federal Power Commission, 1968.

Operation and Maintenance. The O&M cost is based on experience data collected by the FPC for manually-operated conventional hydroelectric plants of the appropriate capacity. The reported value was escalated to represent January 1977 values. O&M costs for transmission lines are related to the line length, nominal voltage, and type of pole. Estimated values are based on a 69 kV single-circuit line using steel towers and amount to JD 52/km. O&M costs are shown in Table L-7.

Table L-7

OPERATION AND MAINTENANCE COSTS FOR DAM AND POWERPLANT

	Maqarin Dam and Powerplant	King Talal Dam and Powerplant
Installed Capacity	20 MW	2 MW
Transmission Line	31 km	9 km
Total O&M	JD 66,600	JD 40,500

Interim Replacement. The interim replacement costs will be used to finance units of property with life spans less than the overall facility service life. The replacement costs are based on an evaluation period of 50 years. The annual amount used for interim replacement of the power facilities is equal to 0.4 percent of the investment cost; for the transmission facilities is equal to 0.35 percent of the investment cost; and for the storage facilities is 0.03 percent of the investment cost. The interim replacement costs are shown in Table L-8.

Table L-8

INTERIM REPLACEMENT COSTS FOR
DAM AND POWERPLANT

	Annual Cost JD
Maqarin Dam	28,000
Maqarin Powerplant	22,000
Maqarin Transmission Line	3,400
King Talal Powerplant	2,400
King Talal Transmission Line	800

Insurance. The annual cost of insurance for fire, storm, vandalism, equipment, public liability, and property damage averages about 0.1 percent of the investment cost. The annual allowance for Maqarin storage and power facilities is JD 101,000 and for King Talal power facilities is JD 1,000.

Administration and General Expenses. The administration and general expenses are for administrative and general salaries, regulatory expenses, outside services employed, injuries and damages, welfare, pensions, and miscellaneous expenses. These expenses were estimated on the basis of FPC experience data to equal about 40 percent of the operation and maintenance cost.

Summary. The operation costs for storage and power facilities are summarized below. The O&M costs for the powerplants is estimated to be about 15 percent of the total O&M cost.

Table L-9

OPERATION COSTS FOR DAM AND POWERPLANT
(JD X 1000)

	Maqarin Dam	Maqarin Powerplant	King Talal Powerplant
O&M	58	19	6
Interim Replacement	28	26	3
Insurance	95	6	1
Admin. & General Expenses	22	4	3
Total	205	45	13

Irrigation Facilities

Based on the operation and maintenance program presented in Appendix K, Irrigation Facilities, the following annual costs were developed for the total project area. All costs of power, daily operation and maintenance, transportation to and in the project area, heavy and light duty equipment and vehicles, spare parts, fuel and other running costs were considered as detailed in the following sections. These costs exclude office buildings and wire/wireless communications, assumed to be provided by the Authority.

Personnel for Operation and Maintenance. The personnel considered for operation and maintenance of the whole project area are assumed to handle all administrative and technical problems that may arise during the expected life of the project. One primary function of the Operation and Maintenance Board would be to forecast water requirements, and deliver and rotate water among consumers.

In Table L-10 the number of personnel required for each category, the annual wage rate, and the annual total cost

222

Table L-10

PERSONNEL REQUIRED FOR OPERATION AND MAINTENANCE OF IRRIGATION FACILITIES

Title	No.	Wage Rate (JD/yr)	Annual Cost (JD/yr)
Manager	1	6,000	6,000
Assistant Manager	2	5,400	10,800
Engineer	3	3,600	10,800
Water Master	3	3,600	10,800
Ditch-Rider	55	1,200	66,000
Pump Operator	35	1,800	63,000
Office Staff	15	1,500	22,500
Maintenance Foreman	4	1,200	4,800
Concrete Man	3	960	2,880
Pump Mechanic	4	1,800	7,200
Electrician	2	1,800	3,600
Carpenter	4	1,920	7,690
Shop Welder	1	1,800	1,800
Machinist (lathe)	1	1,800	1,800
Mechanic	4	1,800	7,200
Shop Assistant	6	1,500	9,000
Driver	25	1,100	27,500
Guard	30	600	18,000
Heavy Equipment Operator	4	1,800	7,200
General Equipment Operator	14	1,500	21,000
Laborer	60	600	36,000
	Total		345,560
	Plus 30% for Overhead		103,670
			449,230
	TOTAL		JD 450,000

are given. The annual wage rate is based on a compromise between the government wage index and private sector rates.

Overhead and fringe benefits are estimated at 30 percent assuming the development project as non-profit.

Equipment for Operation and Maintenance. Covered in this section are all heavy and light duty vehicle required for daily operation, inspection and maintenance of the project. Each vehicle is assigned a driver as may be summarized from the personnel considered.

Table L-11 gives, for every type of equipment, the number required, its initial duty free cost in Jordan, its estimated life and salvage value, and the annual cost based on a 9 percent interest rate.

O&M of Service Equipment. This item covers the operation and maintenance of the equipment used to run the project as detailed earlier.

The cost covers fuel and lubricants maintenance, spare parts, repair, etc.

O&M	90,000
Spare Parts @ 5% of Initial cost	18,000
Total	108,000

Energy. The power and energy for the irrigation facilities will be supplied from the Project power generation facilities. The Project facilities will not be able to provide all of the required energy when needed and, therefore, a cost for exchanging energy with the JEA is included in the O&M cost. The cost includes provision for transmitting power and energy over the interconnected transmission system and amounts to JD 0.0025/kWh.

Table L-11

EQUIPMENT FOR OPERATION AND MAINTENANCE

Item		Quantity No.	Estimated Life years	Total[a/] Initial Cost JD	Salvage Value JD	Present[b/] Worth JD	Annual[c/] Cost JD
1.	Automobile	1	5	2,100	400	1,850	490
2.	Pickup (1/2 ton)	16	5	22,200	5,400	18,850	4,970
3.	Jeep (4 Wheel Drive)	8	5	13,900	2,700	12,220	3,220
4.	Motor Bike	55	5	13,500	-	13,500	3,560
5.	Dump Truck (3 m^3)	4	6	21,600	3,900	19,400	4,450
6.	Flat Bed Truck	2	6	7,000	1,300	6,270	1,440
7.	Water Truck (5700 l)	1	6	5,400	1,100	4,780	1,100
8.	Tractor Dozer (D-6 Equiv.)	2	10	71,100	13,500	65,900	10,730
9.	Mobile Shop (Fully Equipped)	1	10	26,300	5,000	24,390	3,970
10.	Concrete Mixer	2	10	2,000	-	2,000	330
11.	Road Grader (125 HP)	2	10	43,100	7,700	40,130	6,530
12.	Wheel Loader	1	10	21,400	3,800	19,930	3,240
13.	Fork Lift (2 ton)	1	12	7,700	1,400	7,250	1,060
14.	Drag-Line, Truck Mounted	1	15	40,500	11,700	37,700	4,960
15.	Drag-Line, Tractor Mounted	1	15	34,400	9,000	32,250	4,240
16.	Tractor Trailer (Truck)	1	25	16,000	3,000	15,720	1,730
17.	Hoist-Truck (Crane-5 Ton)	1	25	14,200	2,000	13,950	1,540
	Total			362,400	72,600	336,090	57,560
						Say	58,000

a/ Quantity multiplied by unit cost.

b/ Initial cost less present worth of salvage value of 9 percent.

c/ Present worth multiplied by capital recovery factor at 9 percent for estimated life.

The total operating power of the 18 pumping plants as shown in Table VII-3 is 7,056 BHP, with a cumulative flow of 6,265 l/s.

Assuming an 87 percent efficiency of the electric motors, the total electric power required is:

$$7{,}056 \times \frac{100}{87} \times \frac{75}{100} = 6{,}083 \text{ kW}$$

Say 6,100 kW

With a capacity of 6,265 m^3/s the total annual design water requirements of the 10,278.5 ha commanded by the subject pumping plants, i.e. 107 million m^3/yr would require about 5,500 hours of operation. Following is the calculation procedure.

HP 43, HP 48, and all CLP stations fall in the North Zone, with a total area of 7,525.4 ha and require 972.1 mm/yr or 73,154,414 m^3/yr.

HP 99, HP 103, HP 107, HP 110, LP 98 LP, LP 104 and LP 109 stations fall in the South Zone with a total area of 2,753.1 ha and require 1,204.0 mm/yr or 33,147,324 m^3/yr.

The total flow of 106,301,738 cubic meters takes 4,173 hours to be pumped at a rate of 6.265 m^3/s. Therefore, the total kWh required is:

6,100 x 4,713 = 28,750,000 kWh for both the New and Conversion Lands.

