5. COST ESTIMATE

The preliminary construction cost estimate is made based on the estimated unit price and the proposed dam scale which is conveniently represented by the dam volume.

In estimating the unit price of each work item, reference is made to that of similar projects in Jordan such as the Wadi Arab dam and King Talal dam projects and information from governmental agencies such as JVA, WAJ and Ministry of Public Works. Those unit prices have been updated to 1986 price level, and a typical sample is shown in Table F-7, which has been estimated in February 1987 by the same information for the proposed Hasa basin dam and gives the preferable data for the cost estimation roughly for the proposed five dams in this Study.

According to the estimated cost of the above similar filltype dam and embankment volume, the direct cost of the dam construction is estimated roughly as JD.8.785/m^3 (US$25.65/$m^3$), which includes the normal foundation treatment by the groutings. By using the above unit cost per unit embankment volume, the direct costs of the proposed five dams are roughly as follows;

(unit: JD 1,000)

Wala dam	:	8,080 (JD 8.785 x 920 x 10^3)
Hammam dam	:	4,180 (JD 8,785 x 680 x 10^3 x 0.7<1)
Siwaqa C dam	:	250 (JD 8,785 x 28 x 10^3)
Khabra dam	:	2,550 (JD 8,785 x 290 x 10^3)
Nukheila dam	:	8,260 (JD 8,785 x 940 x 10^3)
Qatrana exist.	:	200 (Improvement of existing dam)

Note: <1. Only this dam, designed as a zoned rolled-fill with thick center core without grouting work.

Furthermore, the available potential water and the direct cost for the proposed plans of the surface water resources of the Mujib watershed

are summarized below;

Proposed Surface Water Development Plans

Proposed Plan	Main Purpose	Available Potential Water	Direct Cost (JD.1,000)
1. Wala	Compensation for irrigation water and water supply	1) 5 MCM/y: Shallow aquifer (base flow) 2) 6 MCM/y: Deep aquifer by injection 3) 6 MCM/y: Seepage to channel (Total 17 MCM/y)	1) Dam & Water facilities:8,080 2) Injection wells (11 Nos.): 338 3) O&M for wells: 6.4/year
2. Hammam	Irrigation	0.8 MCM/y: Storage water	Dam & water facilities:4,180
3. Siwaga C	Water supply	0.6 MCM/y: Storage water (Injection to deep aquifer)	1) Dam and water facilities: 250 2) Injection wells (2 Nos.) : 66 3) O & M for wells: 1.2/year
4. Khabra	Undefined purpose	2.7 MCM/y: Storage water	Dam & water facilities:2,550
5. Nukheila	Undefined purpose	1) 8.8 MCM/y: Storage water 2) 4.4 MCM/y: Seepage to channel (Total 13.2 MCM/y)	Dam & water facilities:3,690
6. Qatrana (Exist.)	Water supply or irrigation	3.2 MCM/y: Deep aquifer by injection	1) Drainage work:4 2) Injection wells (7 Nos.): 311 3) O&M for drainage and wells: 10.4/y
7. Sultani (Exist.)	Water supply	0.7 MCM/y: Deep aquifer by injection	1) Excavation work: 450 2) O&M for excavation and wells: 19.2/year

Table F-1 FLOOD RUNOFF AND GROUNDWATER LEVEL AT PLANNED DAMSITES

Dam Name	Catchment Area (km^2)	Most Freq. Flood Run-off(2-year return) (MCM/y)	Average Flood Runoff (MCM/y)	Peak Discharge (200-year return) (m^3/sec)	Ground Water Level (El.m)
1. Wala	1,770	19.31	21.52	1,550	469 (484)<3
2. Rumeil	1,620	16.99	18.99	-	495 (564)
3. Zeinab	490	9.86	11.23	-	535 (635)
4. Halq	720	4.59	5.13	-	540 (656)
5. Hammam	340	1.91	2.15	620	555 (700)
6. Sadir	140	1.35	1.53	-	550 (687)
7. Shabik	240	1.44	1.67	-	555 (658)
8. Mujib	4,340	24.12	29.85	-	130 (132)
9. Nukheila	3,560	20.75	26.15	2,250	175 (179)
10. Sueida 2	520	1.39	1.66	-	630 (642)
11. Sueida 1	460	1.17	1.40	-	652 (696)
12. Siwaqa C	440	1.10	1.32	525	653 (723)
13. Siwaqa N	90	0.19	0.23	-	645 (754)
14. Siwaqa S	280	0.63	0.76	-	653 (751)
15. Qatrana <1	1,640	1.96	2.51	-	675 (753)
16. Qatrana (Exist.)	1,490	1.78	2.28	630	685 (761)
17. Dabb'a	1,430	8.96	11.77	-	620 (636)
18. Khabra	290	6.12	9.01	490	650 (690)
19. Sultani <2	1,010	2.15	3.39	-	730 (810)
20. Sultani (Exist.)	950	2.02	3.19	-	735 (818)

Note: <1 Qatrana: Q Qatrana (Exist.) x A Qatrana / A Qatrana (Exist.)
<2 Sultani: Q Sultani (Exist.) x A Sultani / A Sultani (Exist.)
<3 Parenthetic figure shows river bed level at each dam.

Table F-2 EXISTING DAMS IN JORDAN

Dam	Constructed	Dam Type	Catchment Area (km^2)	Storage Cap. (MCM)	Dam Height (m)	Dam Volume ($10^6 m^3$)
1. King Talal	1987	R	3,700	86.0	108	5.86
2. Ziglab	1970'S	R	110	4.3	49	1.25
3. Kafrein	1967	R	160	3.8	30	0.89
4. Wadi Shueib	1967	R	170	2.5	30	0.90
5. Wadi Arab	1986	R	262	20.0	82.5	3.10
6. Sama Sarhan	1966	E	-	1.7	10	-
7. Ghadeer Abyad.	1950's	C	-	1.7	13	-
8. Um Jimal	1966	GR	-	1.8	-	-
9. Bowayda	1966	C	-	1.7	9.5	-
10. Kaldia	1983	R	-	1.1	15	-
11. Qatrana	1964	R	1,490	4.2(2.0)	-	-
12. Sultani	1964	R	950	1.2	8	-

Note:

R: Rockfill E: Earthfill C: Concrete gravity

GR: Concrete and Rockfill (2.0): Present condition

Table F-3 RESERVOIR AREA AND WATER STORAGE

(1) Wala Dam

Elevation (m)	Area (km^2)	Volume (MCM)
484	0	0
485	0.0045	0.002
490	0.035	0.101
495	0.096	0.427
500	0.194	1.151
505	0.318	2.431
510	0.444	4.336
515	0.581	6.899
520	0.770	10.277
525	1.069	14.927
535	2.017	30.357
550	3.128	68.945
560	3.994	104.555
575	6.833	185.758

(2) Rumeil Dam

Elevation (m)	Area (km^2)	Volume (MCM)
564	0	0
565	0.01	0.005
570	0.082	0.234
575	1.002	2.943
580	1.662	2.943
585	2.462	19.913
590	3.473	34.751
595	4.475	54.621
600	5.520	79.609
605	7.022	110.964

(3) Zeinab Dam

Elevation (m)	Area (km^2)	Volume (MCM)
635	0	0
640	0.076	0.190
645	0.202	0.902
650	0.388	1.395
655	0.625	4.928
660	0.933	8.823
665	1.411	14.683
670	2.100	23.460
675	2.942	36.065

(4) Halq Dam

Elevation (m)	Area (km^2)	Volume (MCM)
656	0	0
660	0.057	0.114
665	0.225	0.819
670	0.901	3.634
675	2.832	12.967
680	5.837	34.640

(5) Hammam Dam

Elevation (m)	Area (km^2)	Volume (MCM)
700	0	0
701	0.011	0.006
706	0.099	0.282
711	1.170	3.455
716	3,510	14.130
721	7.535	41.743

(6) Sadir Dam

Elevation (m)	Area (km^2)	Volume (MCM)
687	0	0
690	0.1058	0.158
695	1.3725	3.854
697.5	3.7148	10.213
700	6.1594	22.556

(7) Shabik Dam

Elevation (m)	Area (km^2)	Volume (MCM)
658	0	0
660	0.0073	0.007
665	0.107	0.293
670	0.299	1.308
675	0.624	3.616
680	1.155	8.064
685	2.031	16.029

(8) Mujib Dam

Elevation (m)	Area (km^2)	Volume (MCM)
132	0	0
135	0.0039	0.006
140	0.017	0.059
145	0.036	0.193
150	0.065	0.445
155	0.122	0.912
160	0.235	1.805
170	0.645	6.205
180	1.306	15.960
190	1.760	31.290
200	2.759	53.850

Table F-4 RESERVOIR AREA AND WATER STORAGE

(9) Nukheila Dam

Elevation (m)	Area (km^2)	Volume (MCM)
179	0	0
180	0.0017	0.001
185	0.044	0.116
190	0.079	0.424
195	0.186	1.086
200	0.298	2.296
205	0.507	4.309
215	0.758	10.534
225	1.002	19.434
235	1.346	31.174
245	1.665	46.229
255	2.039	64.749

(10) Sueida No.2 Dam

Elevation (m)	Area (km^2)	Volume (MCM)
642	0	0
645	0.011	0.002
650	0.049	0.017
655	0.109	0.411
660	0.176	1.123
665	0.304	2.323
670	0.481	4.286
675	0.714	7.273
690	1.670	25.153
700	2.720	47.103

(11) Sueida No.1 Dam

Elevation (m)	Area (km^2)	Volume (MCM)
696	0	0
700	0.0317	0.063
705	0.1428	0.499
710	0.3230	1.664
715	0.6513	4.100
720	1.1804	8.679
725	1.76731	16.048

(12) Siwaqa Dam

Elevation (m)	Area (km^2)	Volume (MCM)
723	0	0
725	0.027	0.027
730	0.155	0.482
735	0.5830	2.327
740	1.598	7.780
745	4.6154	23.313
750	7.938	54.696

(13) Siwaqa N Dam

Elevation (m)	Area (km^2)	Volume (MCM)
754	0	0
755	0.0023	0.001
760	0.074	0.192
765	0.5290	1.700
770	1.100	5.773
775	1.775	12.961
780	2.502	23.654

(14) Siwaqa S Dam

Elevation (m)	Area (km^2)	Volume (MCM)
751	0	0
755	0.032	0.063
760	0.304	0.902
765	1.289	4.865
770	2.997	15.580
775	4.831	35.150

(15) Quatrana Dam

Elevation (m)	Area (km^2)	Volume (MCM)
753	0	0
755	0.0393	0.039
760	0.4934	1.332
765	1.2960	6.739
770	3.1236	24.822
775	5.4683	64.580

(16) Quatrana (Exist.)

Elevation (m)	Area (km^2)	Volume (MCM)
761	0	0
765	0.4665	0.933
770	2.3469	7.967
775	6.9496	31.208

Table F-5 RESERVOIR AREA AND WATER STORAGE

(17) Dabb'a Dam

Elevation (m)	Area (km^2)	Volume (MCM)
636	0	0
640	0.0016	0.003
645	0.0631	0.165
650	0.1279	0.643
655	0.2128	1.495
660	0.3801	2.978
665	0.5727	5.360
670	0.8441	8.902
675	1.2430	14.120

(18) Khabra Dam

Elevation (m)	Area (km^2)	Volume (MCM)
690	0	0
695	0.0660	0.204
700	0.1861	0.834
705	0.4401	2.400
710	0.8381	5.596
715	1.3027	10.948
720	1.9608	19.107
725	2.7087	30.781

(19) Sultani

Elevation (m)	Area (km^2)	Volume (MCM)
810	0	0
810	0.0346	0
812.5	0.3492	0.480
815	3.8090	5.577

(20) Sultani Dam (Exist.)

Elevation (m)	Area (km^2)	Volume (MCM)
818	0	0
820	0.0154	0.007
825	11.2565	28.187

Table F-6 PRINCIPAL FEATURE OF PROPOSED DAM SITES

Item		(1) Wala	(2) (*) Hammam	(3) (*) Siwaqa C	(4) Khabra	(5) Nukheila	(6) (*) Qatrana(Exist)	(7) (*) Sultani(Exist)
Hydrological Condition								
- Catchment area	(km^2)	1,770	340	440	290	3,560	1,490	950
- Reservoir area	(km^2)	2.25	1.45	0.60	1.36	0.85	1.75	1.10
- Annual average runoff	(MCM)	21.52	2.15	1.32	9.01	26.15	2.28	3.19
- Most frequent annual runoff	(MCM)	19.31	1.91	1.10	6.12	20.75	1.78(4.00)<2	2.02
- 200-year return peak discharge	(m^3/sec)	1,550	620	525	490	2,250	-	-
Feature of Dam								
- Dam type		Rockfill	Rockfill or Earthfill	Rockfill or Concrete	Rockfill	Rockfill or Concrete	Rockfill	Rockfill
- Crest level	(El.m)	539.0	713.0	736.5	716.5	240.0	-	-
- Dam height from river bed	(m)	55.0	13.0	13.5	26.5	61.0	-	-
(structural height)	(m)	(65.0)	(16.0)	(16.5)	(29.5)	(67.0)	-	-
- Crest length	(m)	350	2,670	124	455	350	-	-
- Top width	(m)	8	8	8	8	8	-	-
- Dam volume	(10^3m^3)	920	680	28	290	940	-	-
Feature of Reservoir								
- Strage capacity	(MCM)	28.95	2.25	1.65	9.18	31.20	6.0	1.20
- Effective strage capacity	(MCM)	19.30	1.50	1.10	6.12	20.80	4.0	1.20
- Dead storage(Sediment volume)	(MCM)	9.65	0.75	0.55	3.06	10.40	2.0	-
Feature of Spillway								
- Overflow crest length	(El.m)	120	120	100	100	160	-	-
- Overflow crest level	(m)	534.0	712.0	733.5	713.5	235.0		
Storage Efficency<1		21	3	40	22	33	-	-
Available Potential Water	(MCM/y)	16.9	0.8	0.6	2.7	8.8	3.2<2	0.7

Note: Features of dam are determined based on 1/7,500 topographic map but dam with a mark(*) are studied based on 1/15,000 topographic map.

<1 = Storage efficency = Effective storage capacity ÷ Dam volume
<2 = After drainage improvement

Table F-7 BREAKDOWN OF DAM CONSTRUCTION COST (IN CASE OF PROPOSED DAM IN HASSA BASIN)

(Unit: JD 1,000)

NO.	WORK	UNIT	QTY	F/C		L/C		TOTAL	
				U/P	AMOUNT	U/P	AMOUNT	U/P	AMOUNT
I.	PREPARATORY WORK								
	1 ACCESS & SERVICE ROAD	L.S	-		69		34		103
	2 PERMANENT & T. BUILDINGS	L.S	-		141		48		189
	3 POWER SUPPLY & WATER, ETC	L.S	-		185		123		308
	4 MISCELLANIOUS	L.S	-		40		20		60
	(SUB-TOTAL)				435		225		660
II.	DAM								
	1 EXCA, COMMON	CU-M	12,000	.672	8	.528	6	1.2	14
	2 EXCA, WEATHERED ROCK	CU-M	70,000	1.58	111	.42	29	2	140
	3 EXCA, ROCK	CU-M	20,000	2.115	42	2.385	48	4.5	90
	4 EMB, IMPERVIOS CORE	CU-M	133,000	1.352	180	1.248	166	2.6	346
	5 EMB, IMPERVIOS CORE	CU-M	46,000	4.408	203	3.192	147	7.6	350
	6 EMB, ROCK	CU-M	400,000	1.806	722	2.394	958	4.2	1,680
	7 EMB, EXCAVATED ROCK	CU-M	90,000	1.83	165	1.17	105	3	270
	8 EMB, RIPRAP	CU-M	14,000	1.935	27	2.565	36	4.5	63
	9 CONCRETE	CU-M	500	38.325	19	14.175	7	52.5	26
	10 CRUTAIN GROUTING	LIN.M	4,800	24.084	116	20.516	98	44.6	214
	11 BLANKET GROUTING	LIN.M	5,000	22.825	114	18.675	94	41.5	208
	12 MISCELLANIOUS	L.S	-		150		149		299
	(SUB-TOTAL)				1,857		1,843		3,700
III.	SPILLWAY								
	1 EXCA, COMMON	CU-M	58,000	.66	38	.34	20	1	58
	2 EXCA, WEATHERED ROCK	CU-M	100,000	1.458	146	.342	34	1.8	180
	3 EXCA, ROCK	CU-M	35,000	1.74	61	1.26	44	3	105
	4 CONCRETE, OPEN STRUCTURE	CU-M	13,000	34.344	446	8.056	105	42.4	551
	5 REINFORCEMENT BAR	TON	570	314.526	179	38.874	22	353.4	201
	6 MISCELLANIOUS	L.S	-		74		21		95
IV.	OUTLET WORKS								
	1 EXCA, COMMON	CU-M	1,000	1.05	1	.35	0	1.4	1
	2 EXCA, WEATHERED ROCK	CU-M	2,000	1.539	3	.361	1	1.9	4
	3 EXCA, ROCK	CU-M	1,000	2.035	2	1.665	2	3.7	4
	4 EXCA, TUNNEL	CU-M	3,000	12.555	38	16.345	49	28.9	87
	5 CONCRETE, OPEN STRUCTURE	CU-M	400	42.558	17	9.342	4	51.9	21
	6 CONCRETE, TUNNEL & SHAFT	CU-M	2,000	34.709	69	22.191	44	56.9	114
	7 REINFORCEMENT BAR	TON	120	334.656	40	63.744	8	398.4	48
	8 BACKFILL GROUTING	CU-M	400	20.79	8	17.01	7	37.8	15
	9 CONSOLIDATION GROUTING	LIN.M	2,300	24.084	55	20.516	47	44.6	103
	10 MISCELLANIOUS	L.S	-		31		24		53
	(SUB-TOTAL)				264		186		450
	TOTAL OF ITEM I TO IV				3,500		2,500		6,000
V.	CONTINGENCY & RESERVE	L.S	-		350		270		620
VI.	ENGINEERING & ADMINISTRATION	L.S	-		630		270		900
VII.	COMPENSATION	L.S	-		0		190		190
	TOTAL OF ITEM I TO VII				4,480		3,230		7,710
VIII.	PRICE ESCALATION	L.S	-		345		395		740
	GROUND TOTAL				4,825		3,625		8,450

