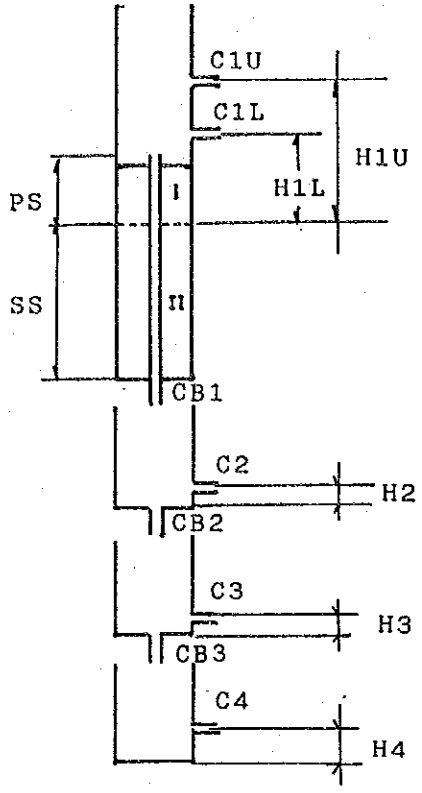



1. Parameter of Tanks

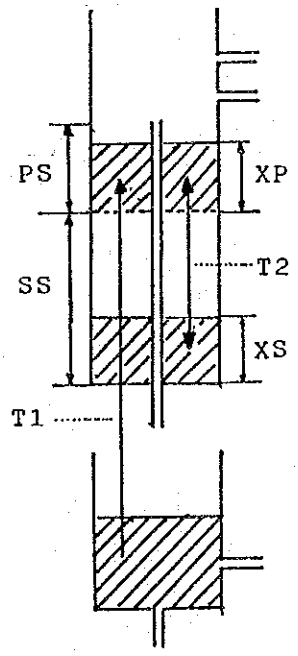
(1) C1U, C1L, C2, C3, C4:
Discharge coefficients of side holes

(2) CB1, CB2, CB3:
Discharge coefficients of bottom holes

(3) H1U, H1L, H2, H3, H4:
Height of side holes

(4) PS:
Capacity of primary soil moisture:

(5) SS:
Capacity of secondary soil moisture:




2. Parameter of Soil Moisture

(1) T1:
Transfer of soil moisture to primary soil moisture from second tank given by

$$T1 = TB\ (1 - XP/PS)$$

where TB: Transfer coefficient
XP: Primary soil moisture

(2) T2:
Transfer of soil moisture between primary soil moisture and secondary soil moisture given by

$$T2 = TC\ (XP/PS - XS/SS)$$

where TC : Transfer coefficient
XS : Secondary soil moisture

If T2 > 0 ,water moves from XP to XS. If T2<0, water moves from XS to XP.

Fig. 3.8
Basic Component of Tank Model

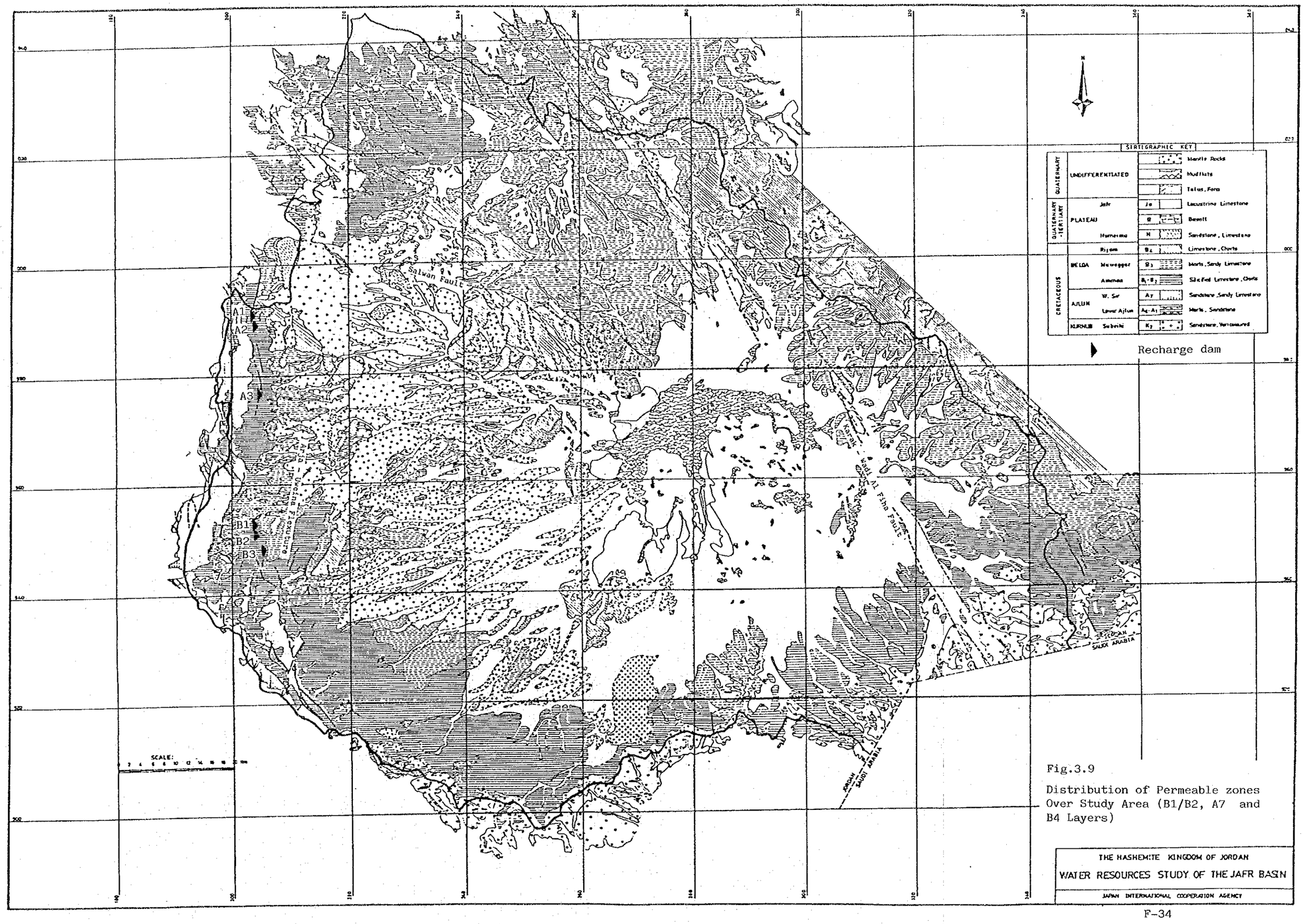



Fig.3.9

Distribution of Permeable zones Over Study Area (B1/B2, A7 and B4 Layers)