For the Potential Lands, an estimate of the consumption was arrived at by proration of area, as follows:

276

$$28{,}750{,}000 \times \frac{1{,}947 \text{ ha}}{(10{,}564 + 13{,}842) \text{ ha}} = 2{,}293{,}488 \text{ kWh}$$

Say 2,294,000 kWh

$$6{,}100 \times \frac{1{,}947 \text{ ha}}{(10{,}564 + 13{,}842)} = 486.6 \text{ kW}$$

Say 500 kW

The total project consumption amounts to 31,044,000 kWh. The total annual charge for power is 31,044,000 x 0.0025 = JD 77,610 (say JD 78,000).

Spare Parts for Pumping Stations. These are estimated at an annual rate of 1 percent of the cost of the stations.

$$4{,}955{,}000 \times \frac{1}{100} = \text{JD } 49{,}550/\text{yr}$$

Say JD 50,000/yr

Office Supplies. These cover all stationary, publications, printing, and other supplies to run the O&M offices. The estimate is JD 35,000 per year.

Maintenance Materials. This item covers cost for maintenance materials such as cement, aggregate, lumber, steel and other necessary materials. The estimated cost for these materials is JD 50,000 per year.

General Property Maintenance. This cost is associated with the maintenance required to keep the office buildings in proper operating order, and is estimated at JD 25,000 per year.

Subsurface Drainage

The requirements for subsurface drainage are expected to be limited with the introduction of sprinkler irrigation. Based on data collected from a groundwater monitoring network the subsurface drains will be installed where required. An allowance of JD 130,000 per year is included in the operation cost. This allowance will provide for the installation of a subsurface drainage system for about 250 ha per year. The drains will be discontinuous concrete pipe or perforated polyethalene tubing. The drains will be 15 cm to 20 cm in diameter and installed at a depth of two meters. It is estimated that subsurface drainage will be required for about 5,500 ha. The cost for 500 ha is included in the Project construction cost. The installation period for subsurface drainage of the remaining area was phased over a 20-year period and is related to the need in the area for drainage under Project conditions. This need presently is not known and can only be determined by monitoring conditions as development progresses.

Summary

A summary of the annual O&M costs for the Project is shown in Table L-12.

229

Table L-12

ANNUAL OPERATION AND MAINTEANNCE COSTS

Item	O&M JD/yr
Maqarin Dam	205,000
Maqarin Powerplant	45,000
King Talal Powerplant	13,000
Irrigation Facilities	
Personnel	450,000
Equipment - Amortization	58,000
- Fuel, Maintenance and Spare Parts	108,000
Pumps - Energy	78,000
- Spare Parts	50,000
Office Supplies	35,000
Maintenance Materials	50,000
General Property Maintenance	25,000
Subtotal	854,000
Subsurface Drainage	130,000
Total	1,247,000

229

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Diversion and Control of Water							
Diversion Portal and Tunnel							
Excavation, Common	37,600 m^3	0.25	9,400	0.50	18,800	0.75	28,200
Excavation, Rock	6,000 m^3	1.00	6,000	2.00	12,000	3.00	18,000
Concrete, Portal	1,900 m^3	21.00	39,900	41.00	77,900	62.00	117,800
Excavation, Tunnel	45,300 m^3	7.00	317,100	12.00	543,600	19.00	860,700
Concrete Tunnel	15,420 m^3	19.00	292,980	38.00	585,960	57.00	878,940
Consolidation Grouting	900 l.m.	56.00	50,400	80.00	72,000	136.00	122,400
Concrete Plug	1,000 m^3	11.00	11,000	20.00	20,000	31.00	31,000
Steel Supports	134,000 kg	0.20	26,800	0.30	40,200	0.50	67,000
Shotcrete & Wire Mesh	11,600 m^2	3.00	34,800	4.70	54,520	7.70	89,320
Rock Bolts	2,110 l.m.	3.00	6,330	6.00	12,660	9.00	18,990
Upstream Cofferdam							
Fill	267,600 m^3	0.75	200,700	1.75	468,300	2.50	669,000
Slurry Trench & Core	L.S.		22,000		49,000		71,000
Downstream Cofferdam							
Fill	37,800 m^3	0.75	28,350	1.75	66,150	2.50	94,500
Slurry Trench & Core	L.S.		17,000		38,000		55,000
Pumping	L.S.		25,000		28,000		53,000
Diversion Closure Gate	L.S.		89,000		194,000		283,000
Closure	L.S.		5,000		20,000		25,000
Subtotal			1,181,760		2,301,090		3,482,850

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Main Dam							
Excavation - Common	2,374,000 m^3	0.30	712,200	0.60	1,424,400	0.90	2,136,600
Excavation - Rock	780,000 m^3	0.90	702,000	1.80	1,404,000	2.70	2,106,000
Consolidation Grouting	L.S.		77,280		115,920		193,200
Curtain Grouting	L.S.		444,900		667,300		1,112,200
Drainage Adits and Drains	L.S.		220,000		330,000		550,000
Special Foundation							
Inspection and Treatment	L.S.		350,200		650,500		1,000,700
Grouting Gallery and Adits	L.S.		280.000		420,000		700,000
Embankment							
Impervious Core	2,560,000 m^3	0.65	1,664,000	1.10	2,816,000	1.75	4,480,000
Impervious Talus	1,350,000 m^3	0.60	810,000	0.90	1,215,000	1.50	2,025,000
Fine Filter	300,000 m^3	1.40	420,000	2.55	765,000	3.95	1,185,000
Coarse Filter	260,000 m^3	1.40	364,000	2.55	663,000	3.95	1,027,000
Random Rockfill							
(from Req'd Excav.)	2,000,000 m^3	0.25	500,000	0.35	700,000	0.60	1,200,000
(from Borrow)	830,000 m^3	0.60	498,000	0.90	747,000	1.50	1,245,000
Alluvium	3,140,000 m^3	0.60	1,884,000	0.90	2,826,000	1.50	4,710,000
Basalt Rockfill							
(from Req'd Excav.)	227,000 m^3	0.25	56,750	0.35	79,450	0.60	136,200
(from Borrow	2,713,000 m^3	0.80	2,170,400	1.50	4,069,500	2.30	6,239,900
Random Fill	940,000 m^3	0.25	235,000	0.35	329,000	0.60	564,000
Instrumentation	L.S.		100,000		400,000		500,000
Subtotal			11,488,730		19,622,070		31,110,800

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Spillway							
Approach Channel							
Open-Cut Excavation-Common	302,600 m^3	0.30	90,780	0.90	181,560	0.90	272,340
Open-Cut Excavation-Rock	1,125,200 m^3	0.55	618,860	1.10	1,237,720	1.65	1,856,580
Reinforced Concrete Training Wall	21,400 m^3	21.00	449,400	42.00	898,800	63.00	1,348,200
Mass Concrete in Training Wall	50,550 m^3	11.00	556,050	20.00	1,011,000	31.00	1,567,050
Ogee and Chute							
Open-Cut Excavation-Common	717,500 m^3	0.35	251,120	0.65	466,380	1.00	717,500
Open-Cut Excavation-Rock	1,794,500 m^3	0.80	1,435,600	1.20	2,153,400	2.00	3,589,000
Mass Concrete for Ogee	32,400 m^3	11.00	356,400	20.00	648,000	31.00	1,004,400
Reinforced Concrete for Piers	44,000 m^3	21.00	924,000	42.00	1,848,000	63.00	2,772,000
Reinforced Concrete for Floor Slab	20,600 m^3	25.00	515,000	45.00	927,000	70.00	1,442,000
Reinforced Concrete for Training Walls	12,100 m^3	21.00	254,100	42.00	508,200	63.00	762,300
Mass Concrete for Flip Bucket	6,100 m^3	12.00	73,200	23.00	140,300	35.00	213,500
Mass Concrete for Gravity Wall	7,400 m^3	11.00	81,400	31.00	229,400	42.00	310,800
Reinforced Concete for Bridge Deck	220 m^3	25.00	5,500	45.00	9,900	70.00	15,400
Compacted Backfill for Walls	56,000 m^3	0.08	44,800	0.90	50,400	1.70	95,200
Rock Anchors	6,800 LM	4.00	27,200	6.00	40,800	10.00	68,000
Spillway Gates 12m x 15m	3	38,500.00	115,500	71,500.00	214,500	110,000.00	330,000
Subtotal			5,798,910		10,565,360		16,364,270