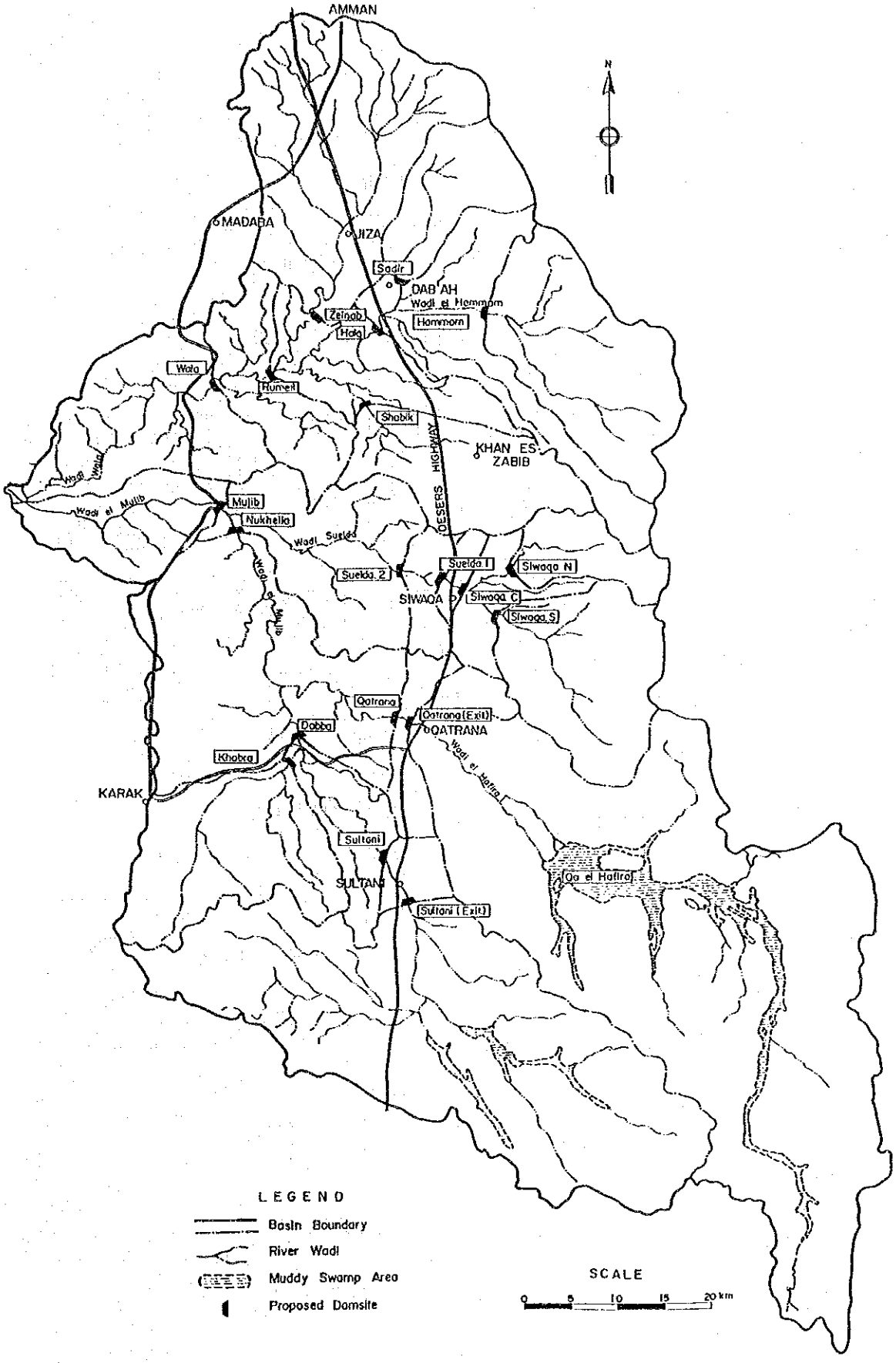
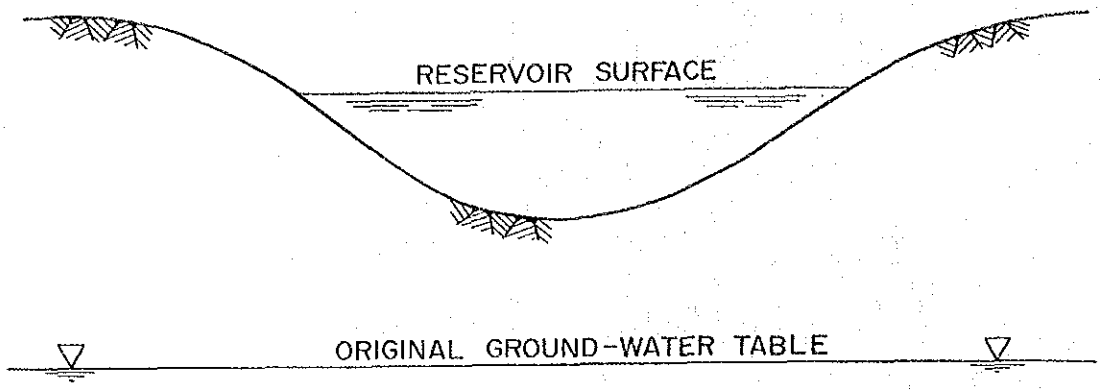
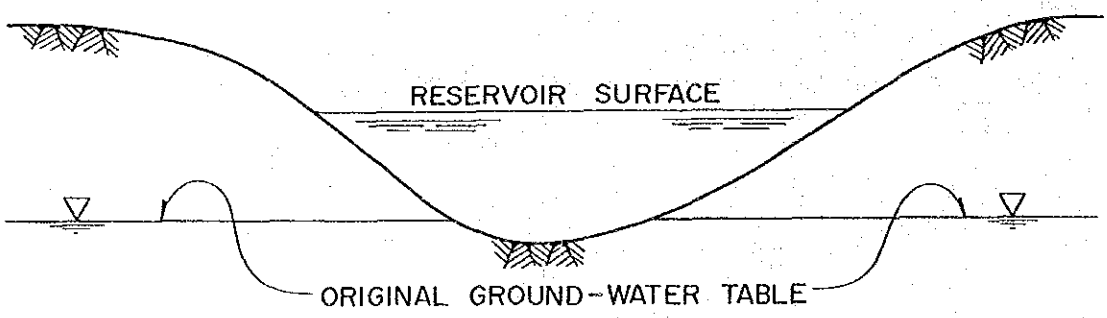


Fig.F-1 The Study Area and Surface Water Development Plan

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY



PERCHED RESERVOIR



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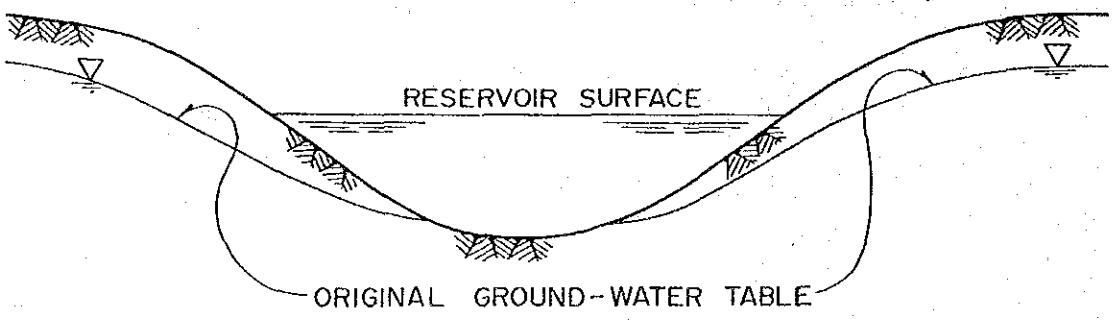


CONFINED RESERVOIR

Fig.F-2 Hydrologic Classification of Reservoirs

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY

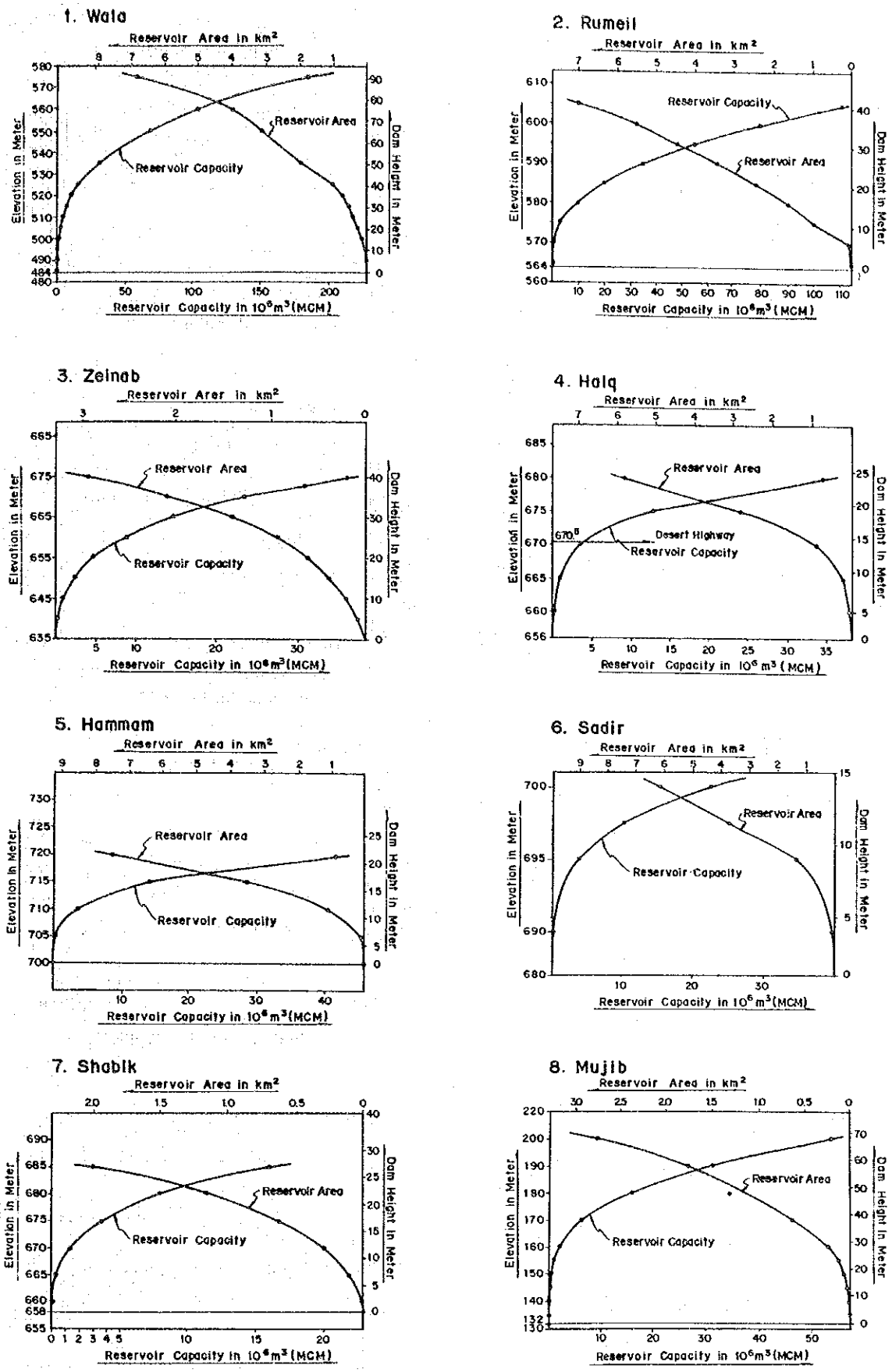
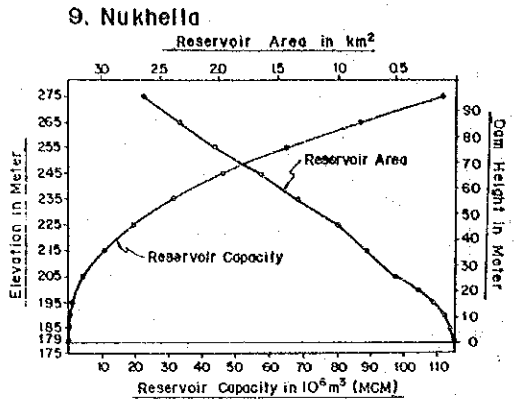
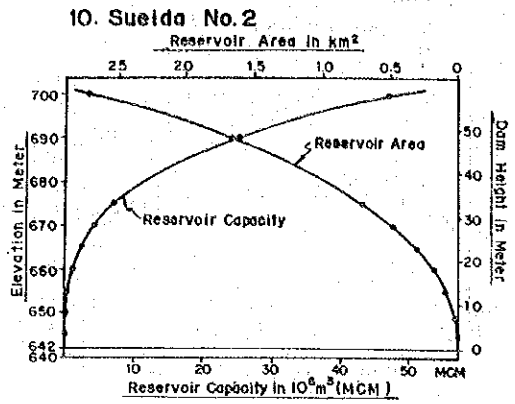
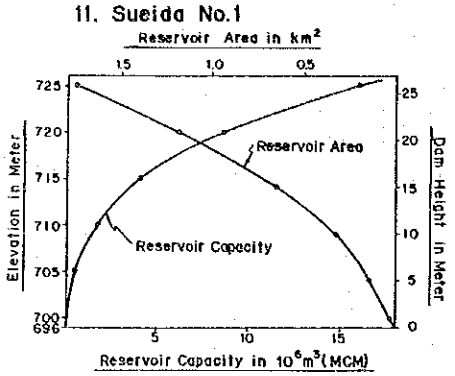


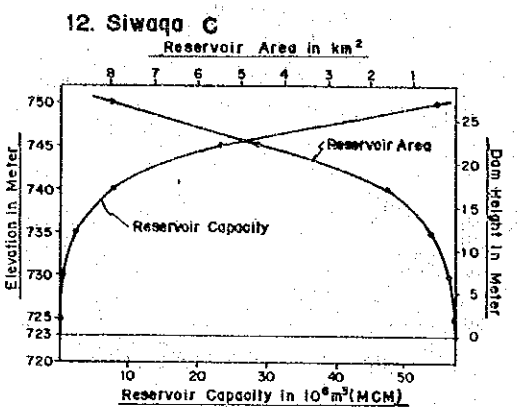
Fig.F-3 Reservoir Capacity Curve (1/3)

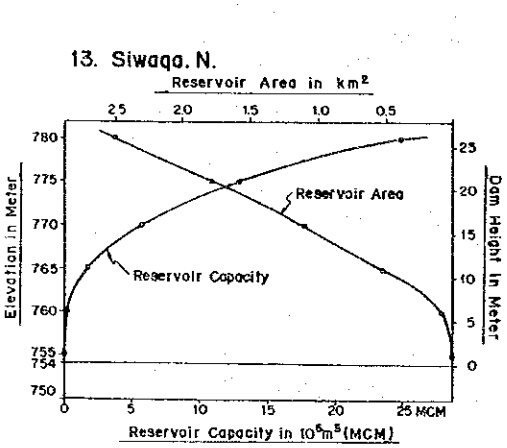
THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY

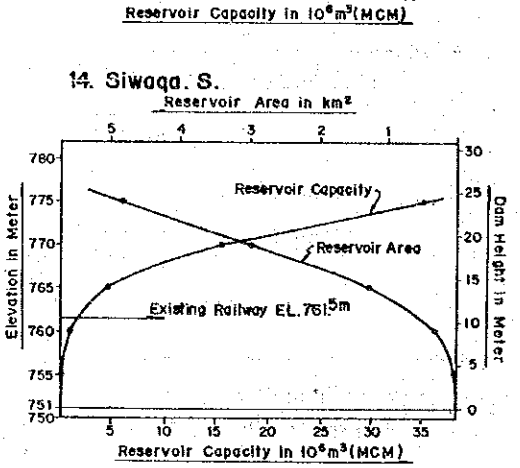


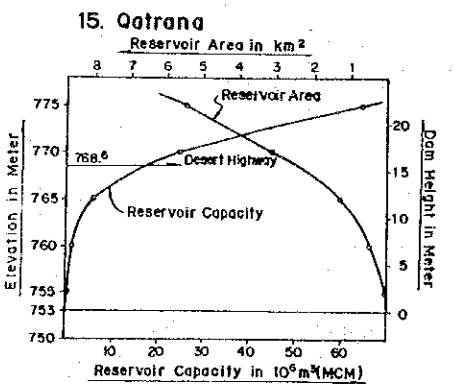












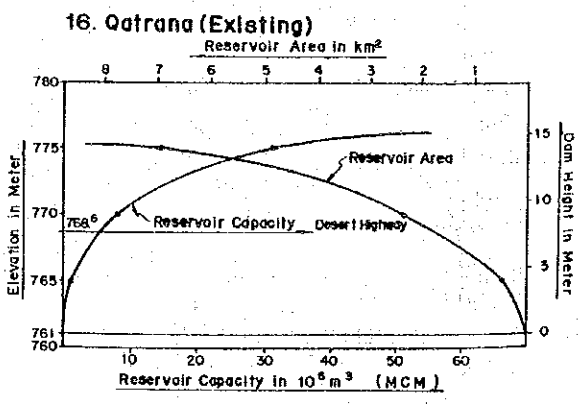


Fig.F-4 Reservoir Capacity Curve (2/3)

THE HASHEMITE KINGDOM OF JORDAN
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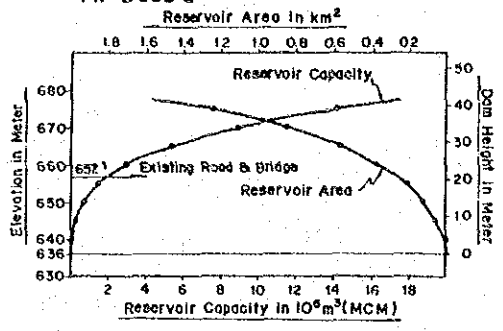
17. Dabb'a



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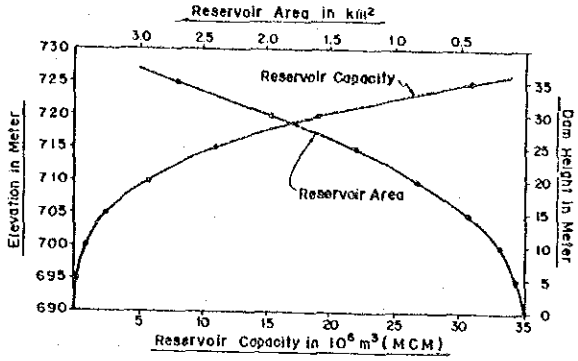

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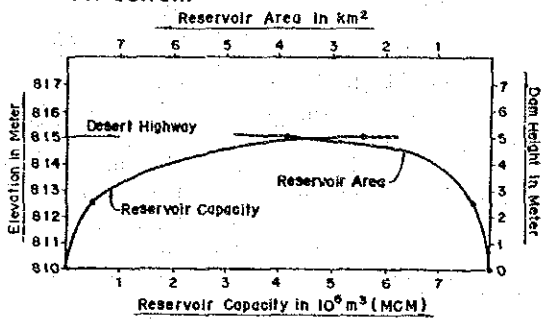

20. Sultani (Existing)

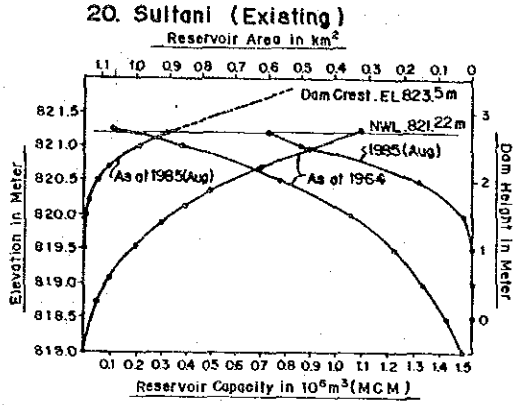

Fig.F-5 Reservoir Capacity Curve (3/3)