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

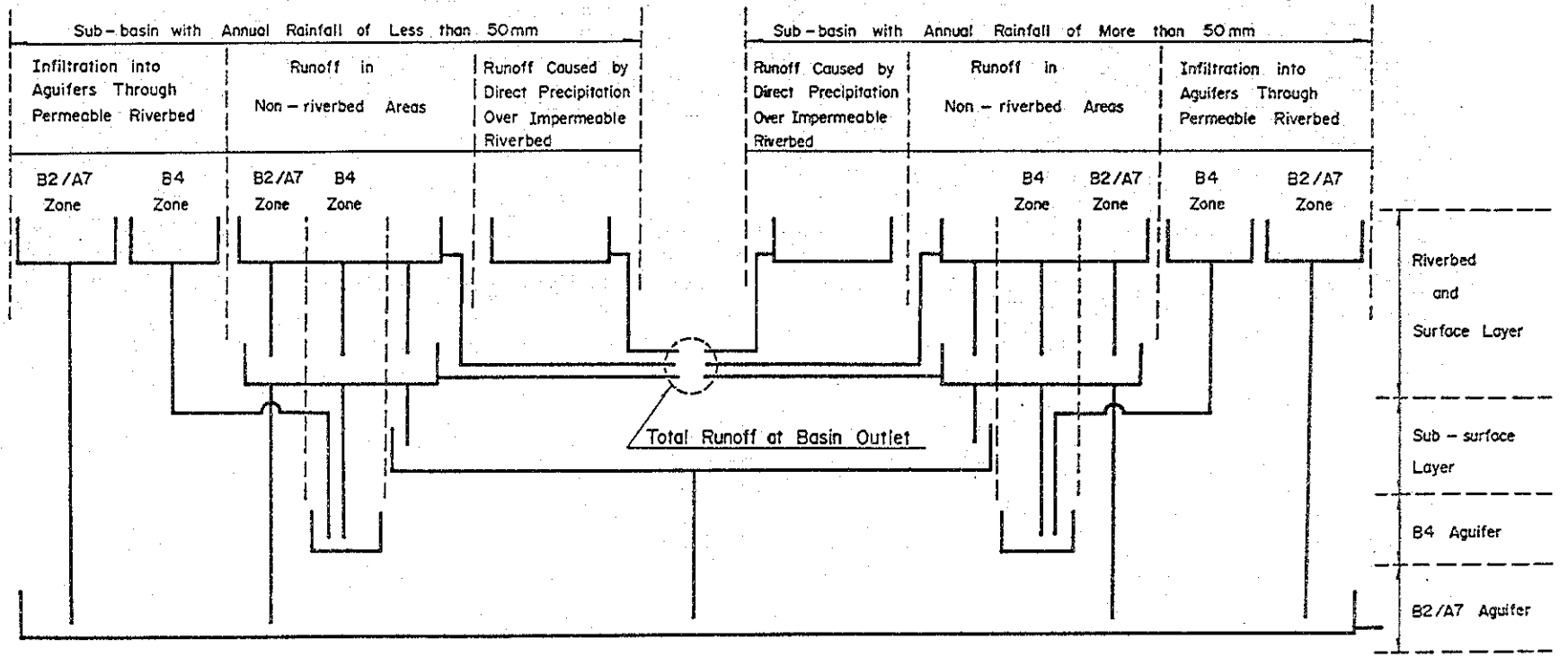



Fig. 3.10 Tank Model of Study Area



THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

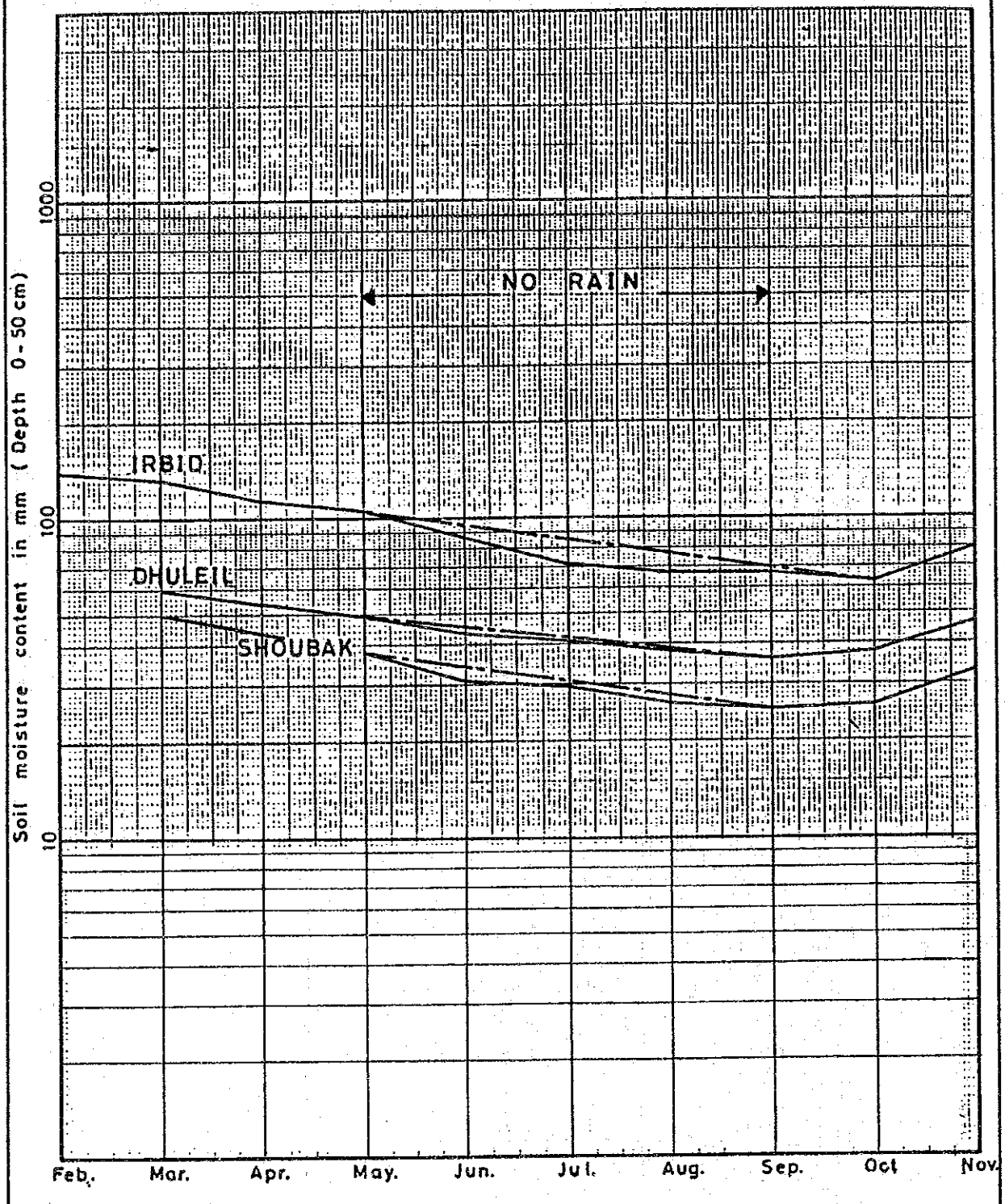
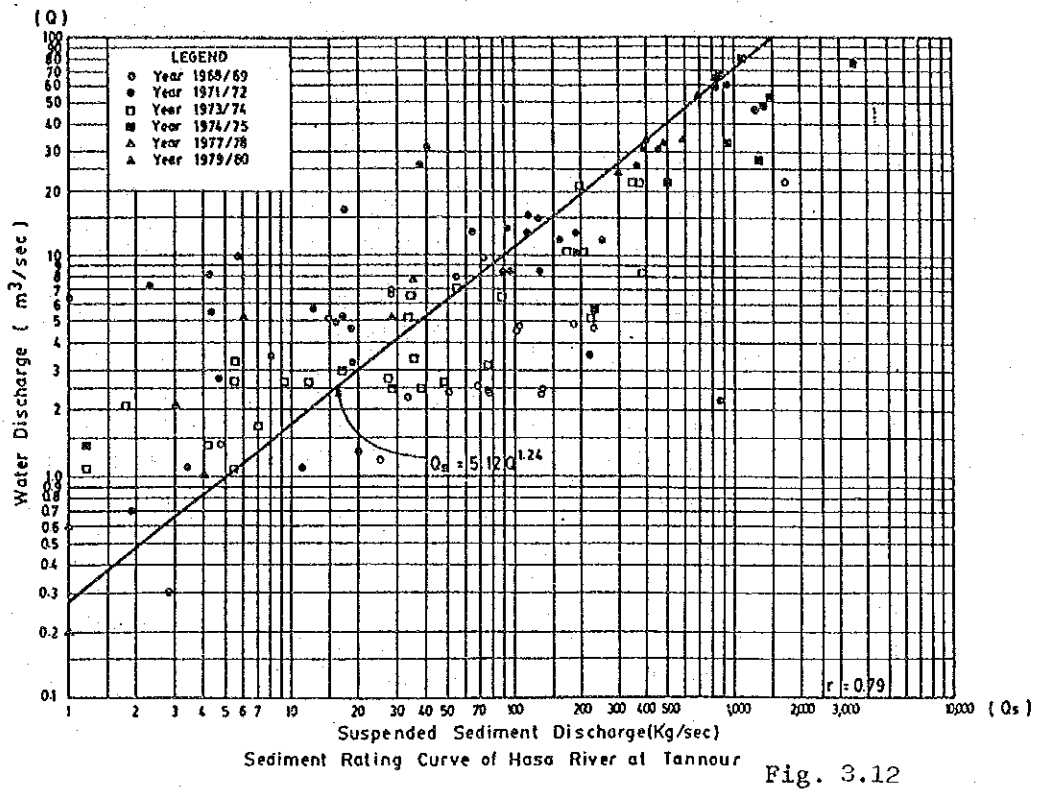