EXHIBIT L-1
SHEET 3 of 14

232

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Low Level Outlet							
Intake Portal							
Excavation - Common	12,000 m^3	0.30	3,600	0.60	7,200	0.90	10,800
Excavation - Rock	3,160 m^3	1.00	3,160	2.00	6,320	3.00	9,480
Reinforced Concrete	300 m^3	21.00	6,300	41.00	12,300	62.00	18,600
Trashrack and Support	43,000 kg	0.55	23,650	0.75	32,250	1.30	55,900
Inlet Tunnel 2.3 m Diameter							
Excavation	380 m^3	22.00	8,360	18.00	6,840	40.00	15,200
Concrete Lining	185 m^3	22.00	4,070	47.00	8,700	69.00	12,770
Steel Supports	5,000 kg	0.20	1,000	0.30	1,500	0.50	2,500
Outlet Conduit							
1.8 m Ø Steel Pipe	127,710 kg	0.40	51,080	0.50	63,850	0.90	114,930
1.8 m Ø Butterfly Valve	L.S.		11,300		22,700		34,000
Concrete Pedestal	150 m^3	21.00	3,150	42.00	6,300	63.00	9,450
Valve House							
Hollow Jet Valve 1.5 m Ø	L.S.		22,300		44,700		67,000
Spherical Valve 1.5 m Ø	L.S.		16,700		33,300		50,000
Concrete in Valve House	50 m^3	25.00	1,250	45.00	2,250	70.00	3,500
Mass Conc. for pipe Support	270 m^3	11.00	2,970	20.00	5,400	31.00	8,370
Subtotal			158,890		253,610		412,500

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Powerplant - Maqarin Dam							
Gate Shafts							
Near Intake							
Excavation - Rock	1,630 m^3	26.00	42,380	22.00	35,860	48.00	78,240
Reinforced Concrete Lining	245 m^3	22.00	5,390	47.00	11,515	69.00	16,905
Reinforced Concrete Superstructure	40	22.00	880	48.00	1,920	70.00	2,800
Reinforced Concrete Foundation	130 m^3	22.00	2,860	52.00	6,760	74.00	9,620
Powerhouse							
Open-Cut Excavation-Common	3,200 m^3	0.35	1,120	0.65	2,080	1.00	3,200
Open-Cut Excavation-Rock	8,400 m^3	0.90	7,560	1.30	10,920	2.20	18,480
Reinforced Concrete	3,200 m^3	22.00	70,400	52.00	166,400	74.00	236,800
Intake							
Open-Cut Excavation - Common	1,000 m^3	0.30	300	0.60	600	0.90	900
Open-Cut Excavation - Rock	1,000 m^3	1.00	1,000	2.00	2,000	3.00	3,000
Reinforced Concrete - Intake	200 m^3	22.00	4,400	52.00	10,400	74.00	14,800
Trashrack and Supports	6,000 kg	0.55	3,300	0.75	4,500	1.30	7,800
Water Conductor (3.2 m Diameter)							
Tunnel Excavation	21,700 m^3	19.00	412,300	16.00	347,200	35.00	759,500
Steel Support	42,000 kg	0.20	8,400	0.30	12,600	0.50	21,000
Rock bolts	2,000 l.m.	3.00	6,000	6.00	12,000	9.00	18,000
Shotcrete & Wire Mesh	18,000 m^2	3.00	54,000	4.70	84,600	7.70	138,600
Concrete Lining	7,090 m^3	15.00	106,350	30.00	212,700	45.00	319,050
Steel Lining	103,000 kg	0.40	41,200	0.50	51,500	0.90	92,700
Concrete behind steel liner	1,100 m^3	15.00	16,500	25.00	27,500	40.00	44,000
Consolidation Grouting	1,770 l.m.	25.00	44,250	37.00	65,490	62.00	109,740
Surge Tank							
Shaft Excavation	2,380 m^3	36.00	61,880	22.00	52,360	48.00	114,240
Concrete Lining	920 m^3	22.00	20,240	47.00	43,240	69.00	63,480
Mechanical Equipment - Maqarin Dam							
Turbine - Governor	2 ea	45,000.00	90,000	255,000.00	510,000	300,000.00	600,000
Spherical Valve, 97 m ø	2 ea	9,000.00	18,000	20,000.00	40,000	29,000.00	58,000
Miscellaneous Mechanical	L.S.		8,000		18,800		26,800
Gates	L.S.		21,000		46,000		67,000
Powerhouse Crane	L.S.		22,000		45,000		67,000
Beams, Valves, & Hoists	L.S.		6,000		13,000		19,000
Electrical Equipment - Maqarin Dam							
Generator	2 ea	20,000.00	40,000	177,000.00	354,000	197,000.00	394,000
Power Transformer	2 ea	5,000.00	10,000	13,000.00	26,000	18,000.00	36,000
Accessory Electrical	2 ea	25,400.00	50,800	54,500.00	109,000	79,900.00	159,800
Subtotal			1,176,510		2,323,945		3,500,455

EXHIBIT L-1
SHEET 5 of 14

234

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Powerplant - King Talal Dam							
Water Conductor							
Excavation Tunnel	215 m^3	26.00	5,590	22.00	4,730	48.00	10,320
Reinforced Concrete Tunnel Lining	60 m^3	23.00	1,380	48.00	2,880	71.00	4,260
Reinforced Concrete Pedestal	10 m^3	23.00	230	48.00	480	71.00	710
Steel Pipe	14,000 kg	0.50	7,000	0.60	8,400	1.10	15,400
Powerhouse							
Open-Cut Excavation - Common	2,450 m^3	0.60	1,470	1.40	3,430	2.00	4,900
Excavation - Rock	800 m^3	1.00	800	2.00	1,600	3.00	2,400
Reinforced Concrete - Substructure	135 m^3	23.00	3,105	55.00	7,425	78.00	10,530
Reinforced Concrete - Superstructure Ring Wall	140 m^3	23.00	3,220	55.00	7,700	78.00	10,920
Miscellaneous	65 m^3	23.00	1,495	55.00	3,575	78.00	5,070
Steel Girder	1,530 kg	0.30	460	0.70	1,070	1.00	1,530
Outlet Structures							
Structural Concrete	75 m^3	23.00	1,725	55.00	4,125	78.00	5,850
Mechanical Equipment - King Talal Dam							
Turbine - Governor	1 ea	7,800.00	7,800	54,700.00	54,700	62,500.00	62,500
Butterfly Valve 0.82 m Ø	1 ea	1,500.00	1,500	3,100.00	3,100	4,600.00	4,600
Miscellaneous Mechanical	1 ea	1,500.00	1,500	3,500.00	3,500	5,000.00	5,000
Ring Jet & Needle Valve	1	LS	12,000	LS	22,000	LS	34,000
Gates	1	LS	700	LS	1,300	LS	2,000
Beams and Hoists	1	LS	2,200	LS	4,000	LS	6,200
Butterfly Valve 0.5 m Ø	1 ea	1,200.00	1,200	2,500.00	2,500	3,700.00	3,700
Electrical Equipment - King Talal Dam							
Generator	1 ea	8,200.00	8,200	46,800.00	46,800	55,000.00	55,000
Power Transformer	1 ea	2,000.00	2,000	5,000.00	5,000	7,000.00	7,000
Accessory Electrical	1 ea	27,000.00	27,000	64,000.00	64,000	91,000.00	91,000
Subtotal			90,575		252,315		342,890
Transmission Line - 66 kv	LS		187,000		346,400		533,400
Transmission Line - 33 kv	LS		42,700		79,000		121,700
Subtotal			229,700		425,400		655,100

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Diversion near Adasiye							
Dam and Desilting Works							
Diversion and Control of Water	LS		8,100		9,500		17,600
Open-Cut Excavation - Common	2,175 m^3	0.30	655	0.60	1,305	0.90	1,960
Reinforced Concrete - Ogee	816 m^3	25.00	20,400	56.00	45,700	81.00	66,100
Reinforced Concrete - Walls	166 m^3	25.00	4,150	56.00	9,300	81.00	13,450
Reinforced Concrete - Slabs	4 m^3	25.00	100	56.00	225	81.00	325
Reinforced Concrete - Canal Lining	56 m^3	25.00	1,400	55.00	3,080	80.00	4,480
Rockfill	1,460 m^3	1.00	1,460	1.80	2,630	2.80	4,090
Compacted Backfill	265 m^3	1.00	265	2.00	530	3.00	795
Clayey blanket	280 m^3	0.70	195	1.50	300	2.20	615
Protective layer on blanket	200 m^3	2.00	400	3.00	600	5.00	1,000
Miscellaneous Civil Works	200 m^3	LS	3,800	LS	8,400	LS	12,200
Mechanical Equipment							
Tainter Gate & Hoist (1.7mx2.5m)	LS		1,400		2,600		4,000
Trashracks	200 kg	0.55	110	0.75	150	1.30	260
Miscellaneous Mechanical	LS		200		400		600
Subtotal			42,635		84,840		127,475
Wadi Rajib Diversion							
Buttress Embankments							
Open-Cut Excavation - Rock	240 m^3	1.50	360	2.50	600	4.00	960
Reinforced Concrete - Buttress	310 m^3	25.00	7,750	56.00	17,360	81.00	25,110
Spillway & Regulating Bays							
Open-Cut Excavation - Rock	30 m^3	1.50	45	2.50	75	4.00	120
Reinforced Concrete, Spillway, Regulating Bays, Top Slab, Piers	55 m^3	25.00	1,375	56.00	3,080	81.00	4,455
Reinforced Concrete - Aprons	10 m^3	25.00	250	56.00	560	81.00	810
Reinforced Concrete - Stop Logs	1 m^3	30.00	30	70.00	70	100.00	100
Diversion Canal (Length ≐ 400 m)							
Open-Cut Excavation - Rock	620 m^3	1.50	930	3.50	2,170	5.00	3,100
Reinforced Concrete - Canal	140 m^3	25.00	3,500	55.00	7,700	80.00	11,200
Compacted Backfill	260 m^3	1.00	260	2.00	520	3.00	780
0.65m x 0.8m clear opening Sluice Gate	1 ea		350		850		1,200
Hand-operated Hoist	1 ea		40		60		100
Miscellaneous Equipment	LS		60		140		200
Subtotal			14,950		33,185		48,135