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY

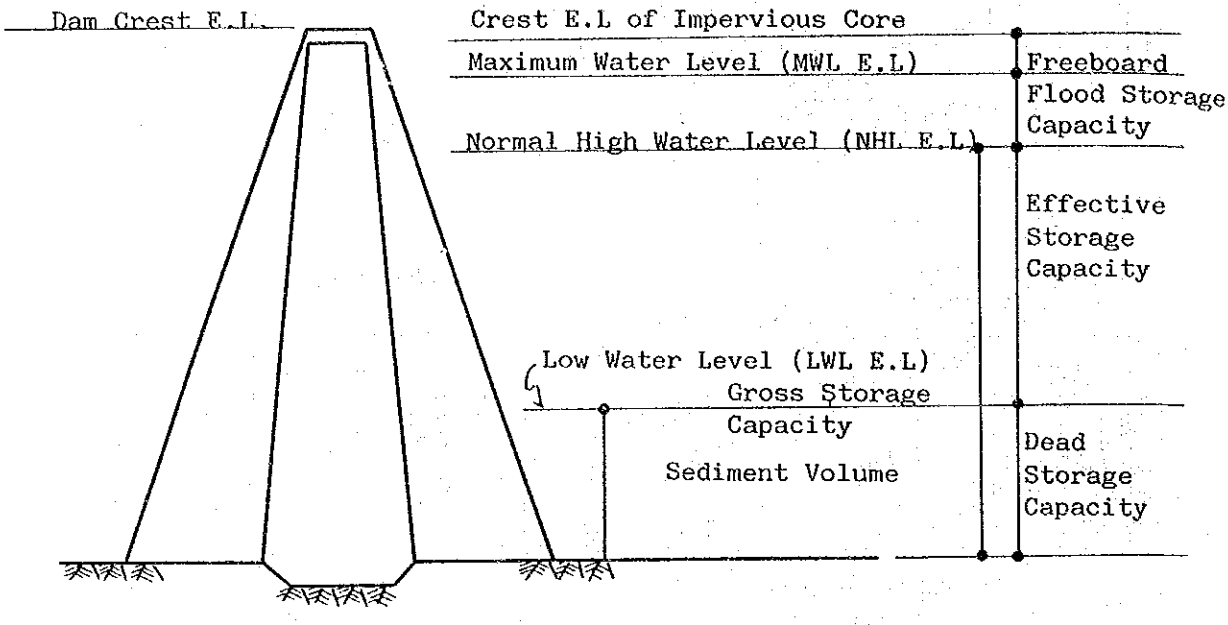

Fig.F-6 Definition of Reservoir Water Level and Storage Capacity

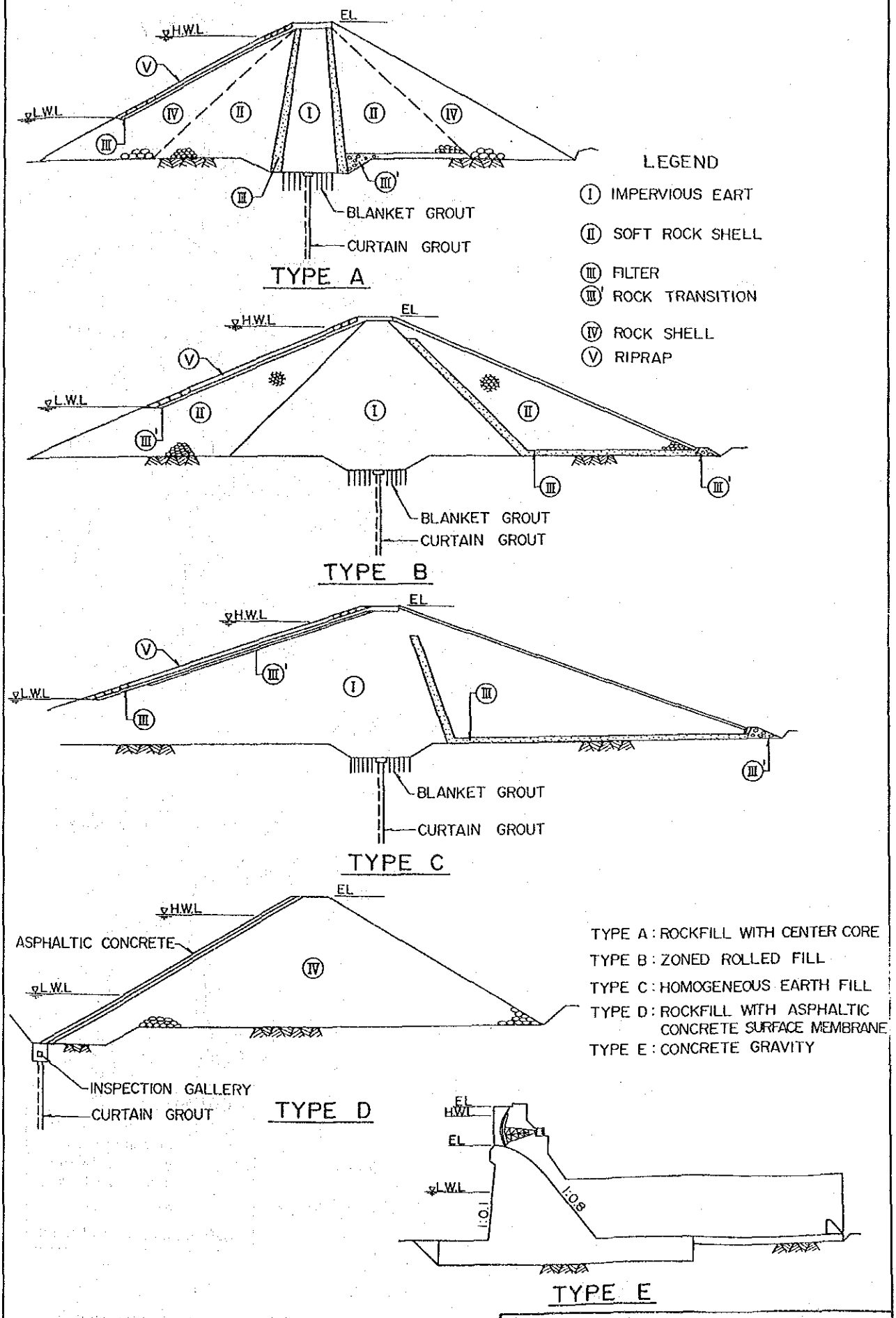

Fig.F-7 Practical Type of Dams

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
JAPAN INTERNATIONAL COOPERATION AGENCY

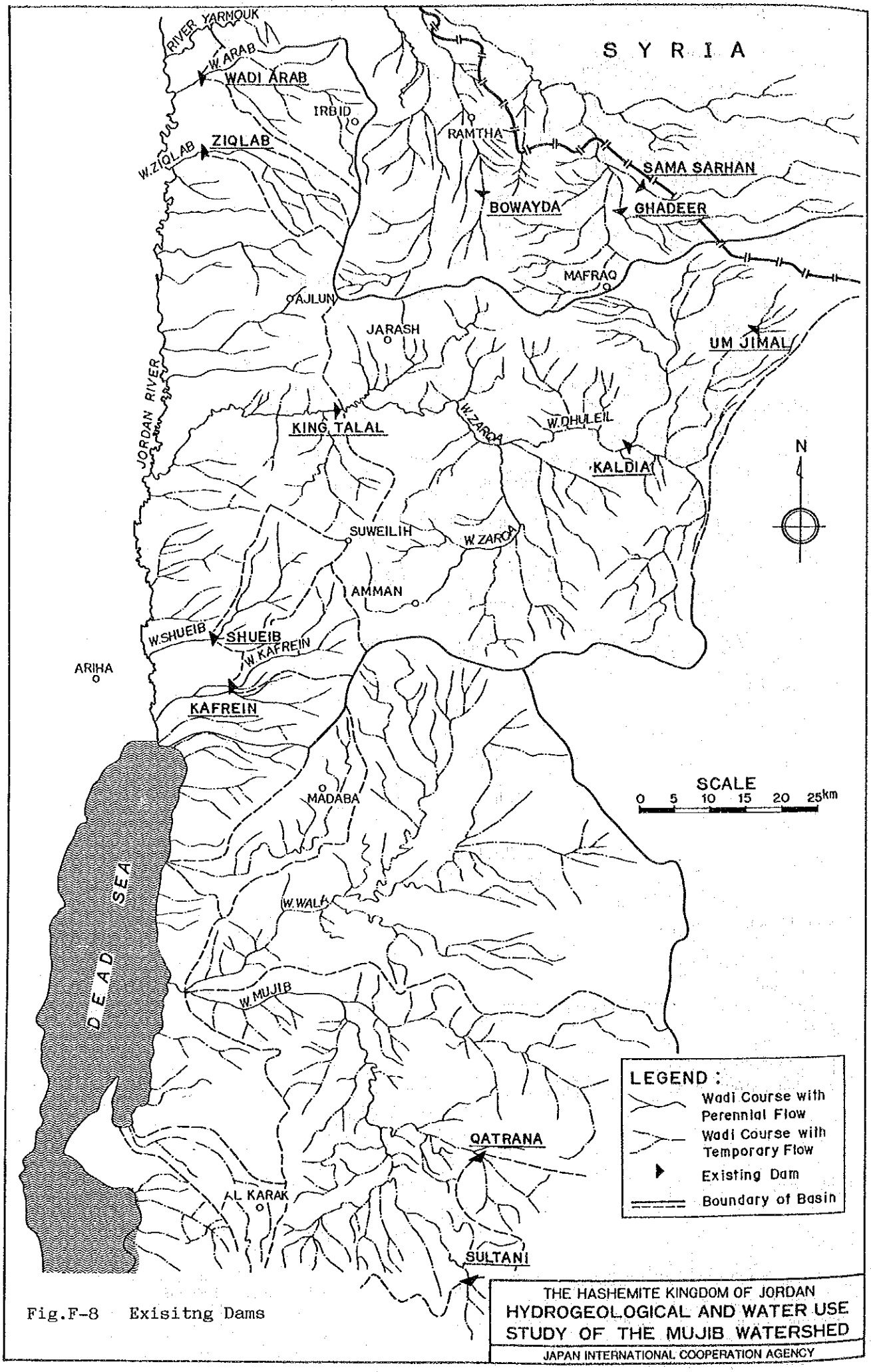

Fig.F-8 Exisitng Dams

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
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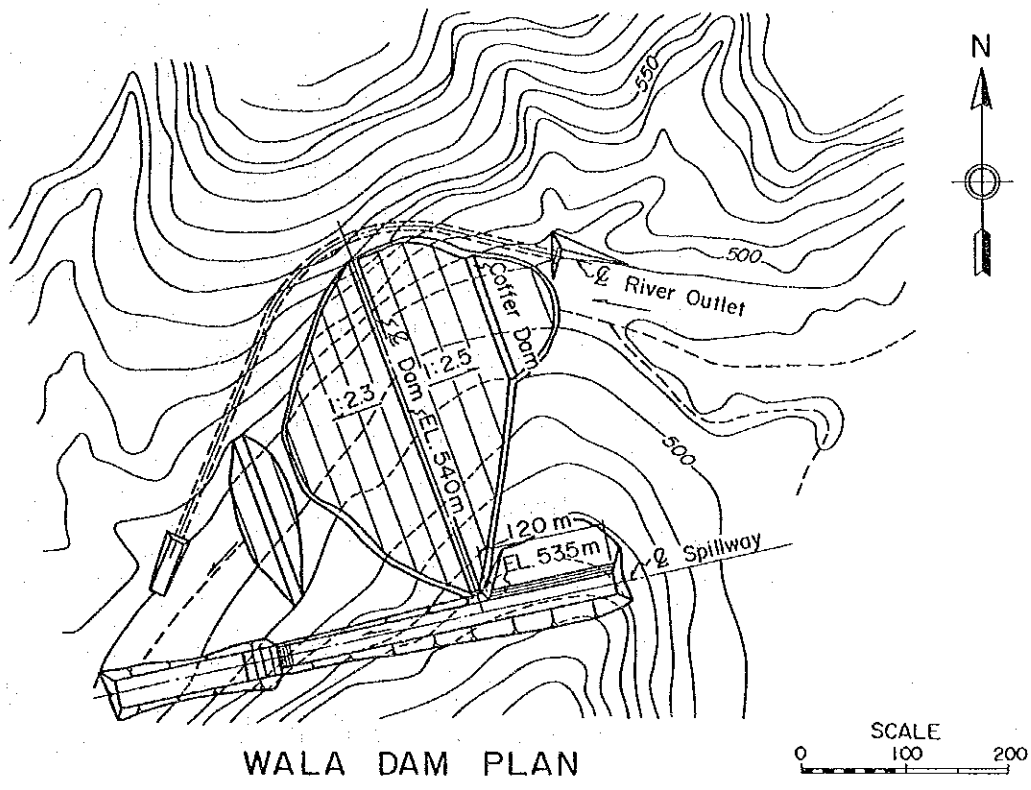
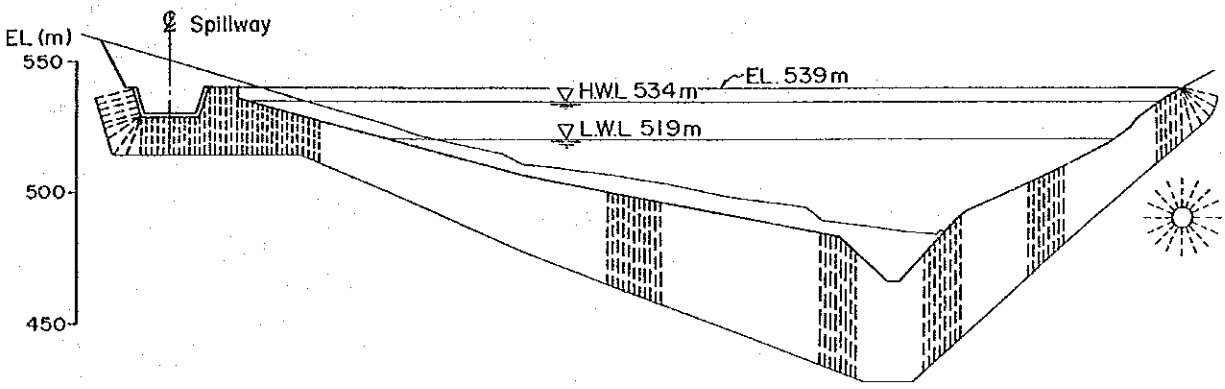
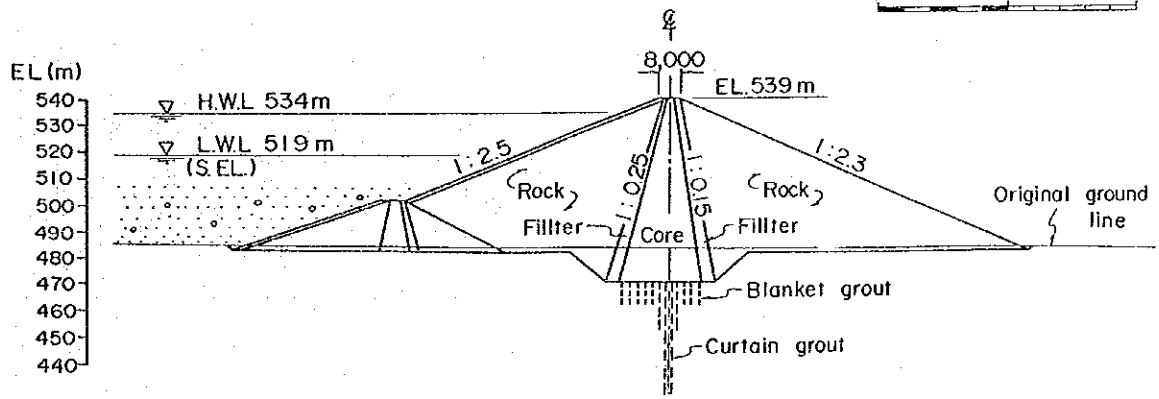


WALA DAM PLAN



UPSTREAM VIEW OF DAM



TYPICAL SECTION OF DAM

Fig.F-9 Proposed Wala Dam

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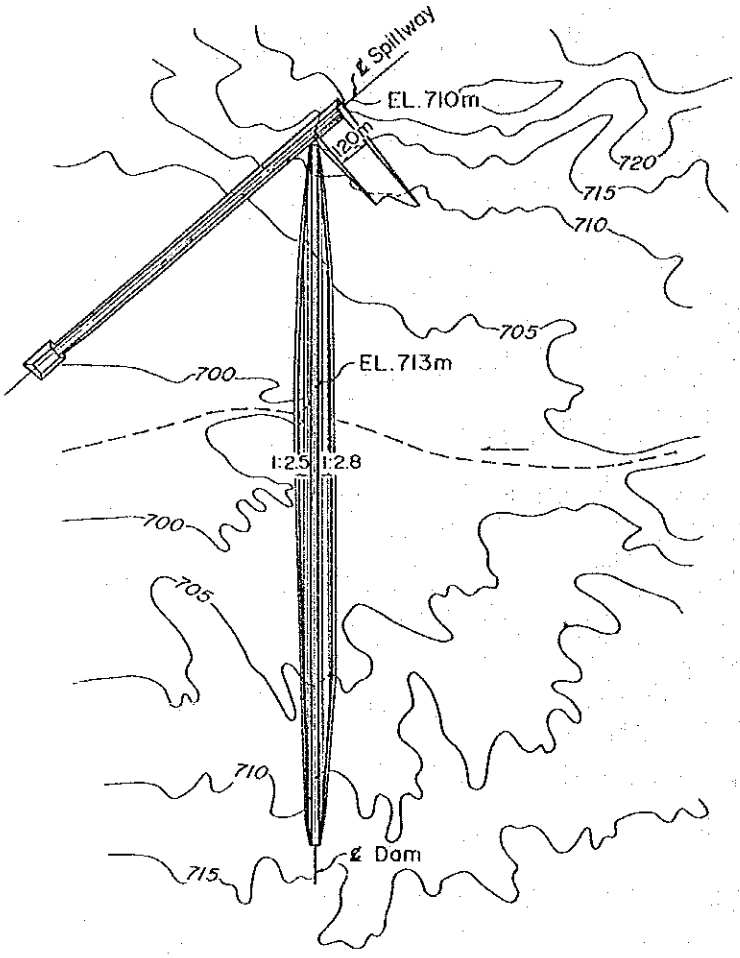
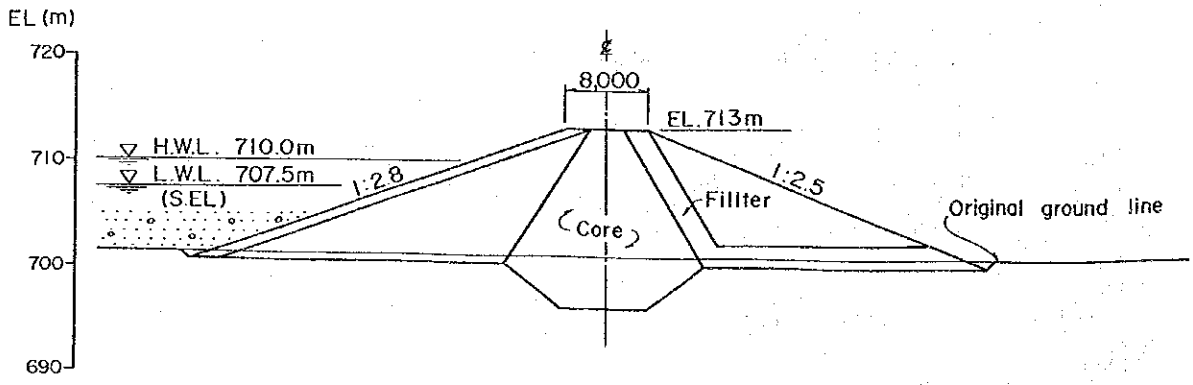