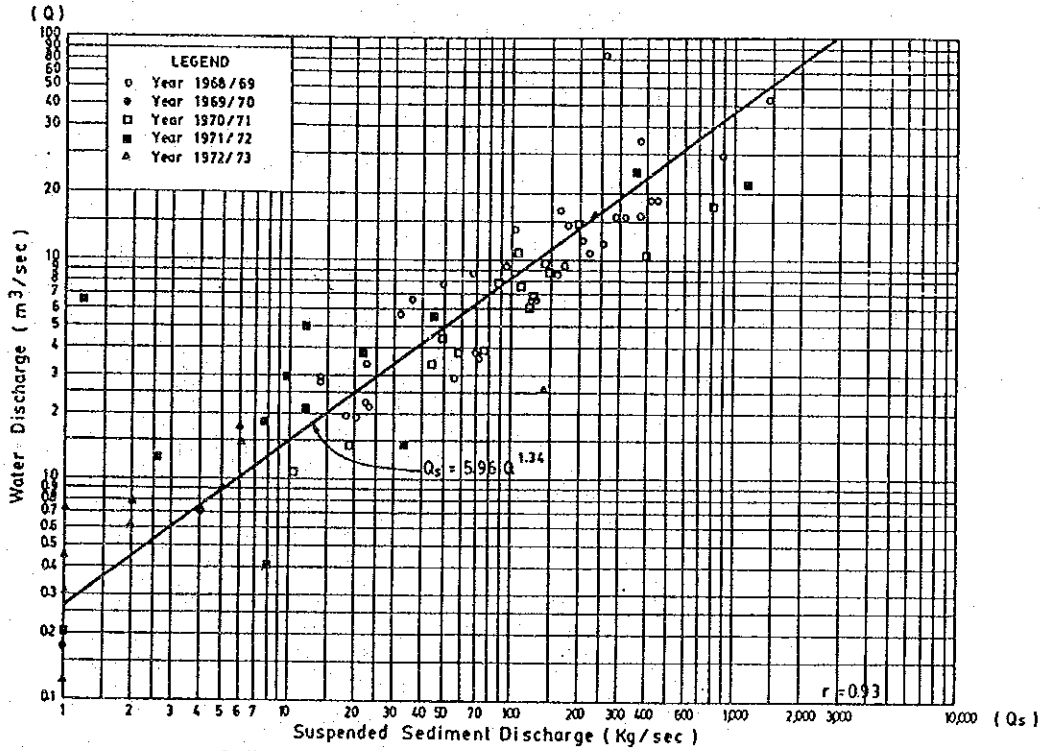

Fig.3.11 Recorded Soil Moisture Content

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY




Sediment Rating Curve of Hasa River at Tannour

Fig. 3.12
Suspended Sediment Rating Curve of Hasa River




Sediment Rating Curve of Wadi Jurdhan at Desert Road

Fig. 3.13
Suspended Sediment Rating Curve of Wadi Jurdhan

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