236

EXHIBIT L-1
SHEET 7 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Wadi Kufrinja Diversion							
Buttress Embankments							
Open-Cut Excavation - Rock	110 m^3	1.50	165	2.50	275	4.00	440
Reinforced Concrete - Buttress	150 m^3	25.00	3,750	56.00	8,400	81.00	12,150
Spillway & Regulating Bays							
Open-Cut Excavation - Rock	30 m^3	1.50	45	2.50	75	4.00	120
Reinforced Concrete - Spillway, Regulating Bays, Top Slab, Piers	55 m^3	25.00	1,375	56.00	3,080	81.00	4,455
Reinforced Concrete - Aprons	10 m^3	25.00	250	56.00	560	81.00	810
Reinforced Concrete - Stop Logs	1 m^3	30.00	30	70.00	70	100.00	100
Diversion Canal (Length ≐ 1700 m)							
Open-Cut Excavation - Rock	2,590 m^3	1.50	3,885	3.50	9,065	5.00	12,950
Reinforced Concrete - Canal	610 m^3	25.00	15,250	55.00	33,550	80.00	48,800
Compacted Backfill	1,100 m^3	1.00	1,100	2.00	2,200	3.00	3,300
0.65m x 0.8m clear opening Sluice Gate	1 ea		350		850		1,200
Hand-Operated Hoist	1 ea		40		60		100
Miscellaneous Equipment	LS		60		140		200
Subtotal			26,300		58,325		84,625
Wadi Yabis Diversion							
Rock Embankment							
Stripping & Clearing	700 m^3	0.30	210	0.60	420	0.90	630
Rockfill - Embankment	800 m^3	0.70	560	1.40	1,120	2.10	1,680
Removal Concrete Bulkhead	3 m^3		200		400		600
Reinforced Concrete - Stop Logs	1 m^3	30.00	30	70.00	70	100.00	100
Subtotal			1,000		2,010		3,010
Access Roads							
To Damsite and Powerhouse	LS		34,600		61,400		96,000
Bridge	LS		58,000		75,000		133,000
Subtotal			92,600		136,400		229,000
Operating Camp	LS		100,000		400,000		500,000
Land Acquisitions	1,300 ha		468,000				468,000
Relocations, R.R.	LS		1,800,000		4,100,000		5,900,000
SUBTOTAL STORAGE AND POWER FACILITIES			22,670,560		40,558,550		63,229,110

237

EXHIBIT L-1
SHEET 8 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Main Canal							
Main Canal Extension							
Excavation - Common	140,000 m^3	0.45	63,000	1.05	147,000	1.50	210,000
Excavation - Rock	30,000 m^3	0.90	27,000	2.10	63,000	3.00	90,000
Compaction	140,000 m^3	0.45	63,000	1.05	147,000	1.50	210,000
Reinforced Concrete-Structures	4,500 m^3	9.20	41,400	30.80	138,600	40.00	180,000
Concrete - Canal Lining	11,000 m^3	8.70	95,700	29.30	322,300	38.00	418,000
Concrete - Blinding	600 m^3	6.40	3,840	21.60	12,960	28.00	16,800
Siphon Pipe	1,400 l.m.	7.50	10,500	42.50	59,500	50.00	70,000
Gravel Surfacing	44,000 m^2	0.31	13,640	0.39	17,160	0.70	30,800
Reinforcing Steel	350 tons	47.50	16,625	142.50	49,875	190.00	66,500
Metal Work	20 tons	100.00	2,000	300.00	6,000	400.00	8,000
Steel Gates	31	750.00	23,250	2,500.00	69,750	3,000.00	93,000
Rock Protection	1,000 m^3	4.00	4,000	1.00	1,000	5.00	5,000
Subtotal			363,955		1,034,145		1,398,100
Main Canal Repair	LS		164,000		326,000		490,000

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
New Land Irrigation System							
Pressure-Pipe Network							
Asbestos-Cement Pipe - 1000 mm	3,000 l.m.	18.00	54,000	102.00	306,000	120.00	360,000
900 mm	4,000 l.m.	15.70	62,800	89.30	357,200	105.00	420,000
800 mm	1,000 l.m.	11.30	11,300	63.70	63,700	75.00	75,000
700 mm	7,000 l.m.	9.00	63,000	51.00	357,000	60.00	420,000
600 mm	9,500 l.m.	6.80	64,600	38.20	362,900	45.00	427,500
500 mm	6,500 l.m.	4.50	29,250	25.50	165,750	30.00	195,000
450 mm	10,000 l.m.	3.90	39,000	22.10	221,000	26.00	260,000
400 mm	15,000 l.m.	3.30	49,500	18.70	280,500	22.00	330,000
350 mm	9,500 l.m.	2.60	24,700	14.40	136,800	17.00	161,500
300 mm	57,500 l.m.	1.80	103,500	10.20	586,500	12.00	690,000
250 mm	80,000 l.m.	1.50	120,000	8.50	680,000	10.00	800,000
200 mm	67,000 l.m.	1.10	73,700	5.90	395,300	7.00	469,000
150 mm	20,000 l.m.	0.90	18,000	5.10	102,000	6.00	120,000
125 mm	17,000 l.m.	0.60	10,200	3.40	57,800	4.00	68,000
100 mm	44,000 l.m.	0.50	22,000	2.50	110,000	3.00	132,000
Fittings	LS		82,000		460,000		542,000
Valves	LS		37,300		209,000		246,300
Thrust Blocks	LS		44,700		251,000		295,700
Steel Pipe	300 tons	100.00	30,000	300.00	90,000	400.00	120,000
Farm Turnouts							
Single Turnout	740	105.00	77,700	595.00	440,300	700.00	518,000
Double Turnout	1,130	150.00	169,500	850.00	960,500	1,000.00	1,130,000
Subtotal			1,186,750		6,593,250		7,780,000
Farm Systems							
Fixed System	3,000	120.00	360,000	680.00	2,040,000	800.00	2,400,000
Portable System	3,000	35.00	105,000	315.00	945,000	350.00	1,050,000
Subtotal			465,000		2,985,000		3,450,000

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Pumping Stations							
HP - 43	LS		77,000		180,000		257,000
HP - 48	LS		150,000		350,000		500,000
LP - 98	LS		47,000		118,000		165,000
HP - 99	LS		63,000		148,000		211,000
HP - 103	LS		87,000		202,000		289,000
LP - 104	LS		120,000		280,000		400,000
HP - 107	LS		63,000		148,000		211,000
LP - 109	LS		82,000		190,000		272,000
HP - 110	LS		68,000		160,000		228,000
Subtotal			757,000		1,776,000		2,533,000
Drainage Works							
Surface Drains	10,600 ha	67.50	715,500	82.50	874,500	150.00	1,590,000
Observation Wells	50	90.00	4,500	110.00	5,500	200.00	10,000
Sub-surface Drains	230 ha	200.00	46,000	208.00	47,840	408.00	93,840
Subtotal			766,000		927,840		1,693,840
Clearing	LS		40,000		60,000		100,000
Gravel Surfacing	960,000 m^2	0.31	297,600	0.39	374,400	0.70	672,000
Fixtures	LS		30,000		70,000		100,000
Operator Housing	12	6,000.00	72,000	1,400.00	168,000	20,000.00	240,000
Automation of Main Canal	LS		18,100		162,500		180,600
Subtotal			457,700		834,900		1,292,600
Subtotal New Land System							
W/ Portable Farm System			3,632,450		13,116,990		16,749,440
W/o Portable Farm System			3,527,450		12,171,990		15,699,440