HAMMAM DAM PLAN

SCALE
0 500 1,000m



TYPICAL SECTION OF DAM

SCALE
0 10 20m

Fig.F-10 Proposed Hammam Dam

THE HASHEMITE KINGDOM OF JORDAN
HYDROGEOLOGICAL AND WATER USE STUDY OF THE MUJIB WATERSHED
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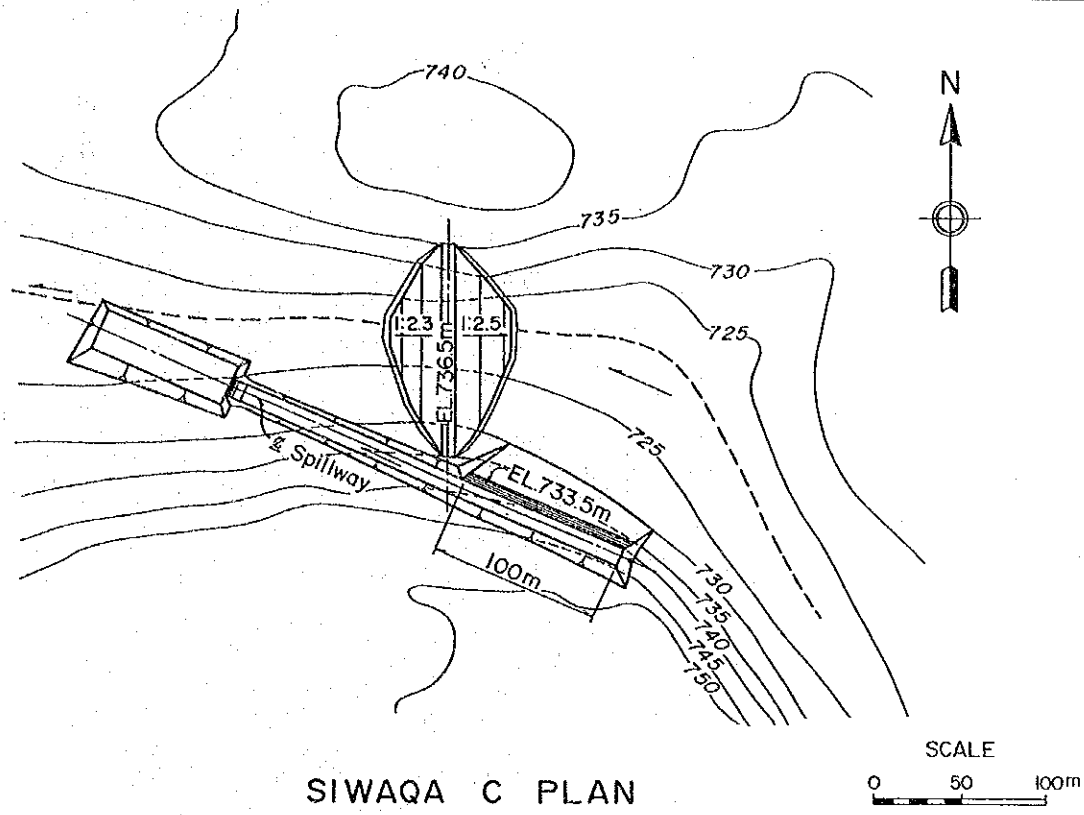
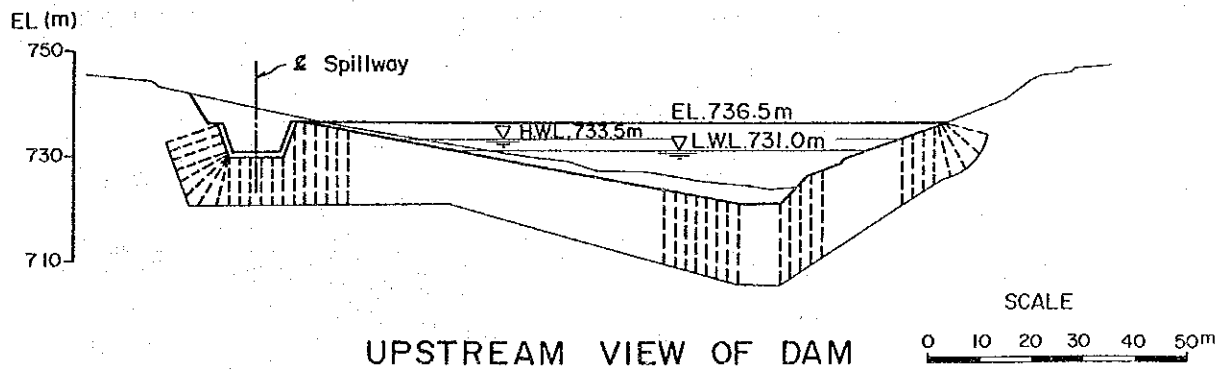
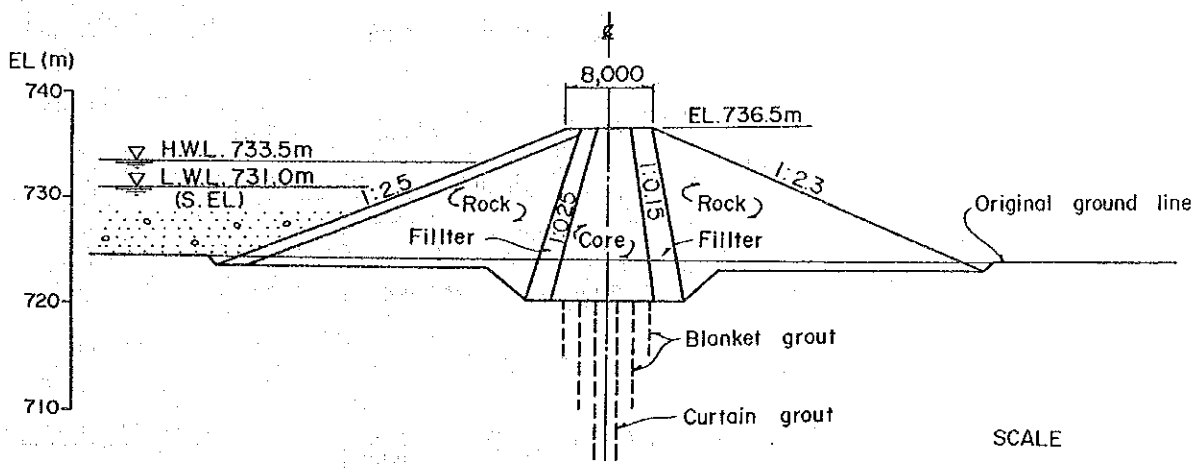


SIWAQA C PLAN



UPSTREAM VIEW OF DAM



TYPICAL SECTION OF DAM

Fig.F-11 Proposed Siwaqa C Dam

THE HASHEMITE KINGDOM OF JORDAN
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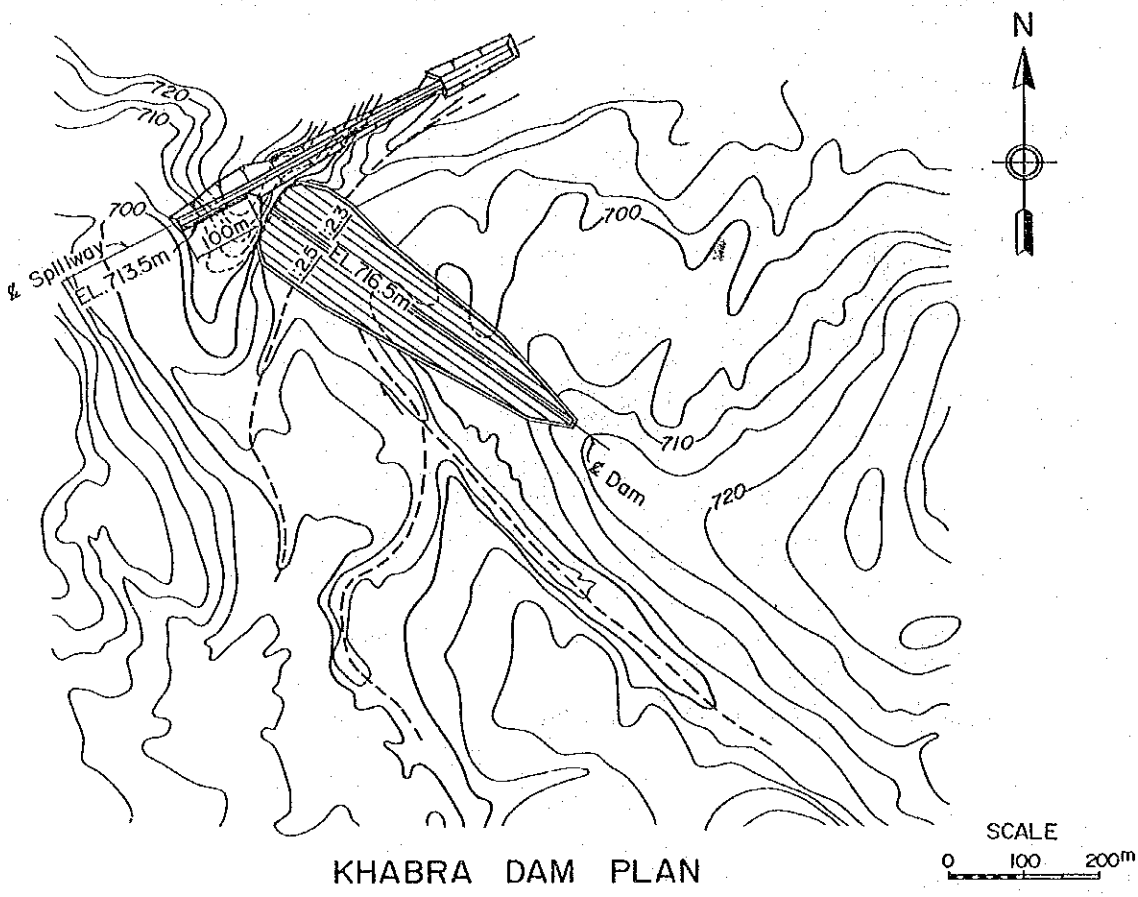
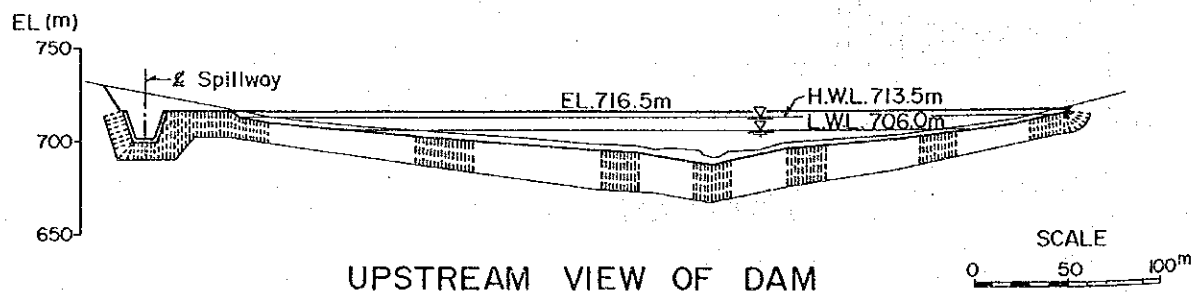
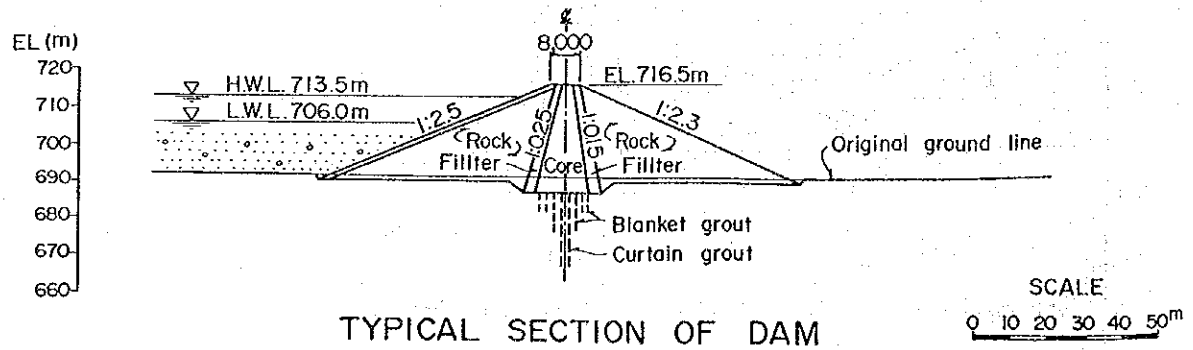


KHABRA DAM PLAN



UPSTREAM VIEW OF DAM



TYPICAL SECTION OF DAM

Fig.F-12 Proposed Khabra Dam

THE HASHEMITE KINGDOM OF JORDAN
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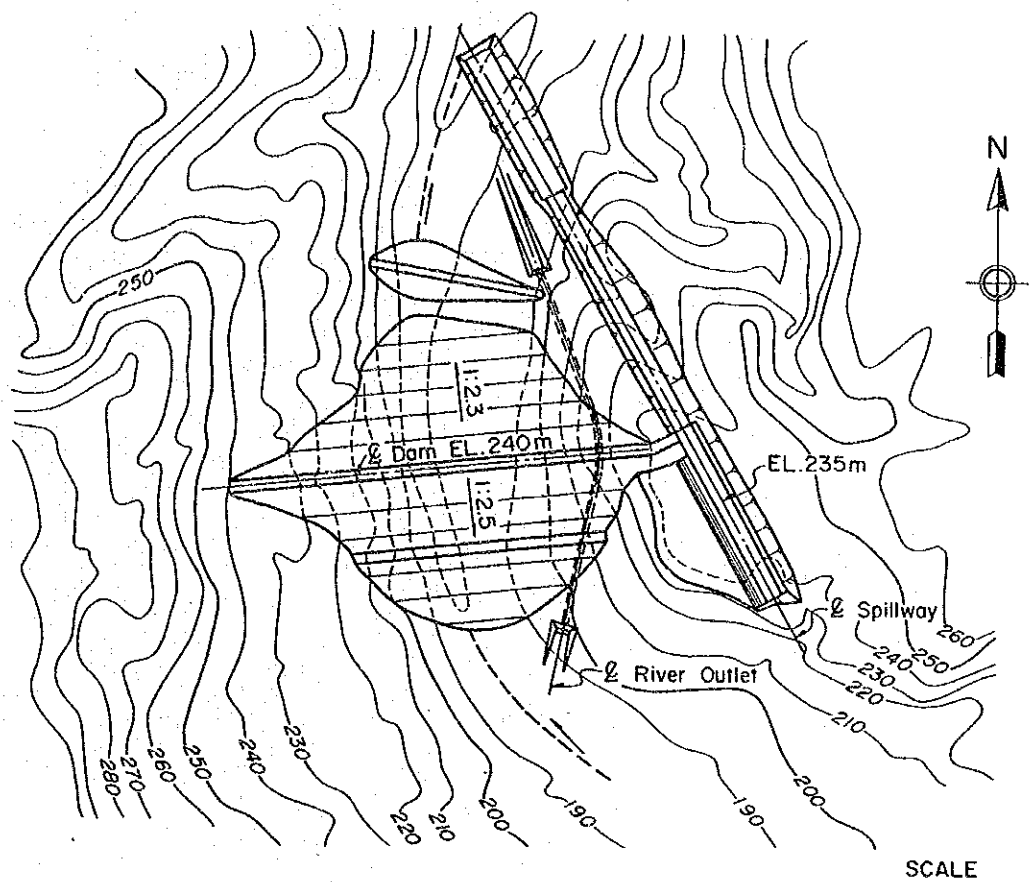
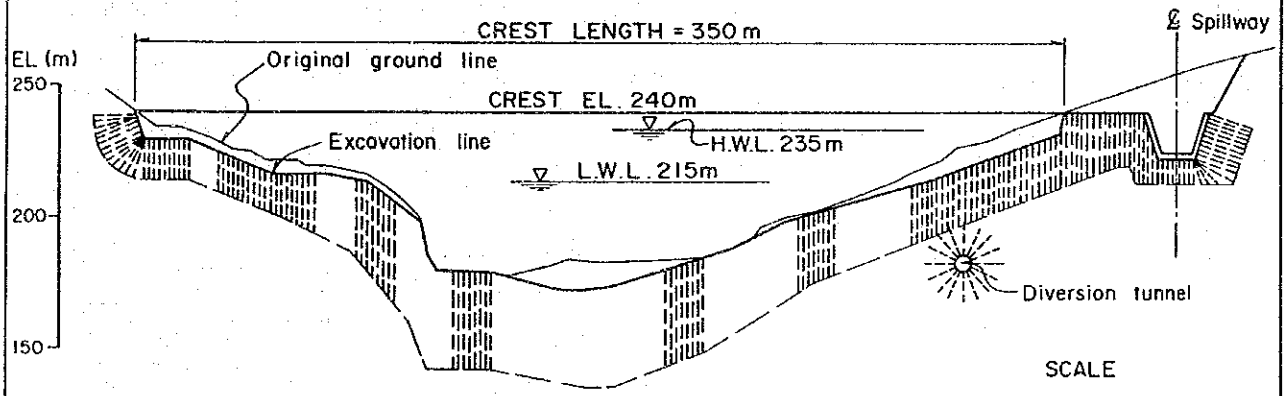


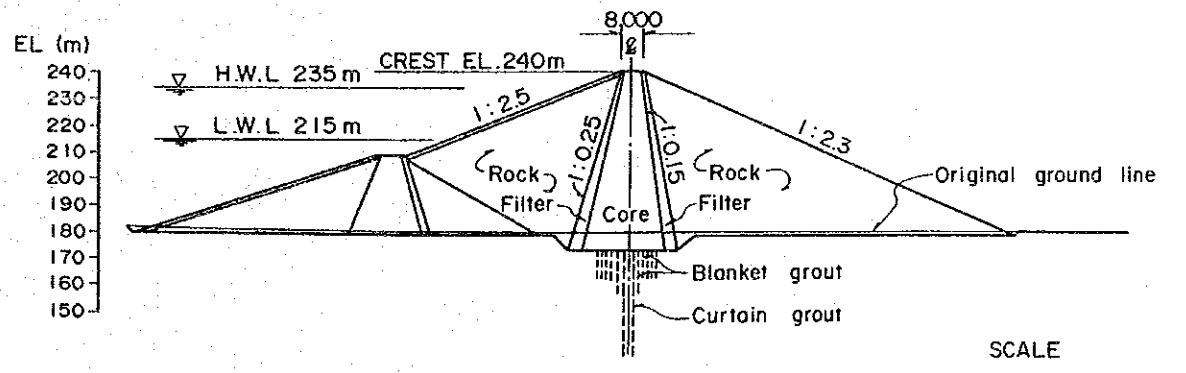
SCALE 0 100 200m

NUKHEILA DAM PLAN



SCALE 0 50 100m

UPSTREAM VIEW OF DAM



SCALE 0 50 100m

TYPICAL SECTION OF DAM

Fig.F-13 Proposed Nukheila Dam

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APPENDIX G

AGRICULTURE

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1. BACKGROUND OF AGRICULTURAL DEVELOPMENT

1.1 Agro-economy

According to the results of the second Five-Year Plan for Economic and Social Development (1981 - 1985), gross national product (GNP) and gross domestic product (GDP) reached respectively 1,856 million JD and 1,395 million JD in 1985. Annual real growth rate of GNP reached 4.2% comparing with 11.0% of the targeted one of the second plan. Average per capita of GNP reached 695 JD. Main reasons for this reduction are the fall in the official transfers from the Gulf states and the levelling off the remittances of Jordanians employed abroad, which are affected by the continuation of the economic slowdown in oil-producing countries. As for GNP on agriculture sector during the 2nd plan, annual real growth rate in GNP reached 7.0% and became less than the targeted one of 7.5%. GDP on agriculture sector in 1985 reached 112.1 million JD and occupied about 8% of GDP in 1985.

According to the statistical year book in 1985 published by the Department of Statistics, export and import balance of main agricultural products is shown in Table G-1.1. Majority of imported agricultural products are cereals, residues and waste for feed, sugar, meat, fats and oil and oil seeds. Comparing with trading amount in 1984, imported quantities of these products in 1985 excluding meat is not changeable. However imported quantity of meat in 1985 increases about two times of that in 1984. Main exported agricultural products in 1985 are vegetables, fruits and nuts. Exported quantity of vegetables declines from about 276,000 ton in 1984 to about 255,000 ton in 1985.

Referring to average agricultural production for the latest five years (1981 - 1985) and targeted production of the second plan, production of cereals, beans, fruits and grapes, red meat and eggs did not reach the targets. Ratios of self-sufficiency on these agricultural products, excluding eggs are rather lower than others as shown in Table G-1.2.

1.2 The Third Five Year Plan for Economic and Social Development

According to the third Five Year Plan for Economic and Social Development (third 5-year Plan) (1986 - 1990), GDP is expected to reach 1,739 million JD in 1990 at 1985 price with an annual growth rate of 5.1%. GNP is expected to grow at an annual rate 5.0% and reach 2,367 million JD in 1990 at 1985 price. In order to reach these economic targets, structural changes of the economy on each sector is expected.

As for the agricultural sector, an annual real growth rate in GNP is particularly planned to reach 7.8% by the increase in extension of irrigation area and grazing land, upgrading of livestocks production, crop diversification and extension services in highlands and efficient use of agricultural inputs. The expected annual real growth rate in GNP is set out rather high than that of the national level. Sectoral investment on agriculture is about 10% of the total investment during the third 5-year Plan, and the total investment is expected at about 290 million JD at 1985 price. Furthermore, investment of public sector also covers construction of irrigation facilities as one of the basic infrastructural projects. The public investment, including agricultural projects, is scheduled to concentrate mostly upon the development of the highlands.

The following strategy on water resources and agricultural developments is recommended in the third 5-year Plan.

a. Water Resources and Irrigation Development

(I) To strengthen the regional socio-economic development, taking into account the water resource development.