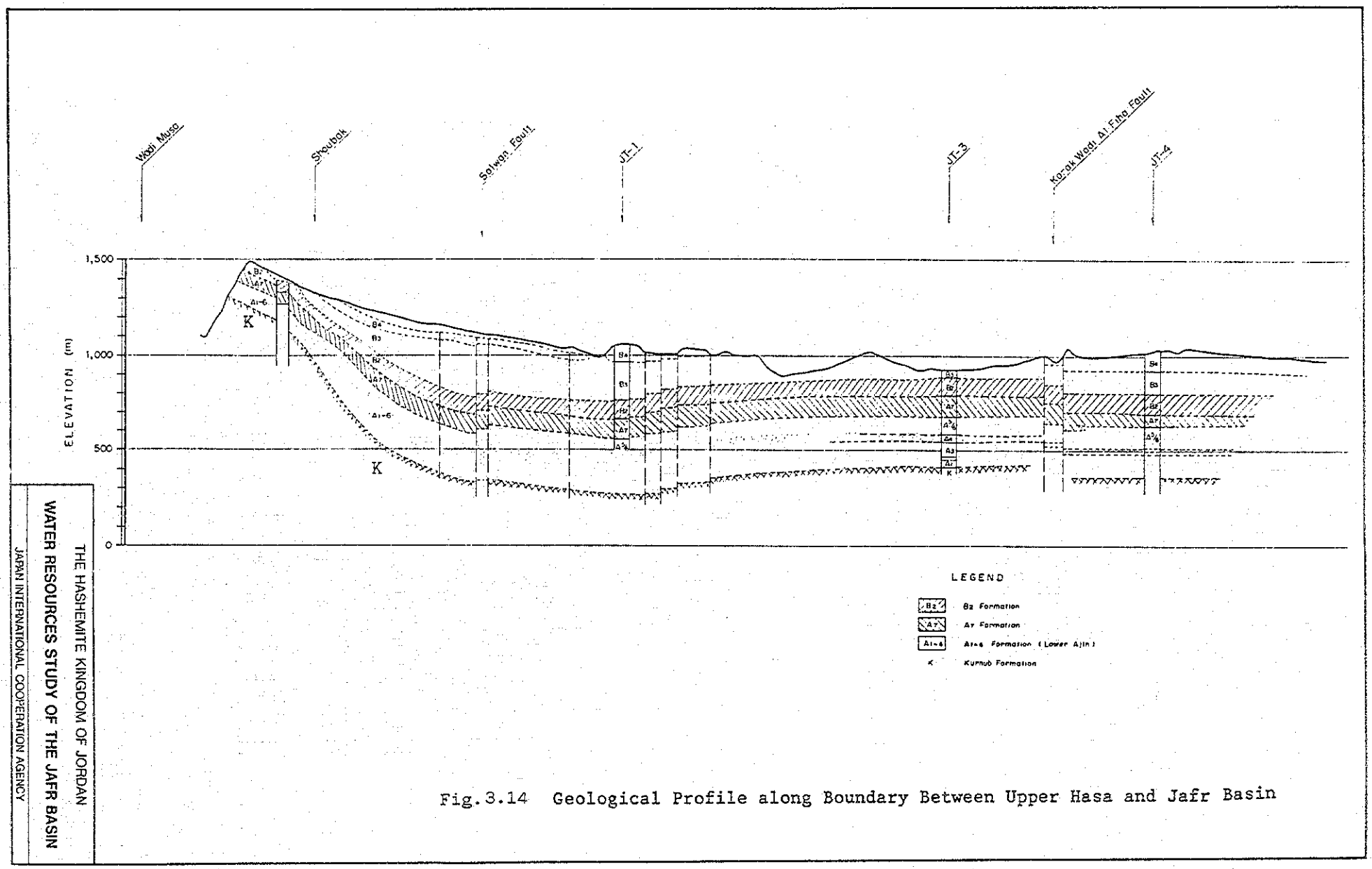



Fig.3.14 Geological Profile along Boundary Between Upper Hasa and Jafr Basin

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

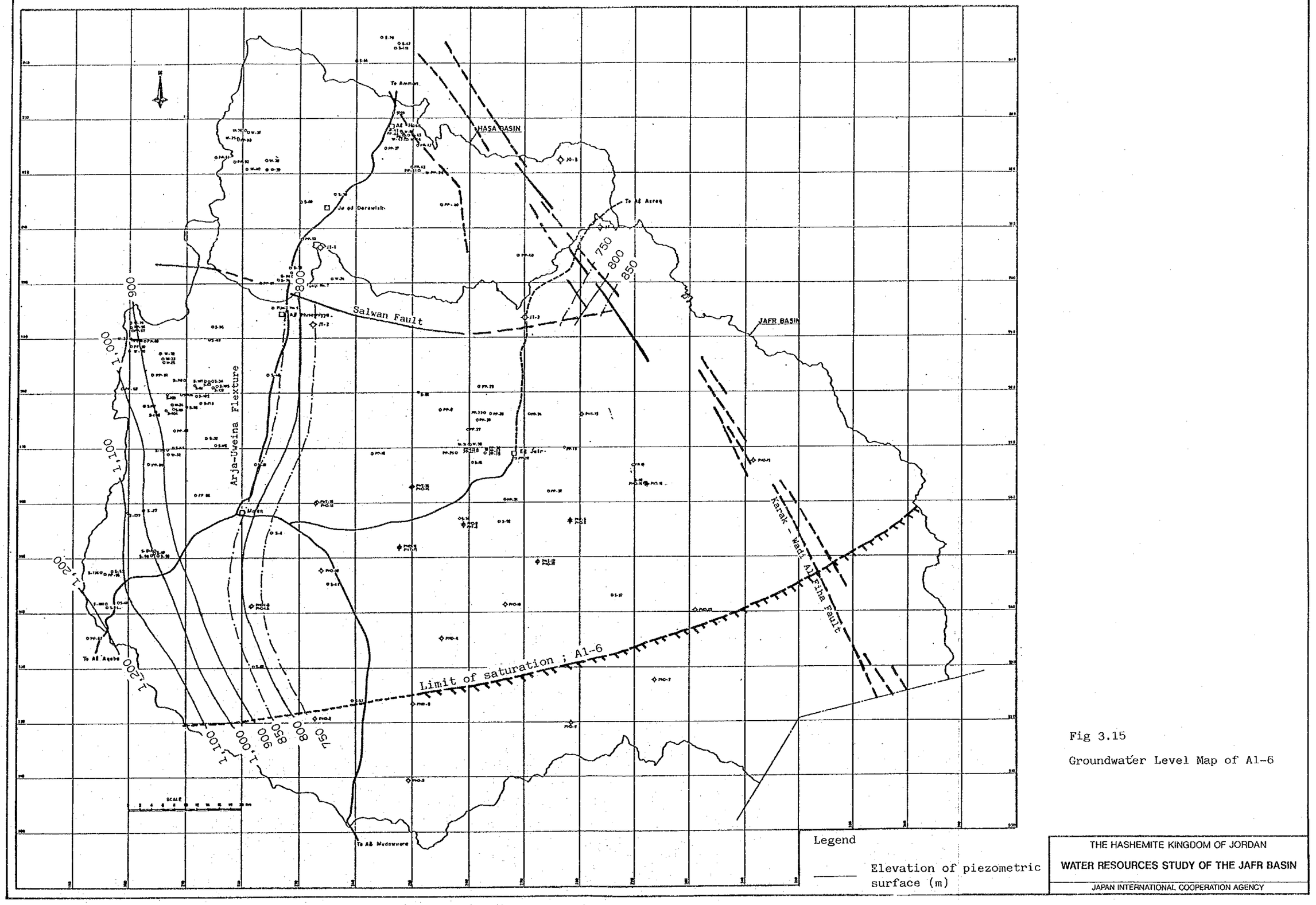



Fig 3.15

Groundwater Level Map of A1-6

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

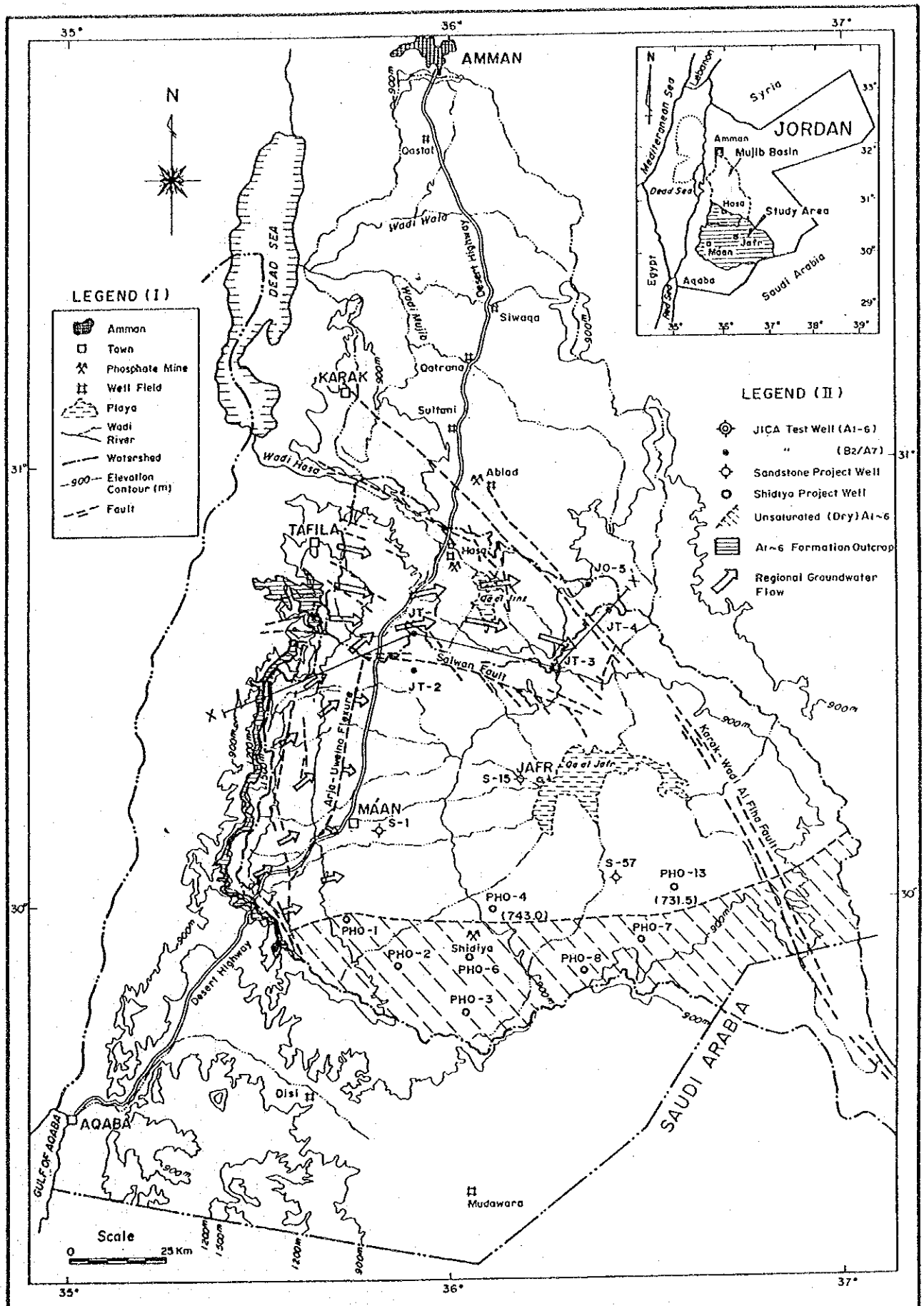
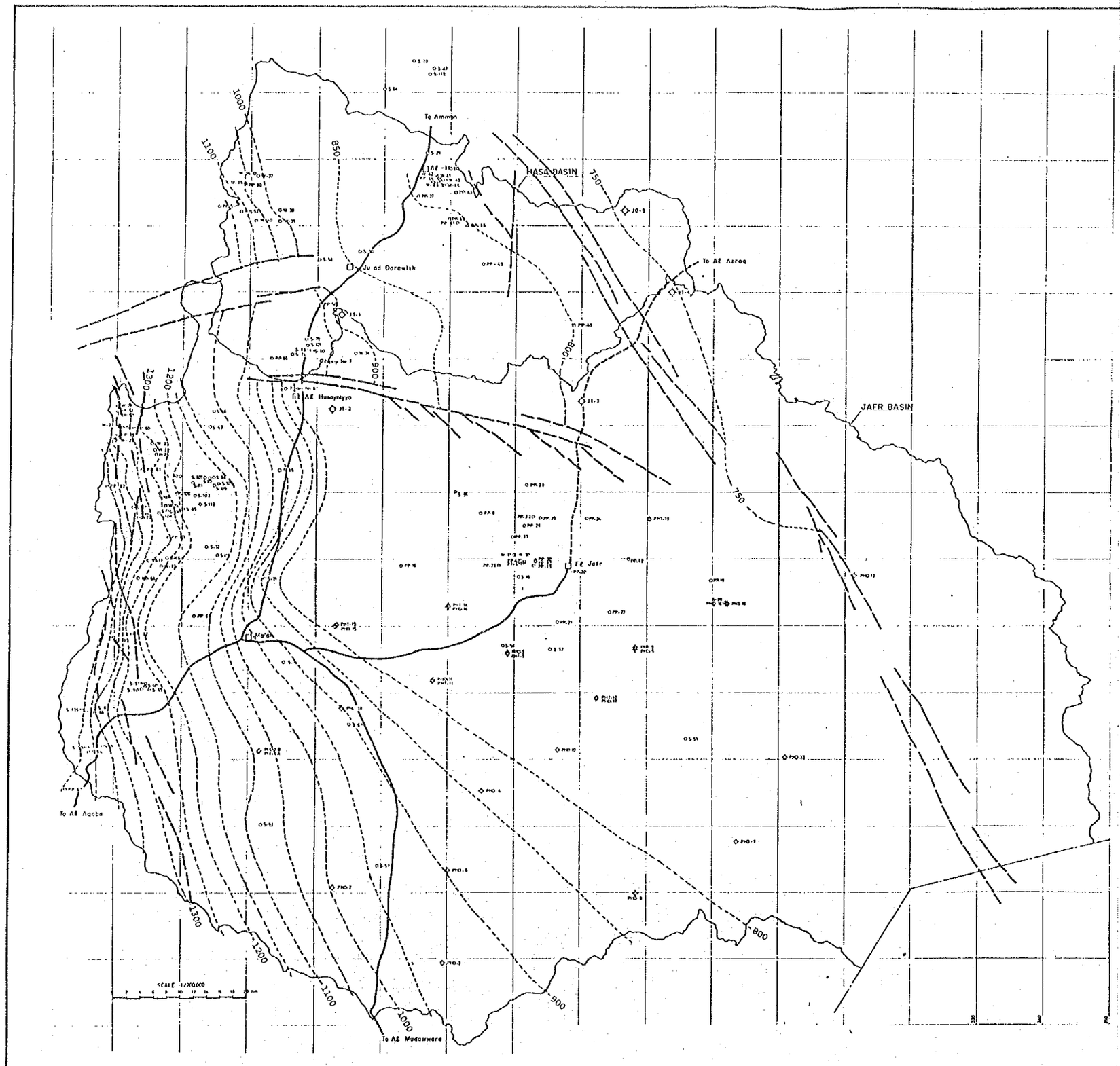
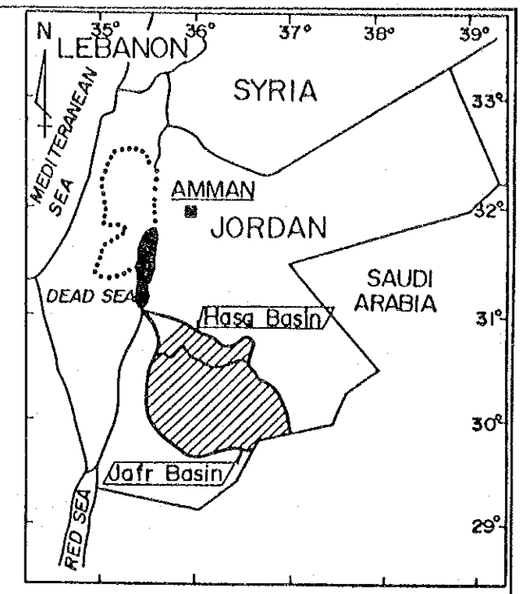