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Potential Land Irrigation System							
W/ Portable Farm System	1,947 ha	1,000.00	1,947,000	2,400.00	4,672,800	3,400.00	6,619,800
W/o Portable Farm System	1,947 ha		1,927,530		4,497,350		6,424,880
Conversion Land Irrigation System							
Pressure-Pipe Network							
Asbestos-Cement Pipe 1,200 mm	7,800 l.m.	28.50	222,300	161.50	1,259,700	190.00	1,482,000
1,100 mm	900 l.m.	22.50	20,250	127.50	114,750	150.00	135,000
1,100 mm	2,700 l.m.	18.00	48,600	102.00	275,400	120.00	324,000
900 mm	4,000 l.m.	15.70	62,800	89.30	357,200	105.00	420,000
800 mm	2,500 l.m.	11.30	28,250	63.70	159,250	75.00	187,500
700 mm	4,000 l.m.	9.00	36,000	51.00	204,000	60.00	240,000
600 mm	9,500 l.m.	6.80	64,600	38.20	362,900	45.00	427,500
500 mm	24,500 l.m.	4.50	110,250	25.50	624,750	30.00	735,000
450 mm	29,000 l.m.	3.90	113,100	22.10	640,900	26.00	754,000
400 mm	38,000 l.m.	3.30	125,400	18.70	710,600	22.00	836,000
350 mm	26,000 l.m.	2.60	67,600	14.40	374,400	17.00	442,000
300 mm	37,500 l.m.	1.80	67,500	10.20	382,500	12.00	450,000
250 mm	83,000 l.m.	1.50	124,500	8.50	705,500	10.00	830,000
200 mm	114,500 l.m.	1.10	125,950	5.90	675,550	7.00	801,500
150 mm	42,000 l.m.	0.90	37,800	5.10	214,200	6.00	252,000
125 mm	35,500 l.m.	0.60	21,300	3.40	120,700	4.00	142,000
100 mm	109,500 l.m.	0.50	54,750	2.50	273,750	3.00	328,500
Fittings	LS		146,400		820,000		966,400
Valves	LS		66,600		372,800		439,400
Thrust Blocks	LS		79,900		447,400		527,300
Steel Pipes for Road Crossing	500 tons	100.00	50,000	300.00	150,000	400.00	200,000
Farm Turnouts							
Single Turnouts	1,800	105.00	189,000	595.00	1,071,000	700.00	1,260,000
Double Turnout	850	150.00	127,500	850.00	722,500	1,000.00	850,000
Subtotal			1,990,350		11,039,750		13,030,100
Provision to keep surface systems operating during construction	LS		280,000		280,000		560,000

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Farm Systems							
Fixed System	3,500	120.00	420,000	680.00	2,380,000	800.00	2,800,000
Portable System	3,500	50.00	175,000	450.00	1,575,000	500.00	1,750,000
Subtotal			595,000		3,955,000		4,550,000
Pumping Stations							
CLP 14	LS		63,000		148,000		211,000
CLP 25	LS		56,000		131,000		187,000
CLP 29	LS		63,000		148,000		211,000
CLP 34	LS		63,000		148,000		211,000
CLP 38	LS		63,000		148,000		211,000
CLP 44	LS		15,000		32,000		47,000
CLP 46	LS		15,000		32,000		47,000
CLP 51	LS		63,000		148,000		211,000
CLP 55	LS		64,000		150,000		214,000
Subtotal			465,000		1,085,000		1,550,000
Drainage Works							
Upgrading Surface Drains	12,900 ha	20.00	258,000	20.00	258,000	40.00	516,000
Sub-surface Drains	270 ha	200.00	54,000	208.00	56,160	408.00	110,160
Subtotal			312,000		314,160		626,160
Clearing	LS		40,000		60,000		100,000
Fixtures	LS		30,000		70,000		100,000
Gravel Surfacing	1,550,000 m^2	0.31	480,500	0.39	604,500	0.70	1,085,000
Operator Housing	16	6,000.00	96,000	14,000.00	224,000	20,000.00	320,000
Main Canal Turnouts	19	750.00	14,250	2,250.00	42,750	3,000.00	57,000
Modification to Zarqa River Weir	LS		48,000		137,000		185,000
Automation of Main Canal	LS		15,200		136,500		151,700
Subtotal			723,950		1,274,750		1,998,700
Subtotal Conversion Land System							
W/ Portable Farm System			4,366,300		17,948,660		22,314,960
W/o Portable Farm System			4,191,300		16,373,660		20,564,960
SUBTOTAL IRRIGATION FACILITIES							
W/ Portable Farm System			10,473,705		37,098,595		47,572,300
W/o Portable Farm System			10,174,235		34,403,145		44,577,380

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
RECOMMENDED SCHEME

COST ESTIMATE
(January 1977 Price Level)
Crest El. 158

1JD = U.S.$3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Without Portable Farm System							
Subtotal Direct Cost			32,844,795		74,961,595		107,806,490
Contingencies			5,095,105		11,624,505		16,719,610
Total Direct Cost			37,939,900		86,586,200		124,526,100
Engineering and Administration			7,670,000		11,503,900		19,173,900
Construction Cost - 1977			45,609,900		98,090,100		143,700,000
Escalation to end of Construction			26,980,000		38,070,000		65,050,000
TOTAL CONSTRUCTION COST			72,589,900		136,160,100		208,750,000
With Portable Farm System							
Subtotal Direct Cost			33,144,265		77,657,145		110,801,410
Contingencies			5,090,000		11,929,090		17,019,090
Total Direct Cost			38,234,265		89,586,235		127,820,500
Engineering and Administration			7,670,000		11,503,900		19,173,900
Construction Cost - 1977			45,904,265		101,090,135		146,994,400
Escalation to end of Construction			27,598,300		38,943,300		66,541,600
TOTAL CONSTRUCTION COST			73,502,565		140,033,435		213,536,000

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Diversion and Control of Water							
Diversion Portal and Tunnel							
Excavation, Common	37,600 m^3	0.25	9,400	0.50	18,800	0.75	28,200
Excavation, Rock	6,000 m^3	1.00	6,000	2.00	12,000	3.00	18,000
Concrete, Portal	1,900 m^3	21.00	39,900	41.00	77,900	62.00	117,800
Excavation, Tunnel	46,000 m^3	7.00	322,000	12.00	552,000	19.00	874,000
Concrete Tunnel	15,680 m^3	19.00	297,920	38.00	595,840	57.00	893,760
Consolidation Grouting	915 l.m.	56.00	51,240	80.00	73,200	136.00	124,440
Concrete Plug	1,000 m^3	11.00	11,000	20.00	20,000	31.00	31,000
Steel Supports	136,000 kg	0.20	27,200	0.30	40,800	0.50	68,000
Shotcrete & Wire Mesh	11,800 m^2	3.00	35,400	4.70	55,460	7.70	90,860
Rock Bolts	2,150 l.m.	3.00	6,450	6.00	12,900	9.00	19,350
Upstream Cofferdam							
Fill	267,600 m^3	0.75	200,700	1.75	468,300	2.50	669,000
Slurry Trench & Core	L.S.		22,000		49,000		71,000
Downstream Cofferdam							
Fill	37,800 m^3	0.75	28,350	1.75	66,150	2.50	94,500
Slurry Trench & Core	L.S.		17,000		38,000		55,000
Pumping	L.S.		25,000		28,000		53,000
Diversion Closure Gate	L.S.		89,000		194,000		283,000
Closure	L.S.		5,000		20,000		25,000
Subtotal			1,193,560		2,322,350		3,515,910

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Main Dam							
Excavation - Common	2,529,000 m^3	0.30	758,700	0.60	1,517,400	0.90	2,276,100
Excavation - Rock	787,000 m^3	0.90	708,300	1.80	1,416,600	2.70	2,124,900
Consolidation Grouting	L.S.		81,140		121,700		202,840
Curtain Grouting	L.S.		467,100		700,700		1,167,800
Drainage Adits and Drains	L.S.		231,000		346,500		577,500
Special Foundation Inspection and Treatment	L.S.		280,000		420,000		700,000
Grouting Gallery and Adits	L.S.		294,000		441,000		735,000
Embankment							
Impervious Core	2,750,000 m^3	0.65	1,787,500	1.10	3,025,000	1.75	4,812,500
Impervious Talus	1,426,000 m^3	0.60	855,600	0.90	1,283,400	1.50	2,139,000
Fine Filter	332,000 m^3	1.40	464,800	2.55	846,600	3.95	1,311,400
Coarse Filter	300,000 m^3	1.40	420,000	2.55	765,000	3.95	1,185,000
Random Rockfill							
(from Req'd Excav.)	2,050,000 m^2	0.25	512,500	0.35	717,500	0.60	1,230,000
(from Borrow)	780,000	0.60	468,000	0.90	702,000	1.50	1,170,000
Select Alluvium	3,485,000 m^3	0.60	2,091,000	0.90	3,136,500	1.50	5,227,500
Basalt Rockfill							
(from Req'd Excav.)	241,000	0.25	60,250	0.35	84,350	0.60	144,600
(from Borrow)	3,809,000	0.80	3,047,200	1.50	5,713,500	2.30	8,760,700
Random Fill	940,000 m^3	0.25	235,000	0.35	329,000	0.60	564,000
Instrumentation	L.S.		100,000		400,000		500,000
Subtotal			12,862,090		21,966,750		34,828,840