(II) To upgrade the efficiency of water use, in particular, irrigation efficiency; and to expand beneficial areas.

(III) To rehabilitate and facilitate the existing irrigation facilities and strengthen operation and maintenance of existing schemes.

b. Agricultural Development

(I) To develop irrigation area for cultivation of cereals, beans and fodder crops, and to strengthen the research technology on cultivation and the extension services on cereals and fodder crops.

(II) To expand irrigation area for vegetables and fruits cultivation in the Jordan Valley, taking into consideration the crop diversification and vegetables production within demand limits.

(III) To manage gradual increase of fruit and olive trees planted during the period 1981 - 1985.

(IV) To extend agro-infrastructure concerned with production, product processing and marketing such as slaughterhouses, egg grading centres, cold storage warehouses for vegetables, fruits and poultry, etc..

1.3 Necessity of Agriculture and Irrigation Development

For these 10 years, public investment for agricultural development has been mostly concentrated into the irrigation development projects in the Jordan Valley, and the investment for highland irrigation development projects has been scarce. Therefore, regional economy development in highlands, including the Study Area, has been hung low.

In addition, the following problems on agriculture in highlands are pointed out in recent years as ones of constraints on the National Agriculture Development Strategy, and the Government will make much

efforts to solve these problems. The problems are also found out in the Study Area.

1) Increase of non-resident farmers: Since planted areas and crop yields in highlands are strictly and yearly affected by hydrological conditions, stable income and upgrading of living standards for farmers are not kept. Therefore, non-resident farmers having employment opportunities in urban area is increasing at present.

2) Insufficient study on land resources in highlands; a lot of cultivable lands still remain as uncultivated areas because of insufficient studies on land and water resource potentials.

3) Insufficient research and extension services on agriculture; sufficient public investment has not been made for agricultural; sufficient public investment has not been made for agricultural research and extension services in highlands and at present, agricultural activities of public sector are hung low.

In this study, excluding the baseflow in the lower reaches of the Mujib basin, the surface flow of the basin which occurs only in the rainy season and is mostly discharged to the Dead Sea without being used, will be planned to make maximum use by means of storage dams. The surface water stored in the dams is planned to meet the water demands such as irrigation, recharge of groundwater to reinforce the water source of the municipal water supply and compensation of the reduction of baseflow.

Taking into account this newly developed surface water resource in the Study Area, it is useful to make irrigation development schemes in order to strengthen the regional socio-economic development. Furthermore, some of the newly developed surface water resources in the Study Area will be planned to combine with existing groundwater

irrigation areas. Management of existing groundwater irrigation areas can be upgraded and strengthened by decreasing the production cost.

On the other hand, the Study Area has much advantages on transportation and communication to urban areas namely Amman, Karak and Ma'an by utilizing the Desert Highway. And besides, the Government emphazises agriculture development projects in highlands in the third 5-year Plan. Therefore, agriculture and irrigation development in the Study Area is necessary for regional economic development and strengthening agricultural research and extension services. Attractive agriculture development which farmers can expect to obtain high income, upgraded living standards and high quality farm management will be necessary.

2. THE STUDY AREA

General conditions of the Study Area are described in the Main report, therefore, present conditions concerned with agriculture and irrigation sectors are only mentioned below.

2.1 Natural Resources

2.1.1 Soils and Land Classification

The field reconnaissance soils survey on possible irrigation area of about 400 km^2 and physio-chemical analyses of the representative soils at 5 test pit sites and 50 auger pit sites are carried out to clarify soil properties and to provide basic data for agriculture development. The results of the survey and analyses of soil samples are shown in SUPPLEMENT-A. Soils and land classification in the surveyed area are characterized as follows.

(A) Soils Classification

According to the Soil Taxonomy Standard of the Department of Agriculture of the United States (U.S.D.A), soils in the surveyed area are classified into the two (2) Soil Orders namely, the Entisols and the Aridisols. The Entisols are the immature soils which have been formed recently and have only an ochric epipedon. These soils cover about 5,700 ha of the surveyed area. The Aridisols are typical desert soils which have ochric epipedon and one or some sub-surface horizons such as argic, cambic, natric, gypsic, calcic, petrocalcic horizons and duripan. These soils cover about 34,700 ha of the area.

The two (2) Soil Orders identified in the surveyed area are, furthermore, classified into the four (4) Soil Great Groups and the two (2) Soil Sub-Groups as shown below.

Soil Order	Soil Great Group/Sub-Groups	Area (Ha)
1. Entisols		(5,678)
	1.1. Torriorthents	5,143
	1.2. Torrifluvents	535
2. Aridisols		(34,726)
	2.1. Paleorthid	6,136
	2.2. Calciorthid	
	2.2.1. Typic Calciorthid	27,475
	2.2.2. Xerrolic Calciorthid	1,115
Total		40,404

Distribution of soils classified is detailedly shown in Table G-2.1.

The main features of the identified four (4) Soil Great Groups are summarized as follows.

(A-1) Torriorthents

The soils generally extend in small rocky plateaus located along wadis and their tributaries and rocky side slopes of deep and moderate wadis. In the surveyed area, these soils extend, in particular, at river bed and steep side slopes from the Zeinab damsite to the Wala damsite, upperstream area of the Siwaqa C damsite, downstream area of the Halq, the Sueida No.1 and No.2 damsites, and downstream areas of the Qatrana and Sultani damsites (See SUPPLEMENT A-4). The soils have loamy or silty ochric epipedon and fragments of stones and rocks such as limestone and chert. The stoniness is more than 80%. Only the one (1) Family of the Soil Great Group, namely the Torrienthents Fragmental is found out in the surveyed area. These soils are not suitable for agriculture development because of much fragments of stones and rocks.

(A-2) Torrifluvents

The soils are found at the recent fluvial deposits of the upperstream area from the Rumeil damsite. The One (1) Soil Family of the Torrifluvents loamy is identified in the surveyed area. Soil texture is mainly of silty clayey loam. In some cases, gravel layer is found within 100 cm in depth. Soil structure is weakly sub-angular and plant roots are found out within 30 cm in depth. Typical soil color is orange (7.5YR 7/6) and soil color varies generally by various depositial layers in the profiles. Soil reaction is alkaline and content of organic matter is less than 1.0%. The soils are suitable for agriculture development. At present, in the certain downstream areas of the Rumeil damsite consisting of these soils, existing irrigation farms are extended.

(A-3) Paleorthids

The soils extend on low plateau areas and flat desert area of the Wadi Siwaqa, Qatrana and Sultani basins. The two (2) Soil Families of these soils , namely, the Paleorthids Fragmental and the Paleorthid Fragmental/loamy, are identified by differentiation of soil texture. Soil structure is fine angular and typical soil color is dull yellow orange (10YR 7/4). The soils have chemical reaction of mild to moderately high alkalinity, high carbonate content of 500 to 900 me/100g soil, rather high cation exchange capacity of 4 to 20 me/100g soil, low organic matter content of less than 1.0%, electric conductivity (EC) of 0.3 to 20 mmhos/cm and exchangeable sodium (Na) content of 1.0 to 14 me/100 g soil. The soils in the surveyed area are not suitable for agriculture development because of much calcium carbonate hard pan and in particular, high salinity contents in northern area of the Qatrana and the Sultani area.

(A-4) Calciorthids

Majority of the surveyed area is covered by the soils of Calciorthids belonging to the Soil Sub-Order of Orthids under the Soil Order of Aridisols. The soils have only the calcic horizon which is of non-argiric B horizon within 100 cm in depth and calcium carbonate concretions.

The soils of Calciorthids are mainly featured by soil color of dull orange (10 YR 7/4) to orange (7.5 YR 6/6), fine granular structure, chemical reaction of pH 7.5 to pH 8.3, alkaline carbonate contents of 550 to 800 me/100g soils, organic matter content of less than 1.0%, electric conductivity of less than 2 mmhos/cm and exchangeable sodium (Na) content of less than 2 me/100 g soil. Furthermore, the Calciorthids is classified into two (2) Sub-Groups, namely, the Typic Calciorthid and the Xerollic Calciorthid. The area covered with each Sub-Group is roughly demarcated by the annual rainfall. The soils of Xerollic extend over areas with the annual rainfall of about 200 mm, while the soils of Typic Calciorthid extend in areas having the annual rainfall less than 200 mm.

(A-4-1) Typic Calciorthid

The Typic Calciorthid is classified into three (3) soil Families, namely, the Typic Calciorthids Fragmental/Lithic, the Typic Calciorthids Fragmental/Loamy and the Typic Calciorthids Loamy.

(a) Typic Calciorthids Fragmental/Lithic

The soils extend in steep slopes and top plains of plateaus located along wadis and side slopes of wadis amd their tributaries, especially, at hill slopes of plateaus located along the Wadi Wala from the Zeinab damsites to the Wala damsite, side slopes of the upper stream wadi from the Rumeil damsite and side slopes of the downstream from the Qatrana damsite. The limestone bed rocks are found out within 50 cm in depth. Effective solum depth of the soils is very shallow and top soils contain

much limestone breccias. These soils are therefore not suitable for agriculture development.

(b) Typic Calciorthids Fragmental/Loamy

The soils extend moderate slopes of low plateaus, especially, slopes of low hills located along the Wadi Hamman, hills extending both banks of the Zeinab damsite, low hills located in the downstream areas of the Halq and the Shabik damsites, gentle slopes of hills extending around the Siwaqa C damsites, the Qatrana town area and the downstream area of the Sultani damsite. Surface of top soils is covered with much stones, but sub-surface soils are loamy. The soils have low salinity. Therefore, the soils are suitable for agriculture development.

(c) Typic Calciorthids Loamy

The soils extend in flat desert areas, especially, flat area of Jiza to the Wadi Hamman, certain flat areas of the downstream from the Shabik damsite, certain areas of small plateaus located around the Zeinab abd Wala damsites, the upper stream area of the Siwaqa C damsite, southern area of the Qatrana town and certain area of the existing Sultani dam reservoir. The bedrocks and stony surface of top soils are not found within 100 cm in depth. Effective solum depth of the soils are more than 100 cm and soil textures are of loamy soils. Therefore, the soils are suitable for agriculture development.

(A-4-2) Xerolbic Calciorthid

The soils extend in areas with the annual rainfall of more than 200 mm, in particular, in the western half areas of the surveyed area along the Kings Highway. The soils have loamy texture and calcic sub-horizon with calcium carbonate concretion. Soil structure is of sub-angular. Typical soil colour is brown (7.5 YR 5/6 - 5/4). The soil fertility is higher than that of the Typic Calciorthid. Therefore, the soils are suitable for agriculture development.

(B) Land Classification

The land classification in the surveyed area is made based on the standard of the United States, Bureau of Reclamation (U.S.B.R). Key factors of the standard are soil texture, soil depth, stoniness, soil salinity and topographic slope, and the land is assessed into six (6) classes according to the key factors mentioned above. By applying the USBR's standard, surveyed area is classified into five (5) classes, namely the Class I to the Class III, the Class V and the Class VI. In general, lands of the Class I to the Class IV are assessed to be arable land and lands of the Class V to the Class VI are defined as non-arable land. However, in case of similar irrigation development projects in the Jordan, land of the Class V is assessed to be possibly arable land for drip irrigation system. The land classification in the surveyed area is as follows:

Land Class	Area (Ha)	Proportion (%)
Class I	14,364	35.6
Class II	9,562	23.7
Class III	1,929	4.8
Class V	7,569	18.7
Class VI	6,980	17.3
Total	40,404	100

The details of land classification are shown in Table-G-2.2. The Hamman, Jiza and Shabik regions are of only suitable lands classified in the Class I and/or the Class II. In Siwaqa, 70% of the area is arable including the Class III land, while the remainder is of the Class VI land. The arable lands of the Classes I and II cover 70% of Halq and 45% of Rumeil and Wala as well as Zainab. Non-arable lands in these lands which cover 10% of Halq, 20% of Rumeil and Wala, and 45% of Zainab. In Qatrana, 60% of the area is of the Classes I and III, while 30% is grouped in the Class V land. In Sultani, less than 10% of the area is arable, comprising the Class I land. About 30% is classified in the Class V. Land classification map of each region is illustrated in SUPPLEMENT A-4.

2.1.2 Climate

The Study Area has two typical seasons, namely, winter season (rainy season) from October to April and summer season (dry season) from June to September, and May is transition period from winter season to summer season. More than 98% of an annual rainfall in the Study Area is concentrated for the seven months of winter season, and the four months in summer season, is no rain. According to average rainfall for the recent 25 years from 1960 to 1984 , annual rainfall in the Study Area ranges from 350 mm to less than 50 mm. The west half areas of the Study Area, in particular, Madaba-Dab'ah area, downstream of the Wadi Wala and Karak hilly areas have somewhat much rainfall and their annual rainfall declines from 350 mm to 250 mm eastward. In desert area, the average rainfall reaches less than 50 mm as shown in Fig. G-2.1. Referring to the average annual rainfall at the representative rainfall stations in the Mujib basin, namely, Madaba, Wadi Wala, Karak, Qatrana and Khan Es Zabib stations, the average annual rainfalls for 25 years are as follows.

Rainfall Station	Average Annual Rainfall (mm/year)
1. Madaba	285
2. Wadi Wala	262
3. Khan Es Zabib	179
4. Karak	353
5. Qatrana	106

Monthly and annual rainfall of each station are shown in APPENDIX-B "Hydrology".

Meteorological data at the six (6) stations in and around the basin are as shown in Table G-2.3.

Mean temperature at each station is affected by its elevation. Excluding the Wadi Wala station (El. 450 m), other four stations, namely Na'our (El. 910 m), Al Jiza (El. 715 m), Madaba (El. 785 m), Rabbah (El. 920 m) and Hassan (El. 1,200 m) stations have similar mean monthly temperature. Mean monthly temperature for three (3) months from December to February at the five (5) stations show less than 10°C and during four (4) months from June to September in summer season, the temperature reaches a range from 21°C to 24°C. For transition period between summer season and winter season, the temperature respectively inclines from 10°C to 20°C for three (3) months from March to May and declines from 20°C to 10°C for two (2) months from October to November. Mean monthly temperature of the Wadi Wala station shows rather high figures than those of other stations.

Mean monthly relative humidity varies with a range from 60% to 75% for four (4) months from December to March and ranges from 40% to 55% for other eight (8) months.

Mean monthly wind run in highlands is generally rather strong and affected by the elevation. Wind run at higher elevated area ranges from 2.6 m/sec to 4.2 m/sec and one at lower elevated area shows a range from 2.0 m/sec to 3.3 m/sec.

Mean monthly sunshine hour has clearly seasonal change and sunshine hour for five (5) months from May to September (summer season) is more than 10 hours/day and in winter season, sunshine hour declines from 9 hours/day to 6 hours/day for five (5) months from October to February.

2.1.3 Water Quality of Surface Flow

During the field investigation period, it makes a success to obtain water samples at two sites, such as the Wadi Qatrana and the Wadi Sultani. The water sample of the Wadi Sultani is perennial flow of waste water from phosphate mine and one in the Wadi Qatrana is flood water in winter. As a result of chemical analyses on water samples, electrical conductivity of waste water of phosphate mine is about 4.5

mm hos/cm and Sodium Absorption Ratio (SAR) of waste water is calculated 1.98. Quality of waste water is assessed to be the Class of C5-S1 according to the diagram for the classification of irrigation water published by the United States, Department of Agriculture (USDA). This result indicates probable occurrence of very high salinity hazard in using this water as irrigation water. Electrical conductivity and S.A.R of flood water in the Wadi Qatrana are respectively about 0.6 mm hos/cm and 3.94 and the water quality is evaluated as the Class C2-S1 by the same diagram. The sodium and salinity hazards are evaluated low to moderate. In addition, Residual Sodium Carbonate and Bicarbonate (R.S.C) of floodwater is estimated at 2.3 meq/l and the sodium hazard of the water is assessed to be marginal. Therefore, this water is suitable for the use of irrigation. Toxicities of the both water are not analyzed yet. The results of the chemical analysis on both water samples are shown in Table G-2.4.

2.2 Land Use and Agriculture

2.2.1 Land use

The Study Area is covered by the three (3) Governorates, namely the Amman, the Karak and the Ma'an Governorate as shown in Fig. G-2.2. The northern half area of the Study Area consists of the eight (8) Subdistricts or Nahias of the Amman Governorate and the southern half area is covered by the three (3) Subdistricts of the Karak Governorate. The south-western area of the Study Area is partly covered by the Ma'an Governorate. According to the National Village Survey 1984, the Ministry of Agriculture, land use in the Study Area, excluding the Asraq Nahia area of the Amman Governorate and the Ma'an Governorate, is respectively estimated at about 8% of forest, about 21% of cultivated area and about 71% of other types of land such as uncultivated land, lands for rest, urban and village area, desert land, etc. as shown in Table G-2.5.

Forest area expands along the north-western boundary of the Study Area, namely the Amman Subdistrict, the Na'our Nahia and the Madaba Subdistrict areas, and along south-western boundary of the Study Area namely, the Al-Qasr Subdistrict and the Karak Subdistrict areas. Rainfed farm areas expand in the northern area namely, the Amman Subdistrict, the Mowaqqar Nahia, the Jiza Nahia and the Madaba Subdistrict areas and in the three (3) Subdistrict areas of the Karak Governorate. Rainfed farm areas of the Jiza Nahia are rather large than those of other Subdistricts or Nahias. Because forest area and rainfed farms are absolutely confined in the areas mentioned above by the range of annual average rainfall. In particular, rainfed farm areas for cereals and fodder crops widely vary every year depending on annual rainfall. The irrigation area occupies about 12% of the total cultivated area in two (2) Governorate areas, and in particular, concentrated in the two (2) Nahias of the Amman Governorate, namely the Mowaqqar Nahia and the Jiza Nahia areas.

2.2.2 Planted Area and Crops

According to the Statistical Year Book 1985 and the Field Crops and Vegetables, Village Survey, the Ministry of Agriculture, planted areas of the East Bank, the Ghors, the Amman and Karak Governorates and the Study Area are as follows.

(Unit: Ha)

Crops	East Bank	Ghors	Amman & Karak Gov.	Study Area
1.Field Crops	149,675(65.8%)	1,703(4.9%)	51,688	52,276(76.8%)
2.Vegetables	22,530(9.9%)	26,559(76.3%)	(No data)	5,460(8.0%)
3.Fruit Trees	55,429(24.3%)	6,529(18.8%)	10,289	10,347(15.2%)
Total	227,634(100%)	34,791(100%)	-	68,083(100%)

Planted area of field crops is about 149,700 ha, equivalent to 66% of total planted area in the East Bank. Main field crops in the four (4) areas are wheat and barley. Total planted area of wheat and barley in the Study Area reaches about 45,700 ha equivalent to about 87% of total planted area.

As for planted area of vegetables in the East Bank, main vegetables are tomato, watermelon, sweet melon, cauliflower, summer squash, cucumber and okra. In the Study Area, tomato also has the widest plantation share and planting share of watermelon, sweet melon and summer squash follow that of tomato.

Main fruit trees in the East Bank are olives, grapes, citrus, apples, figs and bananas. Olives has the widest planting share in the East Bank and its planted area reaches about 29,000 ha. Planted areas of fruit trees in the Amman and Karak Governorates and the Study Area show similar planting shares. Main fruit trees in the both areas are olives and grapes, and total planted areas for the both fruits are more than 4,400 ha equivalent to more than 80% of each total planted area. Detailed planted areas for each crop are shown in Table G-2.6.

The Study Area is located in highland areas of the Jordan. Agriculture in highlands including the Study Area is susceptibly affected by the annual hydrologic conditions, and planted area, production and quality of crops in rainfed farms change strictly. Table G-2.7 shows annual planted area of field crops and vegetables in the Study Area. Planted area of field crops such as wheat, barley and other winter field crops declined extremely from about 75,000 ha in 1983 to about 26,000 ha in 1984 because the year of 1984 was the most droughty hydrologic year for the 5 years from 1981 to 1985. However, planted areas of vegetables have increased moderately for the 5 years. Main reason of this increase is that majority of vegetable areas have been irrigated by groundwater and/or base flow of some wadi surface flow and modernized horticulture techniques such as plastic house plantation, multing techniques and drip tube irrigation method have been carried out.