Fig.3.16 Hydrogeological Map of Lower Ajlun (A1-6) Formation

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY



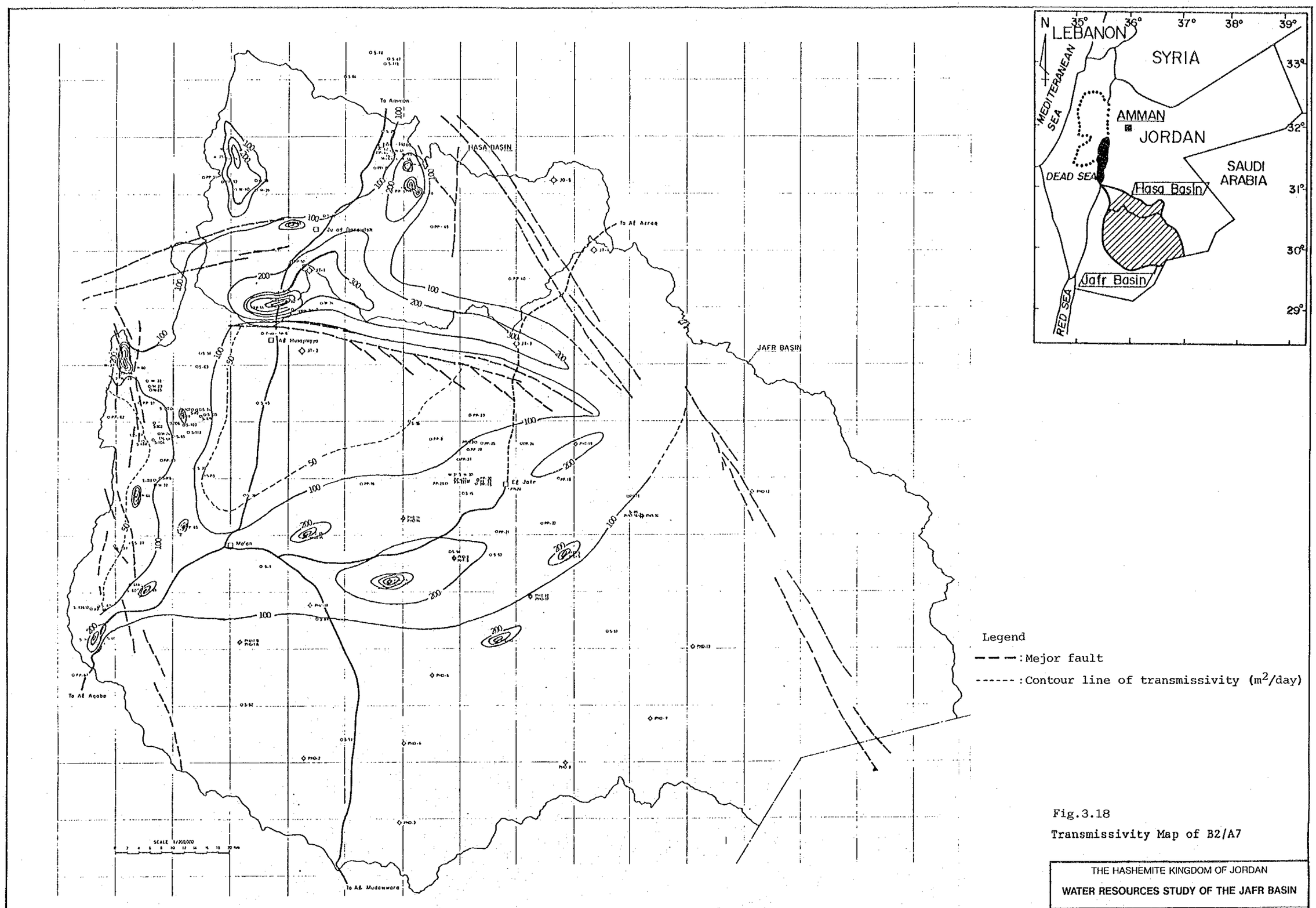

Legend

——:Mejor fault

------:Contour line of static water level (m)

Fig. 3.17
Groundwater Level Map of B2/A7

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY







Legend

———: Mejor fault

------: Contour line of transmissivity ($m^2$/day)

Fig.3.18

Transmissivity Map of B2/A7

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

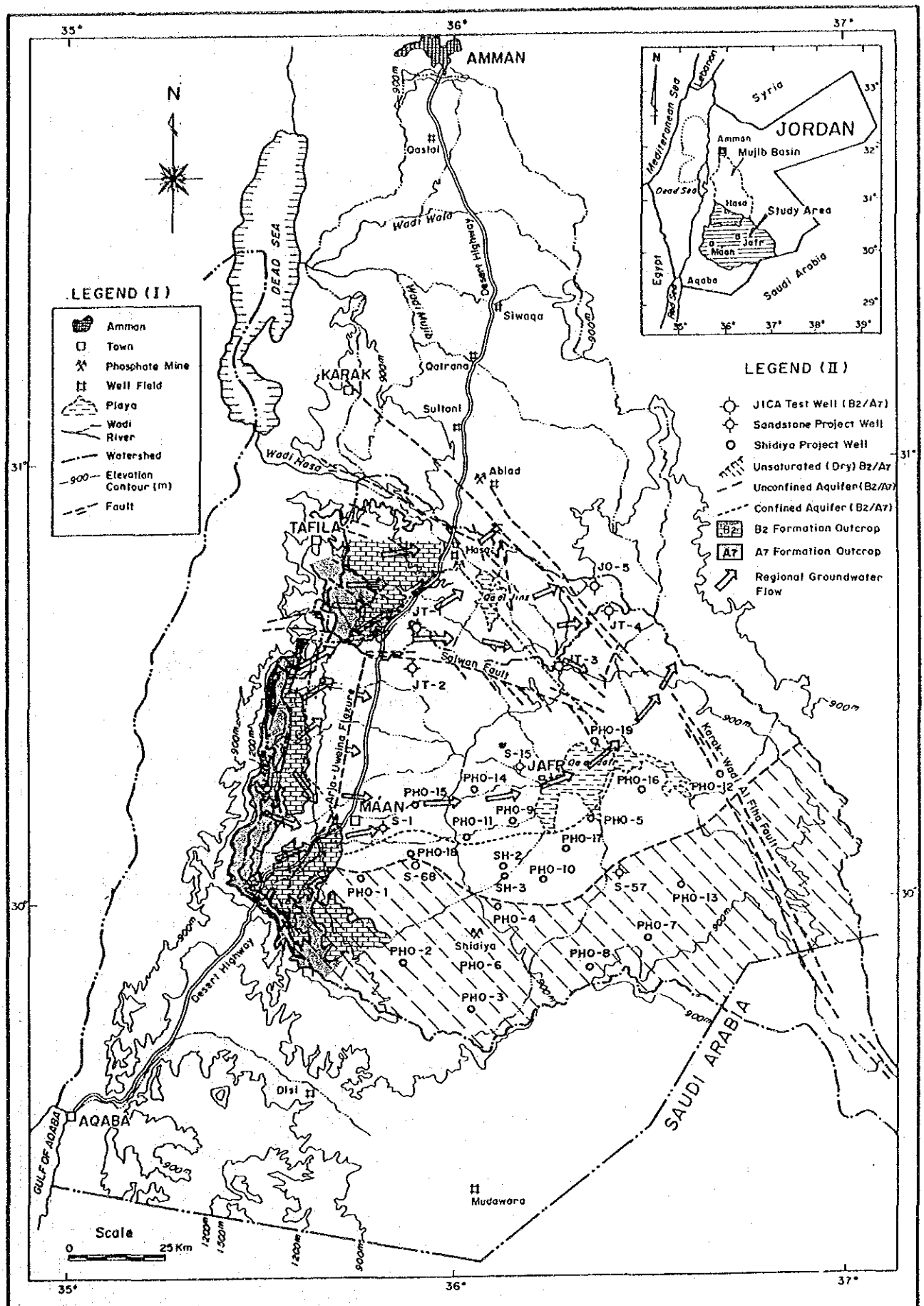
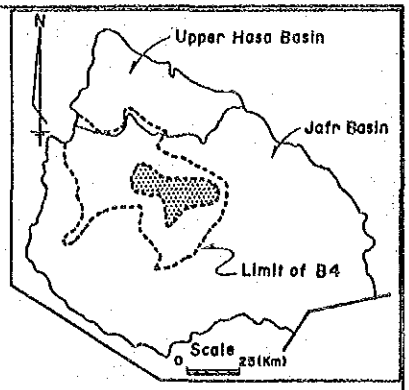