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Spillway							
Approach Channel							
Open-Cut Excavation-Common	252,000 m^3	0.30	75,600	0.90	151,200	0.90	226,800
Open-Cut Excavation-Rock	1,090,000 m^3	0.56	610,400	1.09	1,188,100	1.65	1,798,500
Reinforced Concrete Training Wall	21,400 m^3	21.00	449,400	42.00	898,800	63.00	1,348,200
Mass Concrete in Training Wall	50,550 m^3	11.00	556,050	20.00	1,011,000	31.00	1,567,050
Ogee and Chute							
Open-Cut Excavation-Common	560,000 m^3	0.35	196,000	0.65	364,000	1.00	560,000
Open-Cut Excavation-Rock	1,782,000 m^3	0.80	1,425,600	1.20	2,138,400	2.00	3,564,000
Mass Concrete for Ogee	32,400 m^3	11.00	356,400	20,00	648,000	31.00	1,004,400
Reinforced Concrete for Piers	44,000 m^3	21.00	924,000	42.00	1,848,000	63.00	2,772,000
Reinforced Concrete for Floor Slab	23,140 m^3	25.00	578,500	45.00	1,041,300	70.00	1,619,800
Reinforced Concrete for Training Walls	14,410 m^3	21.00	302,610	42.00	605,220	63.00	907,830
Mass Concrete for Flip Bucket	6,100 m^3	12.00	73,200	23.00	140,300	35.00	213,500
Mass Concrete for Gravity Wall	7,400 m^3	11.00	81,400	31.00	229,400	42.00	310,800
Reinforced Concete for Bridge Deck	200 m^3	25.00	5,500	45.00	9,900	70.00	15,400
Compacted Backfill for Walls	66,000 m^3	0.08	52,800	0.90	59,400	1.70	112,200
Rock Anchors	7,500 LM	4.00	30,000	6.00	45,000	10.00	75,000
Spillway Gates 12m x 15m	3	38,550.00	115,650	71,450.00	214,350	110,000.00	330,000
Subtotal			5,833,110		10,592,370		16,425,980

EXHIBIT L-2
SHEET 3 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Low Level Outlet							
Intake Portal							
Excavation - Common	12,000 m^3	0.30	3,600	0.60	7,200	0.90	10,800
Excavation - Rock	3,160 m^3	1.00	3,160	2.00	6,320	3.00	9,480
Reinforced Concrete	300 m^3	21.00	6,300	41.00	12,300	62.00	18,600
Trashrack and Support	43,000 kg	0.55	23,650	0.75	32,250	1.30	55,900
Inlet Tunnel 2.3 m Diameter							
Excavation	380 m^3	22.00	8,360	18.00	6,840	40.00	15,200
Concrete Lining	185 m^3	22.00	4,070	47.00	8,700	69.00	12,770
Steel Supports	5,000 kg	0.20	1,000	0.30	1,500	0.50	2,500
Outlet Conduit							
1.8 m Ø Steel Pipe	132,000 kg	0.40	52,800	0.50	66,000	0.90	118,800
1.8 m Ø Butterfly Valve	L.S.		11,300		22,700		34,000
Concrete Pedestal	160 m^3	21.00	3,360	42.00	6,720	63.00	10,080
Valve House							
Hollow Jet Valve 1.5 m Ø	L.S.		22,300		44,700		67,000
Spherical Valve 1.5 m Ø	L.S.		16,700		33,300		50,000
Concrete in Valve House	50 m^3	25.00	1,250	45.00	2,250	70.00	3,500
Mass Conc. for pipe Support	270 m^3	11.00	2,970	20.00	5,400	31.00	8,370
Subtotal			160,820		256,180		417,000

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Powerplant - Maqarin Dam							
Gate Shafts							
Near Intake							
Excavation - Rock	1,630 m^3	26.00	42,380	22.00	35,860	48.00	78,240
Reinforced Concrete Lining	245 m^3	22.00	5,390	47.00	11,515	69.00	16,905
Reinforced Concrete Superstructure	40	22.00	880	48.00	1,920	70.00	2,800
Reinforced Concrete Foundation	130 m^3	22.00	2,860	52.00	6,760	74.00	9,620
Powerhouse							
Open-Cut Excavation-Common	3,200 m^3	0.35	1,120	0.65	2,080	1.00	3,200
Open-Cut Excavation-Rock	8,400 m^3	0.90	7,560	1.30	10,920	2.20	18,480
Reinforced Concrete	3,700 m^3	22.00	70,400	52.00	166,400	74.00	236,800
Intake							
Open-Cut Excavation - Common	1,000 m^3	0.30	300	0.60	600	0.90	900
Open-Cut Excavation - Rock	1,000 m^3	1.00	1,000	2.00	2,000	3.00	3,000
Reinforced Concrete - Intake	200 m^3	22.00	4,400	52.00	10,400	74.00	14,800
Trashrack and Supports	6,000 kg	0.55	3,300	0.75	4,500	1.30	7,800
Water Conductor (3.2 m Diameter)							
Tunnel Excavation	21,700 m^3	19.00	412,300	16.00	347,200	35.00	759,500
Steel Support	42,000 kg	0.20	8,400	0.30	12,600	0.50	21,000
Rock bolts	2,000 l.m.	3.00	6,000	6.00	12,000	9.00	18,000
Shotcrete & Wire Mesh	18,000 m^2	3.00	54,000	4.70	84,600	7.70	138,600
Concrete Lining	7,090 m^3	15.00	106,350	30.00	212,700	45.00	319,050
Steel Lining	103,000 kg	0.40	41,200	0.50	51,500	0.90	92,700
Concrete behind steel liner	1,100 m^3	15.00	16,500	25.00	27,500	40.00	44,000
Consolidation Grouting	1,770 l.m.	25.00	44,250	37.00	65,490	62.00	109,740
Surge Tank							
Shaft Excavation	2,380 m^3	36.00	61,880	22.00	52,360	48.00	114,240
Concrete Lining	920 m^3	22.00	20,240	47.00	43,240	69.00	63,480
Mechanical Equipment - Maqarin Dam							
Turbine - Governor	2 ea	45,000.00	90,000	270,000.00	540,000	315,000.00	630,000
Spherical Valve, 97 m Ø	2 ea	10,000.00	20,000	22,000.00	44,000	32,000.00	64,000
Miscellaneous Mechanical	L.S.		10,200		24,000		34,200
Gates	L.S.		21,000		46,000		67,000
Powerhouse Crane	L.S.		22,000		45,000		67,000
Beams, Valves, & Hoists	L.S.		6,000		13,000		19,000
Electrical Equipment - Maqarin Dam							
Generator	2 ea	20,000.00	40,000	187,000.00	374,000	207,000.00	414,000
Power Transformer	2 ea	5,500.00	11,000	14,300.00	28,600	19,800.00	39,600
Accessory Electrical	2 ea	26,900.00	53,800	57,100.00	114,200	84,000.00	168,000
Subtotal			1,184,710		2,390,945		3,575,655

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Powerplant - King Talal Dam							
Water Conductor							
Excavation Tunnel	215 m^3	26.00	5,590	22.00	4,730	48.00	10,320
Reinforced Concrete Tunnel Lining	60 m^3	23.00	1,380	48.00	2,880	71.00	4,260
Reinforced Concrete Pedestal	10 m^3	23.00	230	48.00	480	71.00	710
Steel Pipe	14,000 kg	0.50	7,000	0.60	8,400	1.10	15,400
Powerhouse							
Open-Cut Excavation - Common	2,450 m^3	0.60	1,470	1.40	3,430	2.00	4,900
Excavation - Rock	800 m^3	1.00	800	2.00	1,600	3.00	2,400
Reinforced Concrete - Substructure	135 m^3	23.00	3,105	55.00	7,425	78.00	10,530
Reinforced Concrete - Superstructure Ring Wall	140 m^3	23.00	3,220	55.00	7,700	78.00	10,920
Miscellaneous	65 m^3	23.00	1,495	55.00	3,575	78.00	5,070
Steel Girder	1,530 kg	0.30	460	0.70	1,070	1.00	1,530
Outlet Structures							
Structural Concrete	75 m^3	23.00	1,725	55.00	4,125	78.00	5,850
Mechanical Equipment - King Talal Dam							
Turbine - Governor	1 ea	7,800.00	7,800	54,700.00	54,700	62,500.00	62,500
Butterfly Valve 0.82 m Ø	1 ea	1,500.00	1,500	3,100.00	3,100	4,600.00	4,600
Miscellaneous Mechanical	1 ea	1,500.00	1,500	3,500.00	3,500	5,000.00	5,000
Ring Jet & Needle Valve	1	LS	12,000	LS	22,000	LS	34,000
Gates	1	LS	700	LS	1,300	LS	2,000
Beams and Hoists	1	LS	2,200	LS	4,000	LS	6,200
Butterfly Valve 0.5 m Ø	1 ea	1,200.00	1,200	2,500.00	2,500	3,700.00	3,700
Electrical Equipment - King Talal Dam							
Generator	1 ea	8,200.00	8,200	46,800.00	46,800	55,000.00	55,000
Power Transformer	1 ea	2,000.00	2,000	5,000.00	5,000	7,000.00	7,000
Accessory Electrical	1 ea	27,000.00	27,000	64,000.00	64,000	91,000.00	91,000
Subtotal			90,575		252,315		342,890
Transmission Line - 66 kv	LS		187,000		346,400		533,400
Transmission Line - 33 kv	LS		42,700		79,000		121,700
Subtotal			229,700		425,400		655,100