According to the Agricultural Census in 1983, rainfed area and irrigated area of the Study Area are respectively 87.8% and 12.2%. Irrigation area is extremely a few and vegetables and fruit trees are mainly planted. In rainfed area, planted area of field crops is the largest and fruit tree area follows field crops area (See Table G-2.8). Main crops of field crops are wheat and barley. Planted area of the both crops in the two (2) Sub-Study Areas, namely, the Amman and the Karak is more than 60% of each total palnted area. Furthermore, other field crops such as lentils and chick pea and vegetables have small planting share of less than 3% of each total planted area.

Crop planted in irrigation farms are classified into two (2) vegetable groups by farm types such as field plantation and plastic house plantation. Plastic house plantation was carried out in the irrigated area of about 11% in 1983, referring to data on irrigation area of the Amman and Karak Governorates. Majority of planted crops of the both farm types are tomato, cucumber and eggplant. The most widely planted crop is tomato (See Table G-2.9).

2.2.3 Cropping Pattern

Majority of winter season crops in rainfed farms are cereals such as wheat and barley. Ploughing for cereals in rainfed farms roughly starts on November, before and after the first rainfall, and harvest period of these crops typically ranges from June to July. A little amount of vegetables are planted in irrigated field farms and plastic house farms. Main winter season vegetables are tomato in irrigated field farms and tomato and cucumber in plastic house farms. Planting period of winter season vegetables in irrigated field farms and in plastic houses are about five (5) months from August to December. Main summer season crops are tomato, cucumber, watermelon, sweet melon in irrigated field farms and tomato, cucumber, squash and eggplant in plastic house farms. Planting period of summer season vegetables in the both farm cases are about seven (7) to eight (8) months from January to July or August as shown in Fig. G-2.3 and Fig. G-2.4.

2.2.4 Farming Practices

According to the Agricultural Census 1983, total number of farmer families in the Amman and Karak Governorates is about 19,000 families. Farmer families who use agricultural machineries and make conjunctive use of machineries with animals reaches about 67% of total farmer families (See Table G-2.10). However, holding rate of agricultural machineries per family is extremely low as shown in Table G-2.11. Taking into account the results of field investigation and data mentioned above, mechanized farming in the Study Area is assessed to be carried out only in the small scale areas and with the cooperative use of agricultural machineries.

Majority of field crops is planted in rainfed farms. Ploughing is carried out by tractors and/or by animal powers and mechanical harvesting is usually carried out. In some farms, harvesters are sometime used. Threshing of grains is usually carried by threshers.

Plantation of vegetables is mostly carried out by drip irrigation. Modernized agricultural facilities such as plastic houses, mulching sheets, soluble fertilizers and spray for agrochemicals have been introduced. As for sowing vegetables, direct sowing in open field and transplanting in plastic houses and in mulching farming areas are usually carried out. Soluble fertilizers cosisting of ammonium sulfate, urea, ammonium phosphate and triple super phosphate are used in supplying irrigation water through drip tube systems, and manual spraying of insecticides and fungicides is carried out. However, most farmers in highlands have kept traditional farming practices and modernized farming practices mentioned above are not carried out so widely.

As for plantation of fruit trees, drip irrigation method or furrow irrigation method have been introduced. Training and pruning of fruit trees have not been carried out and these matters become one of the main reasons of unstable fruit productions in the area.

Moreover, majority of farmers use chemical fertilizers, however, consumable amount of fertilizers per hectare, excluding organic fertilizers is very low, comparing to the standard figures of the Manuals on farming practices for vegetables published by the Ministry of Agriculture, as shown in Table G-2.12.

2.2.5 Crop Yield and Production

According to the Statistical Year Book 1985, The Department of Statistics and the Field Crops and Vegetables, Village Survey 1985, the Ministry of Agriculture, Crop Yield and Production in the East Bank, the Ghors, the Amman and Karak Governorate areas and the Study Area are summarized as follows.

(a) Field Crops;

Unit crop yields of wheat and barley show the similar figures with the ranges from 0.6 to 0.8 ton/ha of wheat anf from 0.5 to 0.7 ton/ha of barley in the East Bank, the two (2) Governorate areas and the Study Areas. However, unit crop yields for field crops in the Ghors shows about 1.2 ton/ha of wheat and 1.8 ton/ha of barley.

Production of field crops in the Study Area reaches about 37% in wheat and about 47% in barley comparing to production of each crop in the East Bank.

(b) Vegetables;

Unit yields of majority of vegetables in the Study Area are lower than those in the East Bank, but unit yield of pepper in the

Study Area shows higher figure comparing to that in the East Bank. Unit yields of vegetables excluding potatoes in the Ghors show higher figures comparing to those in the East Bank and the Study Area. Each vegetable production in the Study Area are generally less than 20% of that in the East Bank, but only production of pepper reaches about 65% of that in the East Bank. Out of vegetables in the Study Area, tomato has the largest production and production of watermelon follows.

(c) Fruits;

Generally, unit yield of fruits in the East Bank, the Amman and Karak Governorates and the Study Area are similar. However, unit yields of almond, peaches and cherry in the Study Area show higher figures than those in the East Bank and unit yields of apples, citrus and pears are lower than those in the East Bank.

In the Study Area, major productions of fruits are olives and grapes and these productions reach about 17% and about 33% of that in the East Bank respectively. Productions of other fruits reach about 30% of those in the East Bank. Average unit yield and production of each crop in 1985 are shown in Table G-2.13.

Crop yield and production are also susceptibly influenced by an annual rainfall. Especially, those of field crops are strictly affected as what Table G-2.14 shows.

Average unit yield and production of each crop in the Study Area for these five (5) years from 1981 to 1985 are estimated as shown in Table G-2.15. Production amount and unit yield of major crops in the Study Area are as follows.

Crops	Unit Yield (ton/ha)	Production (ton)
1. Field Crops		
Wheat	0.78	24,404
Barley	0.66	9,421
2. Vegetables		
Tomato	12.71	17,840
Watermelon	14.93	7,914
Cucumber	18.53	5,634
Cauliflower	16.79	5,206
3. Fruits		
Olives	0.93	4,118
Grapes	3.68	14,725

Furthermore, unit yields of vegetables in irrigated farms are estimated according to the Annual Report 1985, the Ministry of Agriculture. Unit yield of each vegetable in highlands is generally lower than that in the Ghors because the Ghors has much long experience of horticulture and modernized techniques on horticulture has been carried out, and in addition, suitable crops for weather conditions, especially seasonal variation of temperature have been screened for horticulture in the Ghors. However, unit yields of some crops such as tomato, onion, potato and melons in summer and zucchini and potato in winter are higher than those in the Ghors as shown in Table G-2.16.

2.2.6 Farming Size and Land Tenure

According to the Agricultural Census 1983, about 80% of both areas of the Amman and Karak Governorates are owners' land. About 20% of the area is used by tenants as shown in Table G-2.17. Holding farm sizes of one (1) family are concentrated into two (2) farm sizes of less than one (1) ha and five (5) to ten (10) ha.

2.2.7 Livestock Raising

According to the National Village Survey 1984, holding numbers of domestic animals in the Study Area are respectively estimated at about 430,000 nos of sheep, at about 120,000 nos of goats, at about 3,500 nos of cows and at about five million nos of poultries, as shown in Table G-2.18. The average holding numbers of one family are roughly estimated at about 35 numbers of sheep and goats and at 200 numbers of poultries.

2.3 Marketing

2.3.1 Marketing System of Agricultural Products and Inputs

The Ministry of Agriculture (MOA) controls the amount of import and export of agricultural products through licensing, and the Ministry of Supply (MOS) provides leadership in the regulation of prices.

Marketing of some imported agricultural commodities such as wheat, sugar, rice and meat excluding frozen goods are monopolized as the essential or basic food under the MOS. As for local production such as wheat, barley, chickpeas, lentils, purchasing prices are announced prior to the crop season, and the Government committee purchases the products with the announced prices, while the prices of local meat and milk are determined under the market mechanism.

The prices of fresh products are determined what the price should be that day by the Government committee in reviewing the previous day's examining wholesale prices at the current day's auctions, and assessing the volume of products in the wholesale market.

The Agriculture Marketing Organization (AMO) was established as an independent government organization responsible for organizing external and internal trade in agricultural products, commercial operations,

support functions such as market research and regulatory activities.

Furthermore, the Agricultural Marketing and Processing Company of Jordan (AMCO) was established with the major objectives and fields of activity as follows:

(1) Trading and marketing of fresh fruits and vegetables especially for external markets.

(2) Marketing research and investigation in order to introduce Jordan's agricultural products into new markets.

(3) Marketing of canned vegetables in neighbouring countries.

(4) To establish, supervise and operate processing factories for agricultural products.

(5) Installation and operation of packing and grading lines for fresh products.

(6) Concluding contracts with farmers to produce required varieties either for processing or for export purposes.

2.3.2 Production Control of Some Crops

The Government has launched a production control program with the major objectives to avoid problems in marketing of some overproduction vegetables such as tomatoes, cucumbers, eggplants and squash and to promote production of some deficit crops such as onions, potatoes, garlic and grains, etc. The MOA regulates the planted area of each selected crop under irrigation through issuing permission to farmers both in the Jordan Valley and Highlands. This is also to promote other crop production by utilizing the saved field amd irrigation water.

Table G-2.19 shows the projected target of each crop for 1985/86 season and actually proved planted area and production in 1985. The production of tomatoes was subjected to decreas from 412 thousand tons in 1985 to 242 thousand tons while that of eggplants was projected to increas to about 160%. Production of squash was projected to increas is 130% in the East Bank and in the Valley in total while, in the Highlands was decreased.

2.3.3 Demand and Supply of Agricultural Products

During five (5) years from 1981 to 1985, annual imports of food and live animals were counted at about JD180 thousand or more than 16% of the total value of national import on an average. Wheat and flour of wheat was counted at about JD31 thousand or 17% of the total imports of food commodities followed by meat of 16%, fruits vegetables and nuts of 16%. During the same period, the value of import of wheat flour increased from JD23 thousand in 1981 to about JD39 thousand in 1984, then slightly dropped to JD28 thousand in 1985. Import of meat counted about JD29 thousand on average. Import of dairy products increased by 170% in value, while import of sugar decreased about 80% in value during the period.

During the same period, export of food and live animals earned about 19% of the total export value in the Jordan. Export of fruits and vegetables counted more than 70% of the total export value of food and animals. Major fruits exported from the Jordan were citrus fruits like oranges, mandarines and lemons followed by banana and melons. The export of vegetables counted about 47% of the total export value of food and animals. Main vegetables exported were tomato, cucumber, squash and eggplant.

According to the Statistical Year Book, 1985, Consumption of major crops in the Jordan are as shown in Table G-2.20.

Consumption per capita on major crops reaches more than 580 kg. Main import crops such as wheat, barley and apples are composed of about 36% of consumption per capita. Main export crops such as tomato, eggplant, cucumber, citrus, sweet melon and pepper are consisted of about 47% of consumption per capita.
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2.4 Agricultural Supporting System

Overall policy for agriculture, including horticulture production and marketing, is set by the Agriculture Higher Council. The Concil is headed by the Prime Minister and composed of the Minister or Director of the Ministries of Agriculture, Supply and Planning, the Jordan Cooperative Organization, the Agriculture Credit Corporation, the Jordan Valley Farmers Association, the Jordan Valley Authority and the Agriculture Marketing Organization.

The Ministry of Agriculture (MOA) deals with, controlling over a wide range of agricultural activities through its various directorates at the headquarter and governorates. The Directorate of Agriculture Research and Extension, the MOA has specifically responsible of research activities such as plant protection, field crops, horticultural crops, soils and fertilizers and irrigation. The Directorate of Agricultural Economics performs several functions including agricultural economic studies, collection of market information and preparation of a monthly plan that serves as the basis for issuing import and export licenses, establishing production control for such vegetables as tomatoes, cucumbers, eggplants and squashes of which prices are affected by over production and market surplus in the recent years.

The Agricultural Credit Corporation (ACC), the Jordan Cooperative Organization (JCO), the Jordan Valley Farmers' Association (JVFA), provide services and credits to the agricultural sector. The Agricultural Marketing Organization (AMO) and the Agricultural Marketing and Processing Company (AMPCO) deal with organizing external and internal trade and processing in agricultural products.

In addition to the above mentioned organizations, the Faculty of Agriculture, the University of Jordan executes agricultural services with its integrated program of teaching, research and extension.

2.4.1 Present Government Organization

The governmental agencies concerned with highlands agriculture and irrigation development projects are the Water Authority of Jordan (WAJ), and the Ministry of Agriculture (MOA).

1. The Water Authority of Jordan (WAJ)

The WAJ is composed of nineteen (19) departments and concerned with water resource development in highlands. Field investigation, study and plan and construction works on development of groundwater, spring water and surface water in highlands have been made. Furthermore, maintenance works on existing pilot irrigation schemes and other small-scale spring development facilities have also been carried out. Out of nineteen (19) departments, one department, namely, the Irrigation Department has been concerned with the study and maintenance of local municipal water supply facilities, existing pilot irrigation schemes and the plan and construction of spring water development in highlands.

The Irrigation Department is composed of six (6) divisions. Main engineering divisions are the Irrigation Division, the O & M Division and the Spring Development Division as shown in Fig. G-2.5. Number of staff at head office of the Irrigation Department is approximately 21 persons and field staff including surveyor are about 90 persons.

2. The Ministry of Agriculture (MOA)

The Ministry of Agriculture is composed of ten (10) departments, head office and twelve (12) regional offices. The most concerned departments with highland agriculture and irrigation development are the

Agriculture Research and Extension Department, the Agricultural Production and Services Department and the Forest and Range Department.

2.4.2 Agricultural Research and Extension

The Directorate of Agriculture Research and Extension, the MOA deals with agriculture research and extension activities in Jordan. Furthermore, the MOA organized the National Center of Agricultural Research and Technology Transfer of Jordan (NCARTT) and thirteen (13) agricultural extension offices all over Jordan. In the Study Area, two (2) extension offices have been constructed.

2.4.3 Credit Service

According to the Agricultural Census 1983, the ACC, the JCO, local development banks and the Farmers Union provide agricultural credit services. However, in the Amman and Karak Governorate areas, user numbers of these credit organizations is not large and reaches about 650 farmers as shown in Table G-2.21. Main finance source for farmers is farmers themselves. Agricultural credit is mostly used for extension of drip tube facilities and preparation of plastic houses for horticulture.

2.5 Farmers' Economy

2.5.1 Farm Inputs and Output

According to data on prices of farming materials and labour surveyed by the Department of Agricultural Economic, the MOA, prices of materials and labour in 1985 are summarized as shown in Table G-2.22. For the estimate of material costs, consumed amount of chemical fertilizer and agrochemicals is assumed about half amount of the Manual on vegetable plantations published by the MOA, and water fee is assumed three (3) fils/m^3. Table G-2.23 shows material cost for each farm type and each crop. Labour costs are estimated as shown in Table G-2.24 referring to the data on the Mujib and Southern Ghors Irrigation Project (Stage II). In rainfed farms, present farming practices are assumed to be carried out extensively and labour requirements on sowing, ploughing, weeding and fertilization are estimated rather lower than those of the Manual.

The estimated total production cost for each crop ranges from about JD30/ha to JD310/ha in rainfed farms, from about JD620/ha to JD1,200/ha in irrigated field farms and from about JD1,900/ha to JD2,600/ha in plastic house farms as shown in Table G-2.25. Production costs for plastic house farms become about 2.5 times of those for irrigated field farms. Main reasons of the increase of production cost are facilities cost of plastic houses and intensive labour requirements.

2.5.2 Farmgate Price and Farm Receipt

According to data surveyed by the Department of Agricultural Economic, the MOA, farm gate price in 1985 is estimated as shown in Table G-2.26. For the estimate of net income on farm, unit crop yield for each crop is assumed as follows.

(a) Crops in rainfed farms:

Crop yields are estimated to adopt average crop yield for five (5) years from 1981 to 1985 in the Study Area. (See Table G-2.15

(b) Crops in irrigated field farms:

Crop yields are estimated to adopt average crop yield in irrigated farms of highlands in 1985. (See Table G-2.16)

(c) Crops in plastic houses farm:

Crop yields are estimated to refer to data on the Agricultural Production Improvement Project in Arab Countries (Phase I), 1985.

Net income on farm of each crop is estimated to range from about JD25/ha to JD180/ha in rainfed farms, from about JD500/ha to JD1,350/ha in irrigated field farms and from about JD650/ha to JD3,800/ha in plastic houses farms as shown in Table G-2.27.

2.6 Existing Irrigation System

2.6.1 Surface Water Irrigation Area

Small surface water irrigation areas are scattered around the Wala bridge of the Kings Highway and downstream from the Mujib bridge of the Kings Highway . Majority of irrigation areas are located at gentle side slopes of the wadis and flat lands of small hills. Irrigation water is lifted up by portable pumps and conveyed by small pipelines. Total irrigated areas are respectively estimated at about 360 ha (registered irrigation area: approximately 600 ha) in the Wadi Wala area and at about 70 ha in the lower reaches of the Mujib. Main planted crop in the

both areas is vegetables.

A lot of springs are found along the slope areas of the Jordan Valley. The total number of springs are estimated at more than 200. The first priority of spring water use is domestic water for village inhabitants, and the second is drinking water for domestic animals and/or irrigation water.

In the Study Area, only one spring is found at Lajjun area, located about 16 km north-eastward from Karak town. The average water discharge of the spring is about 12 l/sec and the irrigation area is estimated at about 40 ha. The main irrigated crop is vegetables and the drip irrigation method is adopted. (see Table G-2.29)

2.6.2 Groundwater Irrigation Area

(A) Pilot Irrigation Schemes

The government has the nine (9) pilot irrigation schemes in the highlands as shown in Table G-2.28, and these schemes are located at about 60 km north-east of Amman to about 80 km south-east of Ma'an. Operation and management of facilities and agricultural research and extension services of these Schemes are made by the Water Authority and the Ministry of Agriculture at present. Operation and maintenance works of production wells, irrigation facilities and related facilities have been dealt with by the Water Authority and agricultural research, technical development of crop farming and extension works have been carried out by the Ministry of Agriculture. Total irrigation areas of these Schemes become more than 1,250 ha and their water resource for irrigation is groundwater excluding the Al-Samra irrigation project. Mainly planted crops are vegetables, fruit trees and cereals. Several irrigation methods such as furrow irrigation, sprinkler irrigation and drip irrigation are adopted, taking into account kinds of crop, soil conditions, water quality and farming practices.

Out of the nine (9) pilot irrigation schemes, the following two (2) schemes, namely the North Qatrana irrigation project and the South Qatrana irrigation project, are located in the Study Area, as shown in Fig. G-2.6. The both Qatrana irrigation projects were constructed at the beginning of 1970, as one of the bedouin settlement projects. At present, the total irrigation area of both projects is 165 ha and the water resource of irrigation is groundwater. The majority of planted crops are vegetables, such as tomato, eggplant, potato, cucumber and watermelon. (see Table G-2.29)

(B) Other Groundwater Irrigation Area

Groundwater irrigation areas expand from southern area of Amman to northern area of Madaba along the Kings Highway, and from the eastern area of Jiza to southern area of Dab'ah along the Desert Highway as shown in Fig. G-2.6. These areas are irrigated by using private production wells and total irrigation area is estimated at about 3,000 ha. The main planted crops are vegetables and fruit trees. In the Amman Governorate area, private production wells of about 250 numbers are estimated. However, in these areas, about 160 numbers of production wells are confirmed by the WAJ's data of well drilling. According to the results of pumping test on these production wells, well yield ranges from 5 l/sec to 25 l/sec and total dynamic watershed varies from 130 m to 280 m. The average well depth is estimated at about 300 m. Monitoring data on operating hours and discharge of pumps, planted crops, crop yield, etc. are not available because of private sector's operation.