Fig.3.19 Hydrogeological Map of Amman - Wadi Sir (B2/A7) Formation

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY



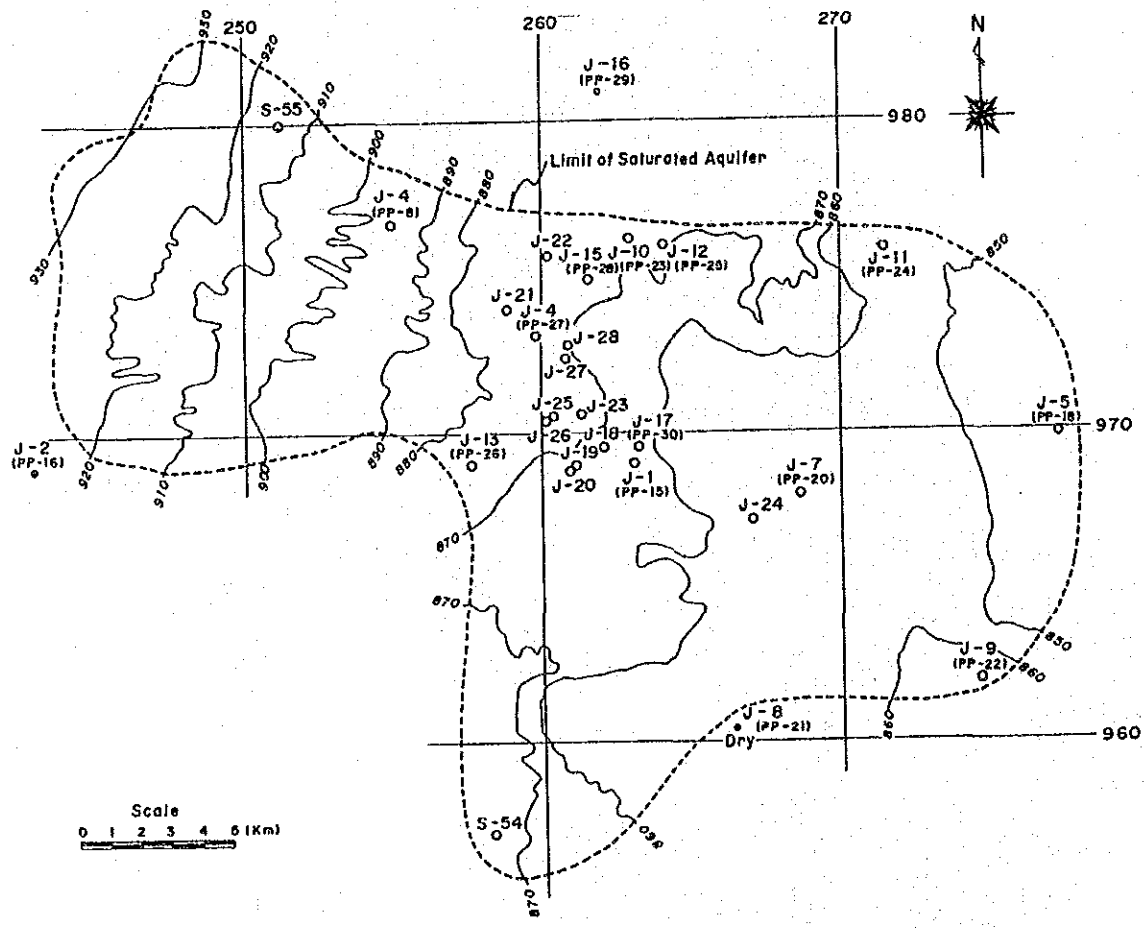



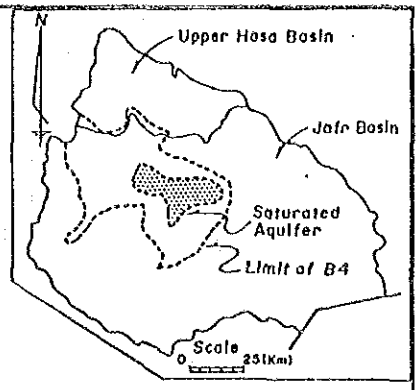

Fig.3.20

Location Map of Rijam (B4) Aquifer

THE HASHEMITE KINGDOM OF JORDAN

**WATER RESOURCES STUDY OF THE JAFR BASIN**

JAPAN INTERNATIONAL COOPERATION AGENCY



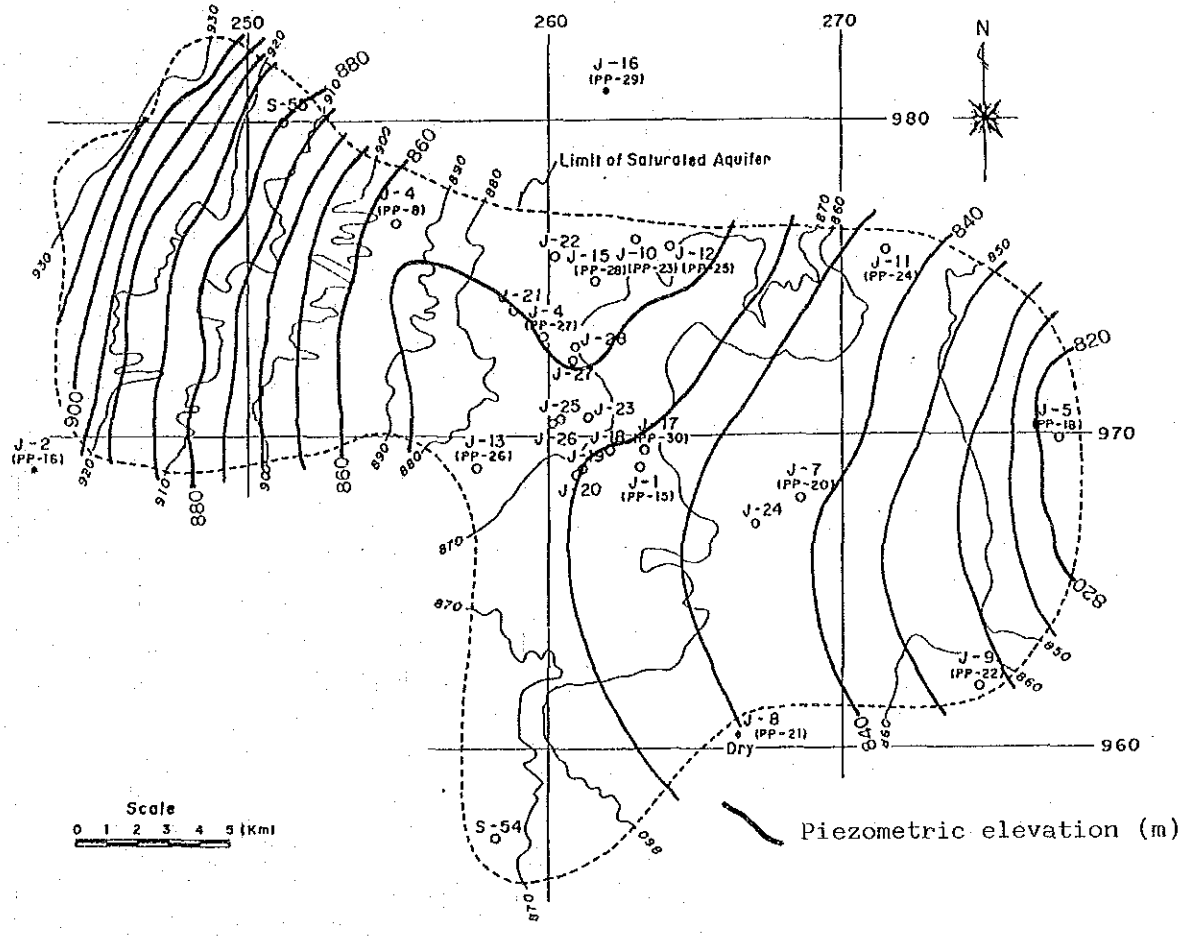




Fig.3.21

Groundwater Level Map of B4

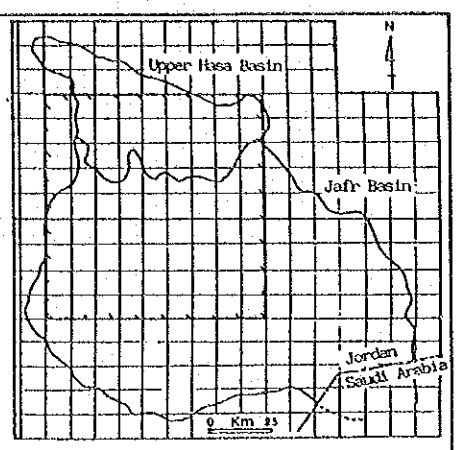
THE HASHEMITE KINGDOM OF JORDAN

**WATER RESOURCES STUDY OF THE JAFR BASIN**

JAPAN INTERNATIONAL COOPERATION AGENCY

List of well No. in Jafr area

| | | | |
|---|---|---|---|
| JAFR-1 | (PP-15) | JAFR-16 | (PP-29) |
| JAFR-2 | (PP-16) | JAFR-17 | (PP-30) |
| JAFR-3 | (PP-17) | JAFR-18 | |
| JAFR-4 | (PP- 8) | JAFR-19 | (PP-470) |
| JAFR-5 | (PP-18) | JAFR-20 | (PP-471) |
| JAFR-6 | (PP-19) | JAFR-21 | |
| JAFR-7 | (PP-20) | JAFR-22 | |
| JAFR-8 | (PP-21) | JAFR-23 | |
| JAFR-9A | (PP-22) | JAFR-24 | |
| JAFR-10 | (PP-23) | JAFR-25 | ( W-30) |
| JAFR-11 | (PP-24) | JAFR-26 | ( W-31) |
| JAFR-12 | (PP-25) | | |
| JAFR-13 | (PP-26) | | |
| JAFR-14 | (PP-27) | | |
| JAFR-15 | (PP-28) | | |