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Diversion near Adasiye							
Intake Structures							
Open-Cut Excavation - Rock	70,800 m^3	1.50	106,200	2.50	177,000	4.00	283,200
Reinforced Concrete - Intake	200 m^3	25.00	5,500	55.00	12,100	80.00	17,600
Canal Transition (Length = 10m)							
Open-Cut Excavation - Rock	400 m^3	1.50	600	2.50	1,000	4.00	1,600
Random Compacted Backfill	270 m^3	1.00	270	2.00	540	3.00	810
Diversion Tunnel (3.5m D horseshoe, 1250m)							
Excavation - Rock	17,430 m^3	17.00	296,310	15.00	261,450	32.00	557,760
Reinforced Concrete Lining	4,730 m^3	30.00	141,900	55.00	260,150	85.00	402,050
Tunnel Support	11,000 kg	0.25	2,750	0.35	3,850	0.60	6,600
Desilting Works 4 - 1.0m x 1.0m Box Conduits (Length = 30m)							
Open-Cut Excavation - Rock	1,830 m^3	1.50	2,745	2.50	4,575	4.00	7,320
Random Compacted Backfill	1,420 m^3	1.00	1,420	2.00	2,840	3.00	4,260
Reinforced Concrete, Box Conduits	120 m^3	30.00	3,600	70.00	8,400	100.00	12,000
Canal (Length = 60m)							
Open-Cut Excavation - Rock	2,830 m^3	1.50	4,245	3.50	9,905	5.00	14,150
Concrete Lining	110 m^3	25.00	2,750	55.00	6,050	80.00	8,800
Gate Structure							
Open-Cut Excavation - Rock	90 m^3	2.00	180	3.00	270	5.00	450
Reinforced Concrete, Gate Structure	70 m^3	30.00	2,100	60.00	4,200	90.00	6,300
Subtotal			570,570		752,330		1,322,900
Wadi Rajib Diversion							
Buttress Embankments							
Open-Cut Excavation - Rock	240 m^3	1.50	360	2.50	600	4.00	960
Reinforced Concrete - Buttress	310 m^3	25.00	7,750	56.00	17,360	81.00	25,110
Spillway & Regulating Bays							
Open-Cut Excavation - Rock	30 m^3	1.50	45	2.50	75	4.00	120
Reinforced Concrete, Spillway, Regulating Bays, Top Slab, Piers	55 m^3	25.00	1,375	56.00	3,080	81.00	4,455
Reinforced Concrete - Aprons	10 m^3	25.00	250	56.00	560	81.00	810
Reinforced Concrete - Stop Logs	1 m^3	30.00	30	70.00	70	100.00	100
Diversion Canal (Length ≐ 400 m)							
Open-Cut Excavation - Rock	620 m^3	1.50	930	3.50	2,170	5.00	3,100
Reinforced Concrete - Canal	140 m^3	25.00	3,500	55.00	7,700	80.00	11,200
Compacted Backfill	260 m^3	1.00	260	2.00	520	3.00	780
0.65m x 0.8m clear opening Sluice Gate	1 ea		350		850		1,200
Hand-operated Hoist	1 ea		40		60		100
Miscellaneous Equipment	LS		60		140		200
Subtotal			14,950		33,185		48,135

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Wadi Kufrinja Diversion							
Buttress Embankments							
Open-Cut Excavation - Rock	110 m^3	1.50	165	2.50	275	4.00	440
Reinforced Concrete - Buttress	150 m^3	25.00	3,750	56.00	8,400	81.00	12,150
Spillway & Regulating Bays							
Open-Cut Excavation - Rock	30 m^3	1.50	45	2.50	75	4.00	120
Reinforced Concrete - Spillway, Regulating Bays, Top Slab, Piers	55 m^3	25.00	1,375	56.00	3,080	81.00	4,455
Reinforced Concrete - Aprons	10 m^3	25.00	250	56.00	560	81.00	810
Reinforced Concrete - Stop Logs	1 m^3	30.00	30	70.00	70	100.00	100
Diversion Canal (Length ≐ 1700 m)							
Open-Cut Excavation - Rock	2,590 m^3	1.50	3,885	3.50	9,065	5.00	12,950
Reinforced Concrete - Canal	610 m^3	25.00	15,250	55.00	33,550	80.00	48,800
Compacted Backfill	1,100 m^3	1.00	1,100	2.00	2,200	3.00	3,300
0.65m x 0.8m clear opening Sluice Gate	1 ea		350		850		1,200
Hand-Operated Hoist	1 ea		40		60		100
Miscellaneous Equipment	LS		60		140		200
Subtotal			26,300		58,325		84,625
Wadi Yabis Diversion							
Rock Embankment							
Stripping & Clearing	700 m^3	0.30	210	0.60	420	0.90	630
Rockfill - Embankment	800 m^3	0.70	560	1.40	1,120	2.10	1,680
Removal Concrete Bulkhead	3 m^3		200		400		600
Reinforced Concrete - Stop Logs	1 m^3	30.00	30	70.00	70	100.00	100
Subtotal			1,000		2,010		3,010
Access Roads							
To Damsite and Powerhouse	LS		34,600		61,400		96,000
Bridge	LS		58,000		75,000		133,000
Subtotal			92,600		136,400		229,000
Operating Camp	LS		100,000		400,000		500,000
Land Acquisitions	1,500 ha		540,000				540,000
Relocations, R.R.	LS		1,920,000		4,480,000		6,400,000
SUBTOTAL STORAGE AND POWER FACILITIES			24,659,165		43,812,380		68,471,545

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Main Canal							
Main Canal Extension							
Excavation - Common	140,000 m^3	0.45	63,000	1.05	147,000	1.50	210,000
Excavation - Rock	30,000 m^3	0.90	27,000	2.10	63,000	3.00	90,000
Compaction	140,000 m^3	0.45	63,000	1.05	147,000	1.50	210,000
Reinforced Concrete-Structures	4,500 m^3	9.20	41,400	30.80	138,600	40.00	180,000
Concrete - Canal Lining	11,000 m^3	8.70	95,700	29.30	322,300	38.00	418,000
Concrete - Blinding	600 m^3	6.40	3,840	21.60	12,960	28.00	16,800
Siphon Pipe	1,400 l.m.	7.50	10,500	42.50	59,500	50.00	70,000
Gravel Surfacing	44,000 m^2	0.31	13,640	0.39	17,160	0.70	30,800
Reinforcing Steel	350 tons	47.50	16,625	142.50	49,875	190.00	66,500
Metal Work	20 tons	100.00	2,000	300.00	6,000	400.00	8,000
Steel Gates	31	750.00	23,250	2,500.00	69,750	3,000.00	93,000
Rock Protection	1,000 m^3	4.00	4,000	1.00	1,000	5.00	5,000
Subtotal			363,955		1,034,145		1,398,100
Main Canal Repair	LS		164,000		326,000		490,000