3. THE SCHEME

3.1 Development Concept

3.1.1 Agricultural Development

An areal scale of newly development schemes becomes less than 200 ha because 100% of groundwater with the safe yield in the whole basin is scheduled to be used for the municipal water supply of Amman and the wadis have non-perennial flow of surface water at proposed damsites. The areal scale of shemes is extremely smaller than those of irrigation development projects in the Ghor regions of the Jordan Valley and execution of the irrigation and agricultural development projects in highlands delays more than a decade than those of irrigation development projects in the Ghor areas. Furthermore, market shares and market prices of agricultural products in the Jordan, specially vegetables are substantially affected by the production amount and season of the Ghor irrigation areas. Therefore, agricultural products in highland irrigation project areas shall have competitive position cope with those in the Ghor irrigation areas. For instance, selection of higher benefit crop and high technical and rational management of agricultural products will be necessary to introduce in highland irrigation areas, taking into account average net benefit of about JD 2,000/ha on farms in the Ghor irrigation areas. Crops to be selected for highland irrigation project areas become horticultural crops of higher market prices in the Jordan and newly horticultural crops. In addition, suitable crops and cropping patterns for weather and soil conditions in highlands shall be examined to select, and crops of lower water consumption type shall be selected as much as possible.

New development scheme areas are proposed as the governmental farms directly managed by the WAJ and a model farm on agricultural management will be established in the development scheme areas to give the impact to existing horticultural farms (plastic houses) expanding in and around the new development schemes. Because project types of regional development for the village inhabitants and farmers and resettlement of the bedouin people are hardly considered, taking into account small scale of development scheme areas and present conditions on agricultural management in the existing pilot irrigation projects for resettlement of the bedouin in highlands. However, in case of the conjunctive use area, existing horticultural farms involved in the new development schemes will continuously belong to the private sector after construction of the

schemes and will be upgraded as the pilot farms on horticulture and modernized agricultural management in order to strengthen agricultural management and agricultural extension of other existing horticultural farms (private sector) and existing pilot irrigation projects (public sector) in and around the scheme areas. Moreover, if possible, agricultural research in the arid region will be strengthened to carry it out in the scheme areas. In particular, in the Dab'ah-Hammam scheme area, new executing body for agricultural research and O & M, namely, the Hammam-Qatrana Scheme Office is proposed to be organized as one of the departments of the WAJ in the future.

3.1.2 Irrigation Development

Selected crops for the schemes in highlands are horticultural crops such as vegetables and development potential of water resource is extremely small. Therefore, taking into account the irrigation method with high irrigation efficiency and useful water, main conveyor of irrigation water and irrigation method of terminal irrigation area are respectively proposed to be pipeline system and drip irrigation method and overall irrigation efficiency will be increased more than 75%.

As for drainage canal system, small tributaries of wadis will be necessary to utilize and involve in drainage canal systems as much as possible. At hillside slopes of the schemes, dry stone fence and collector drains shall be provided to protect Scheme areas from flood in winter season. Small collector drains shall also be provided in terminal irrigation areas to accelerate the discharge of salinity in soils with rain water and flushing water of drip pipes.

In the conjunctive use area, water resource of existing irrigation farm is groundwater at present and production wells of groundwater belong to the Private sector. In the water distribution plan in the overall the conjunctive use area, some alternative water distribution plans for year-round irrigation in the overall scheme areas or some certain areas of the scheme areas will be planned. However, complex water distribution plan of groundwater, which groundwater lifted up at one (1) private farmer's production well is operated and managed the water supply for other farmers' farms, is hardly planned because of farmer's psychological conditiond. Therefore, in the scheme areas, newly developed surface water resource will be distributed to compensate excess water amount compared with present groundwater use in the existing irrigation farms and 100% of irrigation water in the newly developed areas. In addition, for the decrease of O & M costs on pump stations, electric power supply system will be planned, and access road

for the schemes will be connected with farm road networks in the scheme areas for smooth transportation, operation of irrigation facilities and communication.

3.2 Agricultural Development Plan

3.2.1 Selection of Crops

As for the primary screening of proposed crops for the Schemes, suitability of crops for arid weather conditions, salinity on soils and water quality, marketability in the internal and external trade, presently planted crops in highlands and crops to be possibly planted in the future are taken into consideration and twenty six (26) kinds of crops are screened.

In the second step of the screening of crops, three (3) screening factors such as crop budget (net income on farm), reasonable and appropriate cropping pattern involving double cropping and water benefit which is definite to divide net benefit on farm by consumptive water use of crop are adopted. As for possibility of double cropping in the Scheme areas, crops for irrigated field plantation and/or plastic house plantation are examined taking into account more detailed weather conditions in the Scheme areas, growth period of crops and anticipated crop yield, and nineteen (19) kinds of crops are screened. In the next examination, crop budget, in particular, net income on farm of each crop is taken into account. Priority of screening is given to crops which bear net income of more than JD1,500/ha, especially, crops with net income of more than JD2,000/ha are given higher priority.

Strawberry is a hard crop for double planting even at plastic houses in the area. However, strawberry is assessed to be selected as one of the higher priority crops for the Scheme.

After this examination, seventeen (17) kinds of crops are screened and it is clarified that fruit trees and fodder crops in the Scheme areas have low water benefit. On another ward, fruit trees and fodder crops need somewhat much irrigation water, but bear lower benefit than those of other crops in the Scheme areas.

At present, productions of some crops including squash and cucumber are controlled by the Government to keep stable market prices. In this Study, squash and cucumber in plastic house farms are also selected as

alternative crops for double cropping to satisfy the three (3) screening factors because total productions of these crops in the Study Area are not considered large amount comparing with the production amount at the National level. In the examination step, cucumber in plastic house farms is selected and squash is deleted. Because net income on farm of cucumber is estimated at about two and a half (2.5) times higher than that of squash. Finally, the following seventeen (17) kinds of crops are screened for the Schemes.

(I) Vegetables for plastic house - - - - Tomato, Cucumber, Sweet & hot pepper, Sweetmelon, Strawberry, Spinach and Celery.

(II) Vegetables for open field - - - - Radish, Carrot, Potato, Lettuce, Squash, Watermelon, Greenbean, Okra, Onion and Cauliflower.

Detailed screening procedures are shown in Table G-3.1.

3.2.2 Proposed Cropping Pattern

On the basis of the screened crops mentioned in the preceding Chapter, three (3) types of cropping pattern are proposed for the both Schemes. In making rotations of the screened crops, the following matters are taken into account.

(a) For operation of full power and function of the Scheme and demonstration of the ideal horticultural farmings to existing groundwater irrigation area, stable crop production will be made by applying crop rotations and the minimum cropping intensity in case of year-round irrigated farms and winter season irrigated farms will be respectively set up more than 1.5 and more than 1.0.

(b) Crop rotation will be done to minimize crop damage caused by disease and nematode.

(c) Crop rotation will be done to stabilize seasonal labour requirement constantly.

(d) The crops which these productions have been controlled by the Government but the future marketing potentials of these crops are forecasted to become large, especially, tomato,cucumber and squash, are involved in crop rotations with cropping tensity of less than 50%.

Proposed cropping pattern consisting of three (3) types is as shown in Fig. G-3.1. In the each Scheme Area, proposed type of cropping pattern and its area are as follows.

Proposed Cropping Pattern in the Scheme Area

Cropping Pattern	Cropping Intensity	Scheme Area (Ha)	
		Dab'ah-Hammam	Qatrana
Type - 1	1.75	50	0
Type - 2	2.00	50	0
Type - 3	1.00	75	75
Total		175	75

3.2.3 Proposed Farming Practices

Proper farming practices are the most essential factor for realizing full exploitation of agricultural potential in the Schemes. In order to obtain high yield and excellent quality of proposed crops, the following farming practices are proposed.

(i) Soil improvement:

For plantation of root crops such as potatoes and carrots, much manure application and deep ploughing are proposed to improve present soil properties.

(ii) Transplanting:

As for plantation of strawberries, tomatoes, cucumbers, sweet melon, celery, lettuce, sweet peppers and onions, transplanting is proposed to accelerate and strengthen growth of crop nurseries. Moreover, for easy transplanting and smooth management of these nurseries, nursery bed composing of small plastic pots is proposed.

(iii) Planting space:

Planting spaces of some crops such as tomato, cucumber, sweet pepper, lettuce and cauliflower shall be shortened within the standard space recommended by the Manual published by the MOA.

(iv) Fertilization:

Chemical fertilizer application shall be increased about 120% to 150% of present use of that.

(v) Agrochemicals:

Agrochemical application shall be made 3 to 5 times per one crop season.

(a) Manpower Requirement

Considering the improvement of farming practices mentioned above, unit labour requirement for each crop is estimated as shown in Table G-3.2. Annual labour requirement for each cropping pattern is respectively estimated at about 570 man-days/ha for type-1, at about 220 man-days/ha for type-2 and about 110 man-days/ha for type-3 in assuming a daily working time of 8 hours. The peak labour requirement for each cropping pattern will occur on 61 man-days/ha for type-1, on 29 man-days/ha for type-2 and on 25 man-days/ha for type-3 respectively. In Dab'ah-Hammam Scheme area of 175 ha and the Qatrana Scheme area of 75 ha, the peak labour requirements are estimated at about 6,000 man-days on June and at about 1,300 man-days on March as shown in Table G-3.3. These labour requirements will be supplied by local labour potential in and around the Scheme areas.

(b) Farm Input Requirement

Total of farm input requirement for each crop is estimated as shown in Table G-3.4. That for each cropping pattern is estimated as shown in Table G-3.5.

3.2.4 Anticipated Unit Yield and Production

(A) Unit Yield

Anticipated unit yield of each crop in the Scheme areas are estimated as shown in Table G-3.6, taking into account present unit crop yield in highlands of the Jordan, standard crop yield described in the Manual of Vegetables Production, Jordan published by the MOA, reference data on the abroad, present conditions of inputs on farm, ability of farmers' management, etc.. Unit yield of each crop is assumed not to be affected so much from salinity of soils and irrigation water. Because soil salinity is assumed to decrease within the tolerable soil salinity

for crop growth without the decrease of crop yield by reclamation leaching and irrigation leaching for crops.

Build up period of target on unit crop yield is assumed for three (3) years. Unit crop yield with the Scheme condition is estimated as follows:

Crops	Unit Yield (ton/ha)
1. Strawberry	12
2. Tomato	60
3. Cucumber	70
4. Sweetmelon	40
5. Spinach	20
6. Celery	30
7. Sweet pepper	50
8. Potato	40
9. Lettuce	30
10. Watermelon	40
11. Squash	30
12. Greenbean	20
13. Radish	30
14. Carrot	30
15. Okra	15
16. Onion	40
17. Cauliflower	40

(B) Production

Total productions of crops in the Scheme areas are estimated to multiply the anticipated unit yield by proposed planted area. Crop productions in the both Scheme areas are estimated as shown in Table G-3.7

3.2.5 Crop Budget

For assessment of profitability of each proposed crop, crop budget analysis is made. Basic factors for the analysis are assumed as mentioned below.

(A) Crop Production Cost

Labour and material costs for crop production are estimated as shown in Table G-3.8, based on the labour requirement, farm input and materials prices. For the recent three (3) years, material prices show the declined trend and in this estimate, updated material prices in 1986 are assumed to adopt the same prices of those in 1985.

(B) Farmgate Price

Farmgate price of each crop for the Scheme will be generally fluctuated by balance of supply and demand in market and it is hard to estimate the updated farmgate prices. Therefore, the farmgate prices for the Scheme are determined to adopt the average farmgate prices in 1985 as shown in Table G-3.9. Because this average farmgate price is the most recent data in the study stage.

(C) Crop Budget

On the basis of anticipated crop yield, farmgate price and production cost mentioned above, crop budgets on the proposed crops are estimated as shown in Table G-3.10. Strawberry shows to be the most profitable and its unit net income per hectare is estimated about JD6,300 and cucumber, sweet melon and sweet pepper follow.

(D) Net Income of Cropping Pattern and the Schemes

Profitability of each cropping pattern is estimated as shown in Table G-3.11 based on the results of crop budget. Net income for each cropping pattern is respectively estimated at about JD5,900/ha for Type-1, at about JD3,300/ha for Type-2 and at about JD1,900/ha for Type-3. Therefore, total net income of the Schemes are estimated as follows.

Scheme		Dab'ah-Hammam		Qatrana	
Cropping Pattern	Net Income (JD/Ha)	Area (Ha)	Net Income (JD)	Area (Ha)	Net Income (JD)
Type - 1	5,945	50	297,250	0	0
Type - 2	3,263	50	163,150	0	0
Type - 3	1,890	75	141,750	75	141,750
Total			602,150		141,750

3.2.6 Agricultural Supporting System

In order to create and upgrade the Scheme areas as the pilot farm for horticulture in arid region, it is proposed to establish and strengthen the following agricultural supporting system. Moreover, for the strengthening activities of supporting system, necessary staff and budget shall be proposed to prepare or increase.

(a) Agricultural Extension Services:

Existing irrigated field farms and plastic house farms extend in and around the both Scheme areas and horticultural crops are mainly planted. However, frequent extension activities have not been carried out so much. Therefore, future extension works, training campaign on horticulture consisting of the transfer of knowledge and modern techniques on horticulture and introduction of high yield variety of crops are recommended.

(b) Agricultural Research Works:

The research works to be conducted are as follows.

- Variety trials for vegetables and screening of new variety and substitutional variety for future needs.
- Irrigation trials and leaching test for crops.
- Research on virus free seedlings and further modernized farming techniques.

3.3 Irrigation Development Plan

3.3.1 Screening of Development Schemes

Screening of development scheme areas is carried out on the four (4) steps by using four (4) screening conditions such as (1) suitable topographical conditions for irrigation, (2) soil and land classification, (3) water quality of available surface water and (4) available water potential for irrigation which is estimated by the simulation of reservoir operation based on irrigation water requirement, seepage condition of damsites and hydrologic condition of damsites as shown in Fig. G-3.2.

(a)The 1st Step

In screening of irrigation development scheme areas, existing topographical maps on a scale of 1 to 50,000 is used. Suitable topographical slope for irrigable areas is adopted within a range of less than 20% in view point of irrigation engineering aspects. In principle, gravity irrigation method is assumed to save construction and annual operation and maintenance costs of irrigation facilities. The potential irrigable areas are primarily screened by using the above mentioned conditions.

Primarily screened areas are classified into three group areas based on water resources and irrigation water use. The first group is conjunctive use area which uses flood water stored in dam reservoirs and groundwater pumped up from existing production wells. Potential irrigable areas of the conjunctive use are roughly estimated at about 1,500 ha in the area Dab'ah area. The second group is surface water irrigation area which uses only flood water stored in dam reservoirs. The potential irrigable areas of the second group are estimated at about 12,400 ha.

The third group is groundwater irrigation area which uses only groundwater pumped up from newly developed production wells. These groundwater irrigation areas are further potential irrigable areas to be recommended after groundwater resource is fully developed with safe yield of the whole basin in the future. In another word, after reaching the possible development quantity of groundwater within the safe yield of the whole basin, if additional development quantity of groundwater is confirmed through groundwater monitoring works and further study on groundwater balance. This additional groundwater can be supplied to the third group areas as irrigation water, if allowable in view point from water allocation in Jordan. The potential irrigable areas are estimated at about 48,500 ha. However, since 100% of groundwater potential is scheduled to be used as municipal and industrial water supply for the Amman area at present, the third group area is deleted from screening of the 2nd step.

(b)The 2nd Step

Screening of damsites is made in view points of topographical and hydrologic conditions, possibility of water use, geological conditions of damsites and examination of water allocation for municipal and industrial water supply and recharging surface water for groundwater,

and six (6) damsites which can store possible water for irrigation development in the downstream area from damsites are proposed. The screened damsites are the Hammam, Wala, Qatrana (existing dam), Nukheila, Khabra and Sultani (existing dam) dams.

On the other hand, soils and land classifications of irrigable areas expanding around the primarily proposed twenty (20) damsites are made, referring to the results of the reconnaissance soils survey. After detailed dam screenings, the assessment of soils and land capability for irrigable areas concerned with the six (6) damsites is made again, and three (3) damsites namely the Hamman, Qatrana (existing dam) and Sultani (existing dam) dams are evaluated to have suitable soils and land capability for agriculture. Main reasons of the deletion of the three (3) other damsites are as follows:

(b-1)Wala damsite area

Majority of downstream area from the damsite is assessed not to have suitable soils and land capability for agriculture. Because the area extends in side slopes of narrow and deep valleys and immature soils which are not suitable for agriculture extend in the area. However, existing registered irrigation farms of about 600 ha are scattered in the certain small areas of downstream area from the damsite. Out of 600 ha, the area of about 340 ha is irrigated by using portable pumps and small pipe lines and some kinds of vegetables are planted at present. These registered areas are located in flat land of low hills and side slopes of the wadi and areal scales of one farm are small. Taking into account the topographical condition and areal scale of scattered farms it is hard to make new irrigation development plan undertaken by the public sector.

(b-2)Nukheila damsite area

Soils and land capability in the downstream area from site are assessed not to be suitable for agriculture because of immature soils and topographical conditions. However, at present, small irrigated farms extending in side slopes of the Wadi Sueida as well as a narrow strip are found out. These farms are irrigated using the base flow of the Wadi Sueida. It is hard to find out suitable areas for new irrigation development plan in this area.

(b-3)Khabra damsite area

Downstream area from the damsite has a narrow strip of flat land along the wadi and steep side slope of the wadi. As a result of soil and land classifications, soils in the area are assessed to be unsuitable for agriculture because of immature soils.

(c)The 3rd step

According to the results of water quality analysis of surface water, surface water stored in the existing Qatrana dam is classified into the Class C2-S1 by the standard of the United States, the Salinity Laboratory and evaluated the low sodium water that can be used on virtually all soils. Sodium-sensitive plants may suffer damage as a result of Na accumulation. However, surface water in the Wadi Sultani, which the water samples are taken near the Abiad mining area located at upper stream of the existing Sultani dam shows high electric conductivity of more than 4.5 mm hos/cm and are classified into C5-S3. This water is evaluated as high sodium water that are only to be used in combination or organic soil improvement. Downstream area from the Sultani damsite is covered by loamy soils and much sodium hazard of soils is foreseen after commencement of irrigation. Data on water quality of the Wadi Hammam is not available at present. So that, referring to topographical and soils conditions of watersheds of the Hammam and Qatrana dams, water quality of surface flow at the Hamman dam is assumed to be similar to that of the Wadi Qatrana. Therefore, the Sultani damsite area is deleted from the category of irrigable area in this study.

(d)The 4th step

To estimate irrigation areas of the screened two (2) damsite areas on the basis of hydrological data in the watersheds of both dams and unit irrigation water requirement, the simulation of dam reservoir operation is made. Considering into the results of the simulation, irrigation areas for both schemes are determined to satisfy the 80% chance of drought year. In case of the Qatrana scheme, irrigation in the area is planned to carry out in only winter season. The existing dam reservoir is useful for irrigation development and expected irrigable area is not large and evaluated the optimized areal scale for reservoir capacity of the existing dam. Therefore, non extra embankment for the existing dam is assumed. The Hammam scheme is conjunctive use area. In order to extend irrigation area as much as possible, surface water stored in the dam is assumed to distribute the only excess water amount for the existing farms of 100 ha comparing to present groundwater use and 100% of irrigation water requirement for the new

development area. For determination of optimized dam reservoir capacity, trial and error on calculations of the benefit and cost ratio and the Internal Rate of Return (IRR) on several areal scales of the scheme are made. Effective dam reservoir capacities are assumed from 0.5 MCM to 3.0 MCM, referring to hydrologic data and embankment volume of dam. As a result of the trial and error, however, estimated irrigation area of each dam reservoir capacity varies from about 150 ha to 200 ha. The IRR of each areal scale is less than 5% and smaller dam reservoir capacity has the higher IRR.

On the other hand, taking into account canal layout in the scheme involving the three (3) existing farm areas and topographical condition of the scheme, irrigation area covered by proper canal layout varies from 160 ha to 180 ha. Therefore, the scheme which has the effective dam reservoir capacity of about 1.5 MCM and irrigation area of 175 ha is tentatively designed for the estimate of construction cost.