Legend

Isopach contour of B4

Contour line of Transmissivity ($m^2/d$)

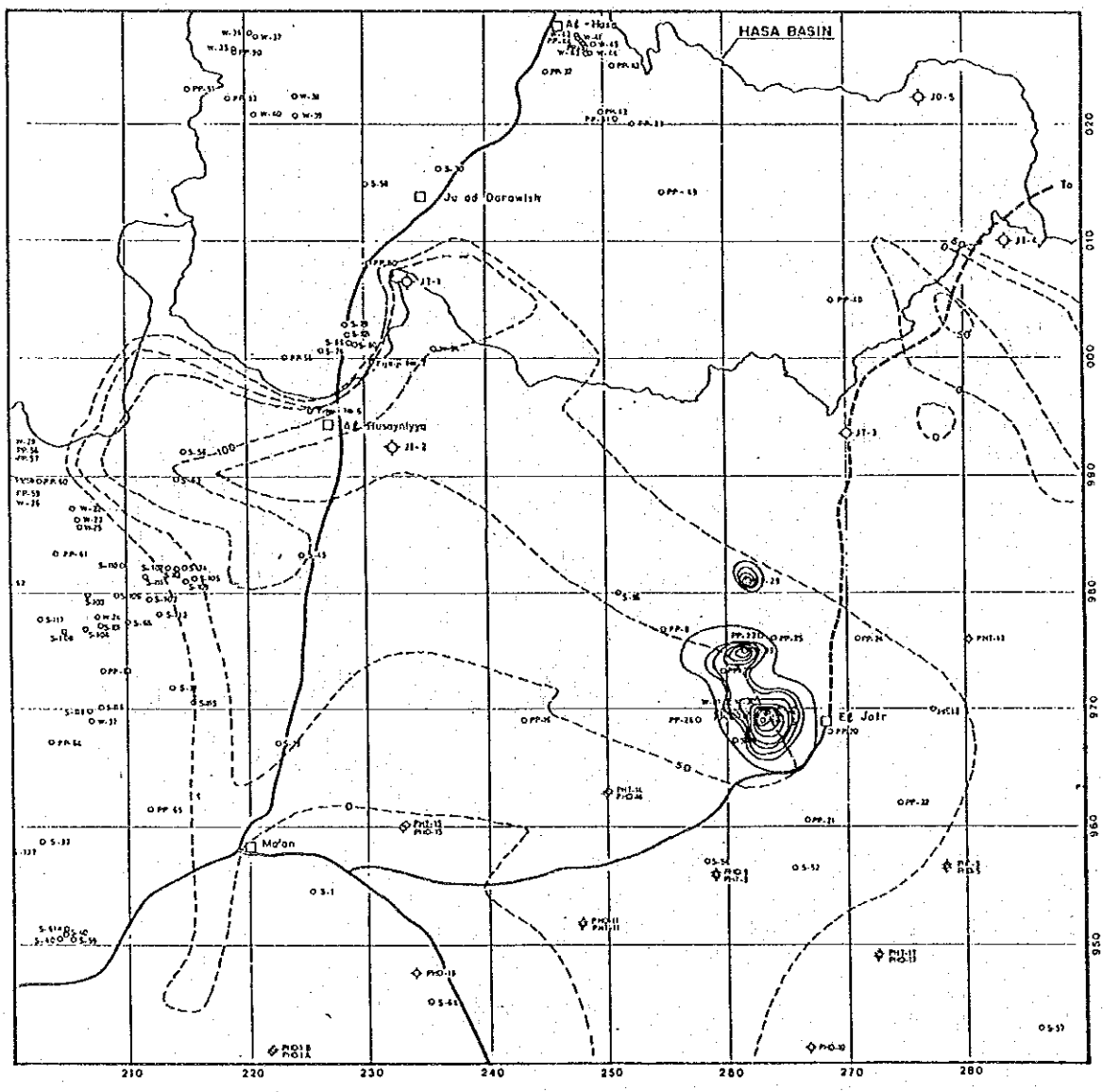



Fig. 3.22

Transmissivity Map of B4

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

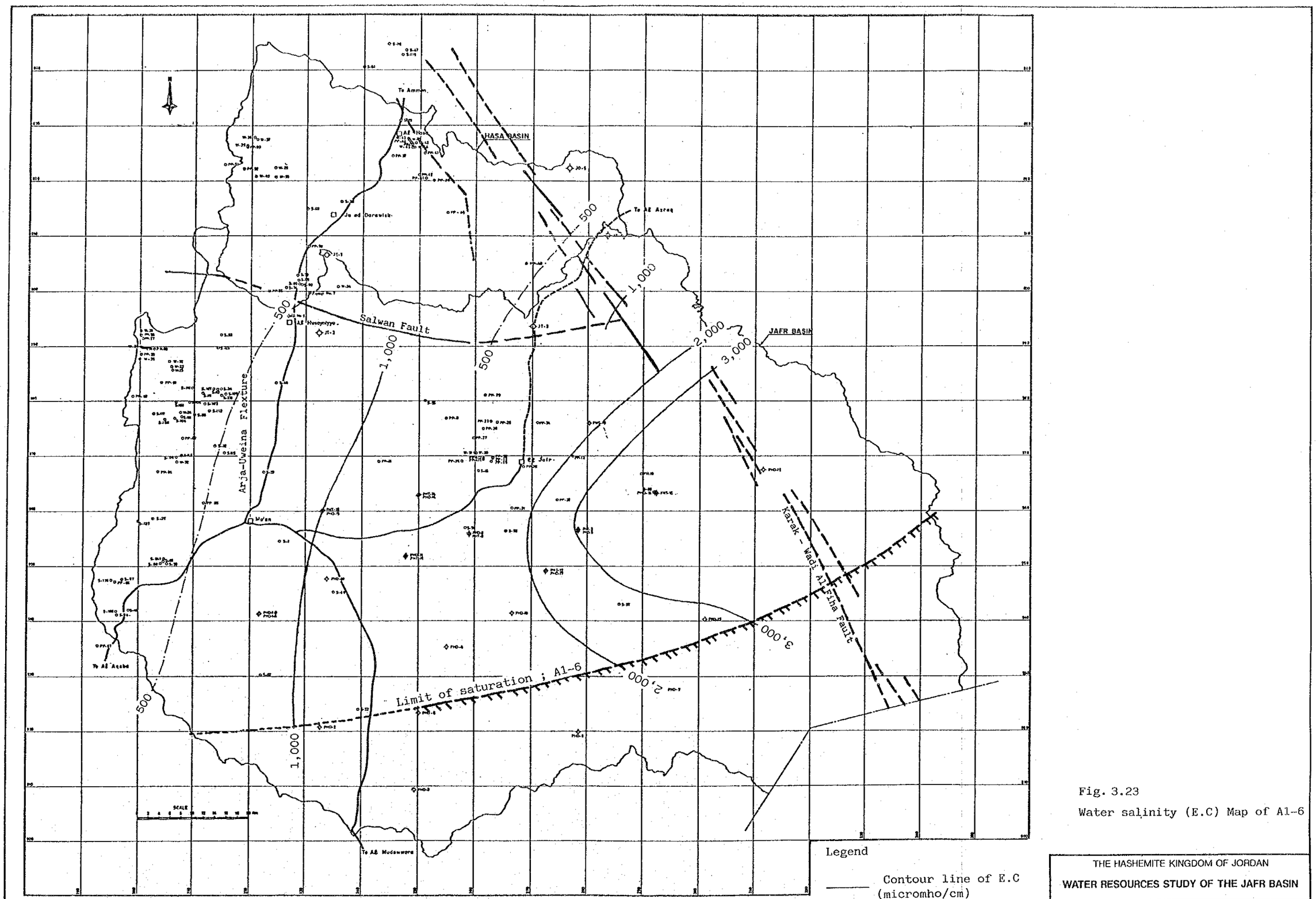
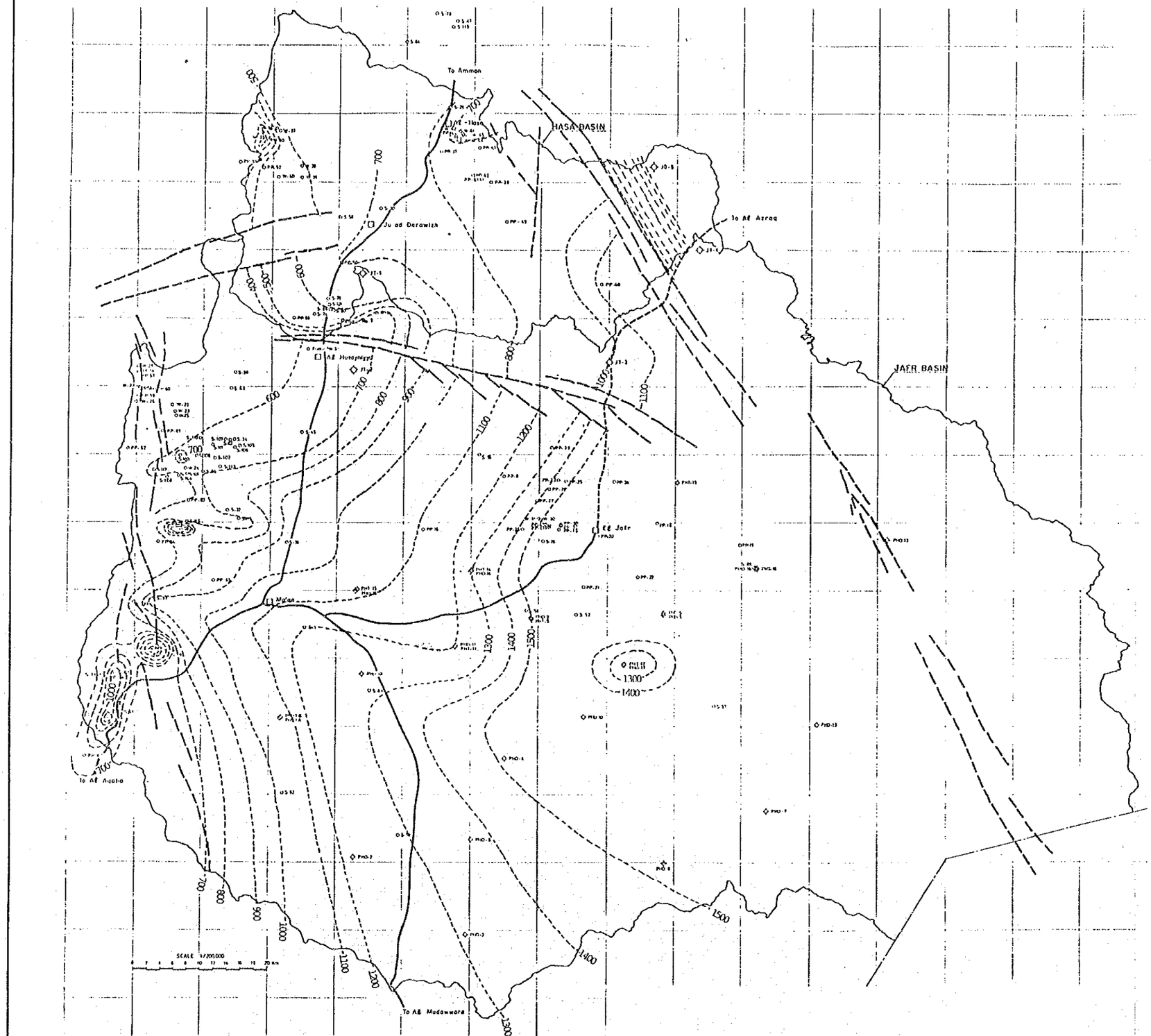
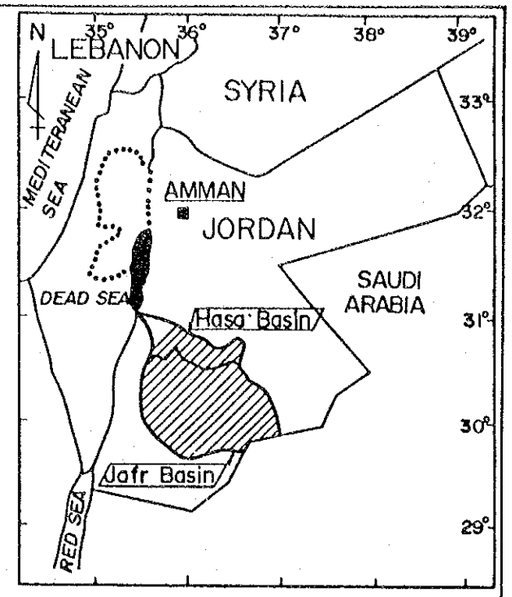



Fig. 3.23