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
New Land Irrigation System							
Pressure-Pipe Network							
Asbestos-Cement Pipe - 1000 mm	3,000 l.m.	18.00	54,000	102.00	306,000	120.00	360,000
900 mm	4,000 l.m.	15.70	62,800	89.30	357,200	105.00	420,000
800 mm	1,000 l.m.	11.30	11,300	63.70	63,700	75.00	75,000
700 mm	7,000 l.m.	9.00	63,000	51.00	357,000	60.00	420,000
600 mm	9,500 l.m.	6.80	64,600	38.20	362,900	45.00	427,500
500 mm	6,500 l.m.	4.50	29,250	25.50	165,750	30.00	195,000
450 mm	10,000 l.m.	3.90	39,000	22.10	221,000	26.00	260,000
400 mm	15,000 l.m.	3.30	49,500	18.70	280,500	22.00	330,000
350 mm	9,500 l.m.	2.60	24,700	14.40	136,800	17.00	161,500
300 mm	57,500 l.m.	1.80	103,500	10.20	586,500	12.00	690,000
250 mm	80,000 l.m.	1.50	120,000	8.50	680,000	10.00	800,000
200 mm	67,000 l.m.	1.10	73,700	5.90	395,300	7.00	469,000
150 mm	20,000 l.m.	0.90	18,000	5.10	102,000	6.00	120,000
125 mm	17,000 l.m.	0.60	10,200	3.40	57,800	4.00	68,000
100 mm	44,000 l.m.	0.50	22,000	2.50	110,000	3.00	132,000
Fittings	LS		82,000		460,000		542,000
Valves	LS		37,300		209,000		246,300
Thrust Blocks	LS		44,700		251,000		295,700
Steel Pipe	300 tons	100.00	30,000	300.00	90,000	400.00	120,000
Farm Turnouts							
Single Turnout	740	105.00	77,700	595.00	440,300	700.00	518,000
Double Turnout	1,130	150.00	169,500	850.00	960,500	1,000.00	1,130,000
Subtotal			1,186,750		6,593,250		7,780,000
Farm Systems							
Fixed System	3,000	120.00	360,000	680.00	2,040,000	800.00	2,400,000
Portable System	3,000	35.00	105,000	315.00	945,000	350.00	1,050,000
Subtotal			465,000		2,985,000		3,450,000

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Pumping Stations							
HP - 43	LS		77,000		180,000		257,000
HP - 48	LS		150,000		350,000		500,000
LP - 98	LS		47,000		118,000		165,000
HP - 99	LS		63,000		148,000		211,000
HP - 103	LS		87,000		202,000		289,000
LP - 104	LS		120,000		280,000		400,000
HP - 107	LS		63,000		148,000		211,000
LP - 109	LS		82,000		190,000		272,000
HP - 110	LS		68,000		160,000		228,000
Subtotal			757,000		1,776,000		2,533,000
Drainage Works							
Surface Drains	10,600 ha	67.50	715,500	82.50	874,500	150.00	1,590,000
Observation Wells	50	90.00	4,500	110.00	5,500	200.00	10,000
Sub-surface Drains	230 ha	200.00	46,000	208.00	47,840	408.00	93,840
Subtotal			766,000		927,840		1,693,840
Clearing	LS		40,000		60,000		100,000
Gravel Surfacing	960,000 m^2	0.31	297,600	0.39	374,400	0.70	672,000
Fixtures	LS		30,000		70,000		100,000
Operator Housing	12	6,000.00	72,000	1,400.00	168,000	20,000.00	240,000
Automation of Main Canal	LS		18,100		162,500		180,600
Subtotal			457,700		834,900		1,292,600
Subtotal New Land System							
W/ Portable Farm System			3,632,450		13,116,990		16,749,440
W/o Portable Farm System			3,527,450		12,171,990		15,699,440

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Potential Land Irrigation System							
W/ Portable Farm System	1,947 ha	1,000.00	1,947,000	2,400.00	4,672,800	3,400.00	6,619,800
W/o Portable Farm System	1,947 ha		1,927,530		4,497,350		6,424,880
Conversion Land Irrigation System							
Pressure-Pipe Network							
Asbestos-Cement Pipe 1,200 mm	7,800 l.m.	28.50	222,300	161.50	1,259,700	190.00	1,482,000
1,100 mm	900 l.m.	22.50	20,250	127.50	114,750	150.00	135,000
1,100 mm	2,700 l.m.	18.00	48,600	102.00	275,400	120.00	324,000
900 mm	4,000 l.m.	15.70	62,800	89.30	357,200	105.00	420,000
800 mm	2,500 l.m.	11.30	28,250	63.70	159,250	75.00	187,500
700 mm	4,000 l.m.	9.00	36,000	51.00	204,000	60.00	240,000
600 mm	9,500 l.m.	6.80	64,600	38.20	362,900	45.00	427,500
500 mm	24,500 l.m.	4.50	110,250	25.50	624,750	30.00	735,000
450 mm	29,000 l.m.	3.90	113,100	22.10	640,900	26.00	754,000
400 mm	38,000 l.m.	3.30	125,400	18.70	710,600	22.00	836,000
350 mm	26,000 l.m.	2.60	67,600	14.40	374,400	17.00	442,000
300 mm	37,500 l.m.	1.80	67,500	10.20	382,500	12.00	450,000
250 mm	83,000 l.m.	1.50	124,500	8.50	705,500	10.00	830,000
200 mm	114,500 l.m.	1.10	125,950	5.90	675,550	7.00	801,500
150 mm	42,000 l.m.	0.90	37,800	5.10	214,200	6.00	252,000
125 mm	35,500 l.m.	0.60	21,300	3.40	120,700	4.00	142,000
100 mm	109,500 l.m.	0.50	54,750	2.50	273,750	3.00	328,500
Fittings	LS		146,400		820,000		966,400
Valves	LS		66,600		372,800		439,400
Thrust Blocks	LS		79,900		447,400		527,300
Steel Pipes for Road Crossing	500 tons	100.00	50,000	300.00	150,000	400.00	200,000
Farm Turnouts							
Single Turnouts	1,800	105.00	189,000	595.00	1,071,000	700.00	1,260,000
Double Turnout	850	150.00	127,500	850.00	722,500	1,000.00	850,000
Subtotal			1,990,350		11,039,750		13,030,100
Provision to keep surface systems operating during construction	LS		280,000		280,000		560,000

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Farm Systems							
Fixed System	3,500	120.00	420,000	680.00	2,380,000	800.00	2,800,000
Portable System	3,500	50.00	175,000	450.00	1,575,000	500.00	1,750,000
Subtotal			595,000		3,955,000		4.550,000
Pumping Stations							
CLP 14	LS		63,000		148,000		211,000
CLP 25	LS		56,000		131,000		187,000
CLP 29	LS		63,000		148,000		211,000
CLP 34	LS		63,000		148,000		211,000
CLP 38	LS		63,000		148,000		211,000
CLP 44	LS		15,000		32,000		47,000
CLP 46	LS		15,000		32,000		47,000
CLP 51	LS		63,000		148,000		211,000
CLP 55	LS		64,000		150,000		214,000
Subtotal			465,000		1,085,000		1,550,000
Drainage Works							
Upgrading Surface Drains	12,900 ha	20.00	258,000	20.00	258,000	40.00	516,000
Sub-surface Drains	270 ha	200.00	54,000	208.00	56,160	408.00	110,160
Subtotal			312,000		314,160		626,160
Clearing	LS		40,000		60,000		100,000
Fixtures	LS		30,000		70,000		100,000
Gravel Surfacing	1,550,000 m^2	0.31	480,500	0.39	604,500	0.70	1,085,000
Operator Housing	16	6,000.00	96,000	14,000.00	224,000	20,000.00	320,000
Main Canal Turnouts	19	750.00	14,250	2,250.00	42,750	3,000.00	57,000
Modification to Zarqa River Weir	LS		48,000		137,000		185,000
Automation of Main Canal	LS		15,200		136,500		151,700
Subtotal			723,950		1,274,750		1,998,700
Subtotal Conversion Land System							
W/ Portable Farm System			4,366,300		17,948,660		22,314,960
W/o Portable Farm System			4,191,300		16,373,660		20,564,960
SUBTOTAL IRRIGATION FACILITIES							
W/ Portable Farm System			10,473,705		37,098,595		47,572,300
W/o Portable Farm System			10,174,235		34,403,145		44,577,380

EXHIBIT L-2
SHEET 13 of 14

JORDAN VALLEY IRRIGATION PROJECT

STAGE II DEVELOPMENT
ALTERNATIVE 1
COST ESTIMATE
(January 1977 Price Level)
Crest El. 168

1 JD = U.S. $3.00

Item	Quantity	National Currency Unit Price JD	National Currency Cost JD	Foreign Currency Unit Price JD	Foreign Currency Cost JD	Total Cost Unit Price JD	Total Cost Cost JD
Without Portable Farm System							
Subtotal Direct Cost			34,994,220		78,471,705		113,465,925
Contingencies			5,497,180		12,314,895		17,812,075
Total Direct Cost			40,491,400		90,786,600		131,278,000
Engineering and Administration			8,069,800		12,104,200		20,174,000
Construction Cost - 1977			48,561,200		102,890,800		151,452,000
Escalation During Construction			28,000,000		39,498,000		67,498,000
TOTAL CONSTRUCTION COST			76,561,200		142,388,800		218,950,000
With Portable Farm System							
Subtotal Direct Cost			35,293,690		81,167,155		116,460,845
Contingencies			5,492,510		12,618,645		18,111,155
Total Direct Cost			40,786,200		93,785,800		134,572,000
Engineering and Administration			8,069,800		12,104,200		20,174,000
Construction Cost - 1977			48,856,000		105,890,000		154,746,000
Escalation During Construction			28,474,000		40,180,000		68,654,000
TOTAL CONSTRUCTION COST			77,330,000		146,070,000		223,400,000