Finally, net irrigation areas of the both schemes are respectively determined 175 ha for the Hamman damsite area and 75 ha for the Qatrana damsite area.

3.3.2 Screened Scheme Areas

Scheme areas are screened in two (2) sites of the Study Area. One of the screened areas, namely, the Dab'ah-Hammam scheme area is located at about 13 km southeast-ward from Jiza, and the other screened area, namely, the Qatrana scheme area is located at western area of Qatrana. The both scheme areas are located in the arid region. However, each scheme area has its own natural physical and agricultural conditions.

(A) The Dab'ah-Hammam Scheme

The Dab'ah-Hammam area has somewhat much rainfall in winter season comparing with that of the Qatrana area and average annual rainfall ranges from 150 mm to 250 mm. The scheme area is located in shallow and wide valleys with somewhat gentle undulations. Salinity of soils is low to moderate and the electrical conductivity of soils ranges from 0.3 mmhos/cm to 4.3 mmhos/cm. The scheme area has a little agricultural background. Three (3) existing production tubewells for agriculture have been developed in the scheme area, and vegetable plantations such as cucumber, tomato and eggplants are managed in plastic houses and open fiels by using groundwater. The Dab'ah-Hammam Scheme area is delineated 175 ha as net irrigation area consisting of existing groundwater

irrigation farms of 100 ha and newly development areas of 75 ha. Irrigation canal layout of the scheme is composed of the Hamman dam, intake structure, regulating pond, sandfilters, booster pumps, main, secondary and tertiary pipe lines and drips lines on terminal irrigation farms. Main features of irrigation and drainage canal networks are as follows:

(i) Intake structure (Intake tower type)
Conduit Ø500 x Length 22 m

(ii) Regulating pond (Concrete lining pond)
Reservoir capacity - - - 1,800 m^3

(iii) Sand filters (Capacity 30 l/s) - - - - - - - - - - - - - 8 Nos

(iv) Booster pump station

(iv-1) Pump station - - - - - - - - - - - - - - - - - - - 46 m^2

(iv-2) Booster pumps including electric panels
Pump capacity - - - 3.6 m^3/min
Total dynamic water head - - - 20 m
Number of pumps - - - 4 Nos

(v) Distribution line - 4 km
including transformer
of 200 KVA

(vi) Main and Secondary pipe line
Reinforced concrete pipe Ø450 - - - - - - - - - - - 1.2 km
Ø300 - - - - - - - - - - - 0.8 km
Ø150 - - - - - - - - - - - 5.8 km

(vii) Stone fence and collector drain
(vii-1) Stone fence - - - - - - - - - - - - - - - - - - 4.7 km
(vii-2) Collector drain - - - - - - - - - - - - - - - - 3.2 km

(viii) Drainage canal - 5.5 km

(ix) Access and farm road - - - - - - - - - - - - - - - - - 8.6 km
Cross drain str. - - - - - - - - - - - - - - - - - - - 7 Nos

(x) Terminal irrigation development
newly developed area - - - - - - - - - - - - - - - - - 75 ha

(xi) Office building - 260 m^2

Canal layout of the scheme is illustrated in Fig. G-3.3.

(B) The Qatrana Scheme

The Qatrana area is located in downstream from existing Qatrana dam and the area extends in gentle side slopes of the Wadi. Average annual rainfall ranges from 50 mm to 100 mm. In the upper stream from existing dam, two (2) pilot farms of about 160 ha have been developed. Main aims of the two (2) existing pilot projects is to make a settlement of bedouin peoples and at present, plantation of vegetables and fodder crops and livestock production are carried out by using groundwater. In the scheme area, natural range development for livestocks is only carried out by using rainfall water. Salinity of soils in the scheme area is low and its electrical conductivity ranges from 0.5 mmhos/cm to 7.5 mmhos/cm.

The Qatrana Scheme area is delineated 75 ha as net irrigation area. Irrigation canal layout is composed of the existing Qatrana dam, pump station, regulating pond, sand filters, booster pump station, main, secondary and tertiary pipe lines and drip tubes on terminal irrigation farms. Main features of irrigation and drainage canal networks are as follows:

(i) Pump station
  (i-1) Pump station - - - - - - - - - - - - - - - - - - - 46 m^2
  (i-2) Pumps including one stand by pump and electric panels
    Pump capacity - - - 3.5 m^3/min
    Total dynamic water head - - 14 m
    Number of pumps - - - - - - - 4 Nos

(ii) Regulating pond (Concrete lining pond)
    Reservoir capacity - - - 1,300 m^3

(iii) Sand filters (Capacity 30 l/sec) - - - - - - - - - - - - - 6 Nos

(iv) Booster pump station
  (iv-1) Pump station - - - - - - - - - - - - - - - - - - - 39 m^2
  (iv-2) Booster pumps including electric panels
    Pump capacity - - - 3.5 m^3/min
    Total dynamic water head - - 20 m
    Number of pumps - - - - - - - 3 Nos

(v) Distribution line including
transformer of 200 KVA - - - - - - - - - - - - - - - - - - - 2 km

(vi) Main and secondary pipe line
Reinforced concrete pipe Ø300 - - - - - - - - - - - - 2.9 km
Ø150 - - - - - - - - - - - - 5.8 km

(vii) Stone fence and collector drain
(vii-1) Stone fence - - - - - - - - - - - - - - - - - - 1.1 km
(vii-2) Collector drain - - - - - - - - - - - - - - - - 0.7 km

(viii) Drainage canal - 0.2 km

(ix) Access and farm road - - - - - - - - - - - - - - - - - - 4 km
Cross drain str. - 4 Nos

(x) Terminal irrigation development
newly developed area - - - - - - - - - - - - - - - - - 75 ha

(xi) Rehabilitation of existing intake structure - - - Lump Sum

Canal layout of the scheme is illustrated in Fig. G-3.4.

3.3.3 Irrigation Water Requirements

Irrigation water requirement for proposed scheme areas consists of crop irrigation water requirement and leaching water requirement. Procedures and key factors of calculations are summarized as follows:

(i) $Cu = ETo \times Kc$
(ii) $CI = Cu + LP - Re$
(iii) $NI = CI/(1 - LR)$
(iv) $GI = NI/Ie$

where Cu = Consumptive use of crops
ETo = Potential evapotranspiration
Kc = Crop coefficient

CI = Crop irrigation water requirement
Re = Effective rainfall
LP = Land preparation requirement

NI = Net irrigation water requirement

LR = Leaching requirement

GI = Gross irrigation water requirement
Ie = Irrigation efficiency.

(a) Crop Irrigation Water Requirement (CI)

Key factors of crop irrigation water requirement are potential evapotranspiration, crop coefficient, land preparation requirement and effective rainfall.

(a-1) Potential Evapotranspiration (ETo)

To estimate potential evapotranspiration in the scheme areas, the modified Penman method authorized by FAO is adopted. According to useful climatic data at seven (7) weather stations in and around the Study Area, potential evapotranspiration in the Study Area is estimated to decline low (4 mm/day to 2 mm/day) in winter season from November to March and rapidly increase on April to May and reach around 9 mm/day on June to August. As shown in Table G-3.12 potential evapotranspiration at each weather station shows a little difference on even same season. Potential evapotranspiration for plan and design is determined to find out representative value referring to the estimated value of the nearest weather stations to each scheme area as shown in Fig. G-3.5. The values for plan and design are as follows:

(Unit: mm/day)

Scheme Area	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
(I) Dab'ah-Hammam Scheme Area	5.0	4.0	2.0	2.0	2.5	3.5	5.5	7.5	9.0	9.5	9.0	7.5
(II) Qatrana Scheme Area	5.0	3.5	2.0	2.0	3.0	4.0	7.0	8.0	8.5	9.5	8.0	7.0

To estimate potential evapotranspiration for plastic houses plantation, climatic conditions of each weather station and the Albedo factor of the modified Penman formula are roughly modified based on the following assumptions. The modified values of climatic factors are shown in Table G-3.13.

Asssumptions:

(i) Monthly mean temperature in plastic houses is assumed about 5°C higher than those in open field.

(ii) Monthly mean relative humidity in plastic houses is respectively assumed about 10% and 5% higher than those in open field during the period from September to April and the period from May to August.

(iii) Monthly mean wind run is assumed about 0.5 m/sec during only five months from June to October.

(iv) The Albedo factor of the modified Penman formula is assumed about 0.35 because of plastic sheets.

The calculated potential evapotranspiration for plastic house at each weather stations decreases about 1 mm/day to 2 mm/day in winter season and about 2 mm/day to 3 mm/day in summer season comparing to those in open field. Design potential evapotranspiration for the Dab'ah-Hammam area declines from the beginning of winter and reaches about 2.0 mm/day on December to january and during the period from February to May, it increases gently and reaches about 6.5 mm/day on June to July and starts declining as shown in Fig. G-3.6. The design potential evapotranspiration is adopted as follows:

(Unit: mm/day)

Scheme Area	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dab'ah-Hammam	3.5	2.0	1.0	1.0	1.5	2.5	3.5	5.0	6.5	6.5	6.0	5.0

(a-2) Crop Coeficient (Kc)

Crop coefficients for selected crops are determined according to the indication of the Irrigation and Drainage Paper No. 24 published by FAO. Average crop coefficient of each selected crop is shown in Table G-3.14.

(a-3) Land Preparation Water Requirement (LP)

Scheme areas are located in the arid zone. Taking into consideration present farming practices in groundwater irrigation area and rainfed area, ploughing is carried out in using groundwater or rainfall water before sowing, seedling or transplanting period. Referring to proposed land preparation requirement in the similar irrigation development projects of Jordan, land preparation water requirement for the scheme is, in

principal, assumed 60 mm per once.

(a-4) Effective Rainfall (Re)

According to the isohyetal maps in the Study Area published by this hydrologic study and the National Water Resource Master Plan in 1977, the western half area of the Study Area has an average annual rainfall ranging from about 200 mm to 350 mm and annual rainfall in the eastward areas from the western half area declines from 200 mm to 50 mm. Referring to the estimated effective rainfall of similar irrigation development projects in the semi-arid and arid regions, effective rainfall in the project areas where average annual rainfall is less than 300 mm has been evaluated being the lowest reliability in calculating the irrigation water requirement for crops and has been neglected in the calculation. The both selected scheme areas are located in the arid region and the annual rainfall are about 200 mm in the Dab'ah-Hammam scheme area and about 100 mm in the Qatrana scheme area.

Therefore, effective rainfall for the both scheme areas is not counted in calculation of the irrigation water requirement.

(b) Net Irrigation Water Requirement

Net irrigation water requirement is consist of two (2) factors such as crop irrigation water requirement and leaching water requirement for crops.

(b-1) Crop irrigation water requirement

Crop irrigation water is calculated conforming to the proposed cropping patterns and scheme area. Crop irrigation water requirement for each crop is shown in Table G-3.15.

(b-2) Leaching water requirement

As for leaching water requirement for crops, tolerable degree of soil salinity for each crop is assumed to decrease minimum tolerance for crop production with non-yield decrementby land reclamation leaching. Leaching fraction affected by soil texture is assumed 0.7 because of loamy soils covering the both scheme areas. Since drip irrigation method is adopted in the scheme areas, leaching requirements in the both scheme areas are estimated by the following authorized formula.*

$$LR = \frac{ECiw}{2(Max.ECe)} \times \frac{1}{LF}$$

where,

LR = Leaching Requirement
ECiw = Electrical Conductivity of irrigation water (mmhos/cm)
Max.ECe = Maximum tolerable electrical conductivity of the soil saturation extract for a given crop appropriate to the tolerable degree of yield reduction.
LF = Leaching fraction

According to the chemical analysis of water quality of the Wadi Qatrana in this field survey, electrical conductivity of water sample is about 0.6 mmhos/cm. At present, since data on water quality of surface water in the Wadi Qatrana and Hamman are scarce, electrical conductivity of irrigation water which will be taken off the Wadi Qatrana and Hamman is assumed 1.0 mmhos/cm for the plan and design. Leaching requirements for crops in the both scheme areas range from 0.05 to 0.18 in the Dab'ah-Hammam scheme area and from 0.07 to 0.10 in the Qatrana scheme area as shown in Table G-3.16. Therefore, leaching water requirement for the design of the both scheme areas is assumed at 0.1, considering into the average leaching water requirement for crops.

(c) Gross Irrigation Water Requirement (GI)

Gross irrigation water requirement is determined to divide the net irrigation water requirement (NI) by irrigation efficiency.

(c-1) Irrigation Efficiency (Ie)

Irrigation efficiency mainly consists of conveyance efficiency including operation efficiency and field application efficiency in terminal irrigation farms. Conveyance irrigation efficiency for the both schemes is adopted 90% referring to those of pipe line system of similar irrigation development projects in and around the Study Area. Field application efficiency is adopted 85% because proposed crops for the schemes are vegetables and most suitable irrigation method for vegetables in the arid region is drip irrigation method. Therefore, overall irrigation effficiency for

the schemes becomes 77%.

(c-2) The GI of each cropping pattern

Conforming to the proposed cropping patterns for the Scheme Areas, the gross irrigation water requirement of each cropping pattern are estimated as follows:

Cropping Pattern	Gross Irrigation Water Requirement	
	Annual Total	Peak Requirement
(I) Dab'ah-Hammam Scheme Area	(mm)	(mm/day)
Type - 1 (Plastic houses)	980	6.0
Type - 2 (Vegetables, year-round irrigation)	1,302	8.8
Type - 3 (Vegetables, Winter season only)	685	6.2
(II) Qatrana Scheme Area		
Type - 3 (Vegetables, Winter season only	757	6.7

Seasonal variation of the GI for each cropping pattern is shown in Table G-3.17, and detailed calculation of the GI for each cropping pattern is shown in SUPPLEMENT B.

(c-3) The GI of each scheme area

Gross irrigation water requirement of each scheme area is estimated taking into account the GI of each cropping pattern, areal proportion of conjunctive use area and water allocation for existing irrigation area of the Dab'ah-Hammam Scheme.

The Qatrana Scheme area has no conjunctive use area and only winter season irrigation is carried out because of limited availability and dependability of surface water stored in dam. Therefore, the GI for the Qatrana Scheme area is estimated at 757 mm per year equivalent to 567.8 x 10^3 m^3 per year. Peak water requirement in the area is 0.76 1/sec/ha.

The Dab'ah-Hammam Scheme area is composed of conjunctive use area of 100 ha and newly developed area (non conjunctive use area) of 75 ha. The conjunctive use area has been irrigated by groundwater. For determination of water amount to be distributed to the conjunctive use area from dam reservoir, the following

assumptions are given:

(i) Water to be distributed compensates nearly equivalent water amount which are exceeded by the proposed cropping pattern comparing with present annual groundwater use in existing farms.

(ii) Distribution period of surface water supply is a half year, from December to May because of a higher dependable storing period of surface water.

(iii) For the estimation of present groundwater use, present planted crops and cropping intensity and operation conditions of irrigation water in existing farms of the Study Area are taken into consideration. Estimated groundwater use in the conjunctive use area is about 940 mm per year as shown in Table G-3.18.

As a result of these assumptions, seasonal irrigation water use in conjunctive use area is estimated as shown in Fig. G-3.7 and annual surface water amount to be distributed to the area from the dam reservoir is estimated at 236 mm equivalent to 236 x 10^3 m^3, and groundwater use in the future increases about 6 mm per year on the basis of the proposed cropping pattern.

Moreover, as for winter season irrigation for the newly developed area of 75 ha, the GI of 505 mm equivalent to 505.3 x 10^3 m^3 will be estimated.

Therefore, gross irrigation water requirement for the Dab'ah-Hammam Scheme is 741.3 x 10^3 m^3 per year. Peak water requirement is estimated at 0.36 l/sec/ha. Table G-3.19 shows the summary of gross irrigation water requirement for the both schemes.

3.3.4 Reclamation Leaching

Data on reclamation leaching trials in highlands in the Study Area is scarcely available at present. According to the results of soil survey and chemical analysis of soil samples in the Study Area, soil salinity of effective root zone for crops in the both scheme areas ranges from 0.5 mmhos/cm to 7.5 mmhos/cm in the Qatrana scheme area and from 0.3 mmhos/cm to 4.3 mmhos/cm in the Dab'ah-Hammam scheme area. These soil salinities are assessed to be slightly moderate and required slightly reclamation leaching water.

Referring to the data of the Jordan Valley Authority's (JVA) trials

on reclamation leaching in the Jordan Valley areas, leaching requirement for land reclamation is considered to be more than 1,000 mm with installation of sub surface drainage pipes and deep drainage canals. Soils in the trial farms before reclamation leaching is evaluated as very high salinity soils of more than 15 mmhos/cm of electrical conductivity and after reclamation leaching of about 1,000 mm, electrical conductivity of soils declines to a range of slightly moderate salinity to low salinity. Therefore, in this study, reclamation leaching water in the both scheme areas is assumed to be 1,000 mm in view of the results of the JVA's trials on land reclamation leaching. This reclamation leaching is scheduled to be carried out in the initial stage before starting irrigation for crops.

3.3.5 Typical Design of Irrigation and Drainage Facilities

(A) Design irrigation water requirement

Peak irrigation water requirements for the both schemes are respectively estimated at 0.36 1/sec/ha for the Dab'ah-Hamman scheme area and at 0.76 1/sec/ha for the Qatrana scheme area based on the proposed cropping patterns and excess amount of surface water for the existing groundwater irrigation areas. Design irrigation water requirements are determined three (3) times of each peak irrigation water requirement, viz, 1.08 1/sec/ha for the Dab'ah-Hammam scheme and 2.28 1/sec/ha for the Qatrana scheme because daily irrigation hours in the scheme area are assumed to be about 8 hours, taking into account working conditions of pump operators.

(B) Intake structure

In the Dab'ah-Hammam scheme area, concrete structure of intake tower type is designed. Height of the tower portion is about 6 m and concrete barrel portion is about 33 m in length. Existing intake structure of the Qatrana dam will be rehabilitated to stop water flow and intake structure for the Qatrana scheme will be substituted pump station for existing intake structure because of higher elevation of newly developed irrigation area.

(C) Pump stations and Booster pump stations

Concrete foundation area for one set of pump and motor is given 4.35 m^2 (2.9 m x 1.5 m) and operator's room is kept about 10 m^2. Pump house is composed of concrete floor, concrete walls, large sliding door of one side wall, window, metal door for entrance and concrete roof.

Pump house spaces for four (4) pumps and three (3) pumps are respectively given 46 m^2 and 39 m^2.

(D) Regulating Pond

Regulating pond is designed to make easy water operation and stable water distribution in each terminal irrigation areas and to promote stilling the suspended load in surface water. Reservoir capacity of regulating pond is giving irrigation water amount for about 2 hours. Regulating ponds for both schemes are narrow rectangular type of concrete lining. Dimension of ponds for both schemes are as follows:

	Width	Length	Depth
Dab'ah-Hammam Scheme	20 m	90 m	1.0 - 2.0 m
Qatrana Scheme	20 m	130 m	1.0 - 2.0 m

In central portion of ponds, collector ditches of 2 m in width and 0.5 m in depth are provided to collect the suspended and bed loads.

(E) Main and Secondary pipe lines

Reinforced concrete pipes of less than Ø450 mm are adopted, taking into account inside water pressure, material costs, quantity of pipe lines and present production conditions of asbestos pipes in abroad.

Concrete pipes are designed being the semi-burried for operation and maintenance works for pipes, and sand foundation for pipes is provided.

At crossimg points with farm road, pipes are rolled by mass concrete and burried. Turnout valves are provided at head portion of each lower grade pipe line.

(F) Stone fence and Collector drain

Dry masonry fence of about 0.3 m in width and 0.5 m in height is provided at hillside boundaries of the schemes. Outside of stone fence, collector drains of about 0.2 m in width and 0.3 m in depth are provided along stone fence, keeping a distance of about 2 m from stone fence.

(G) Drainage canal

Collector drains of about 0.2 m in width and 0.3 m in depth are provided along farm roads, keeping a distance of about 2.0 m. At