Water salinity (E.C) Map of A1-6

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY




Legend

———:Mejor fault

------:Contour line of electric conductivity (micro mho/cm)

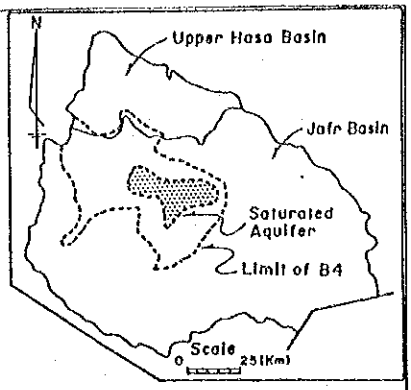
Fig. 3.24

Water Salinity (E.C) Map of B2/A7

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY



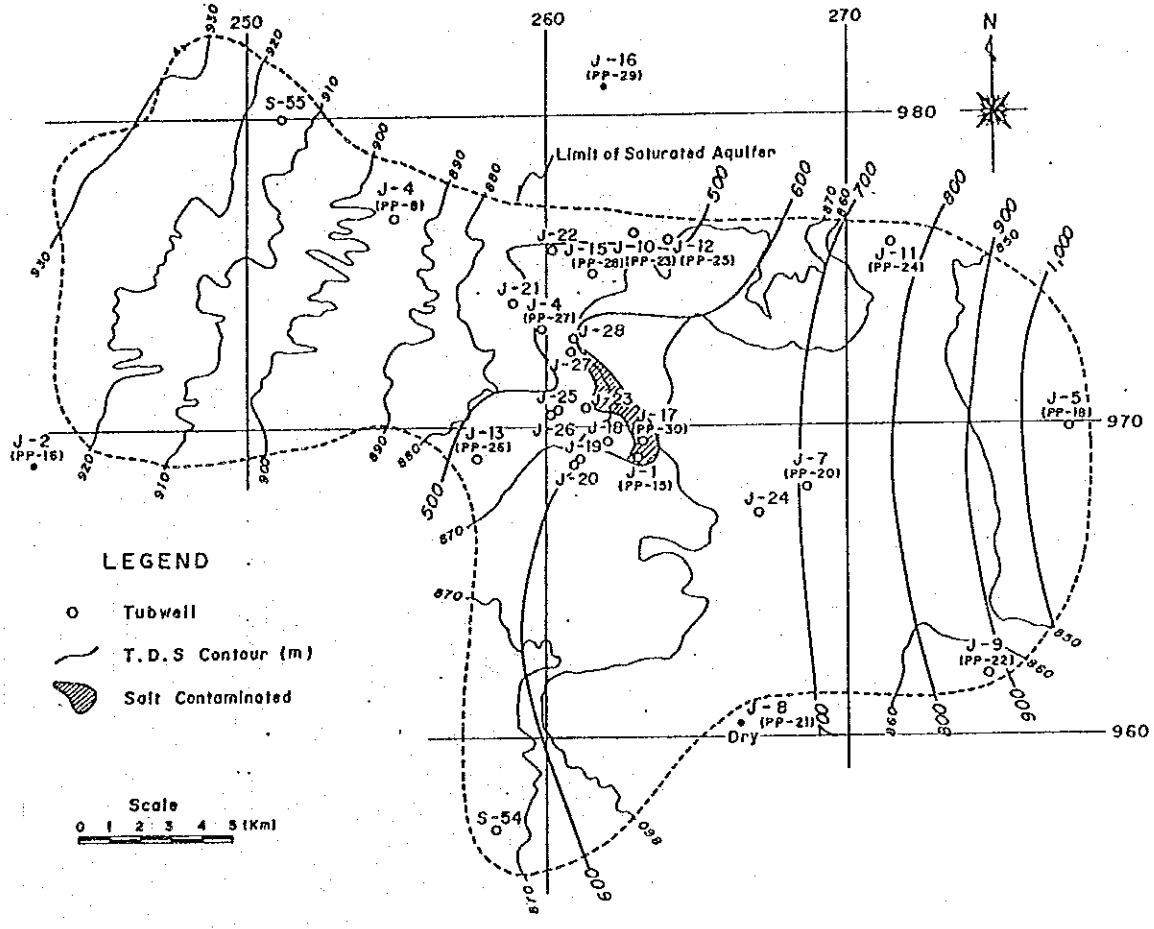
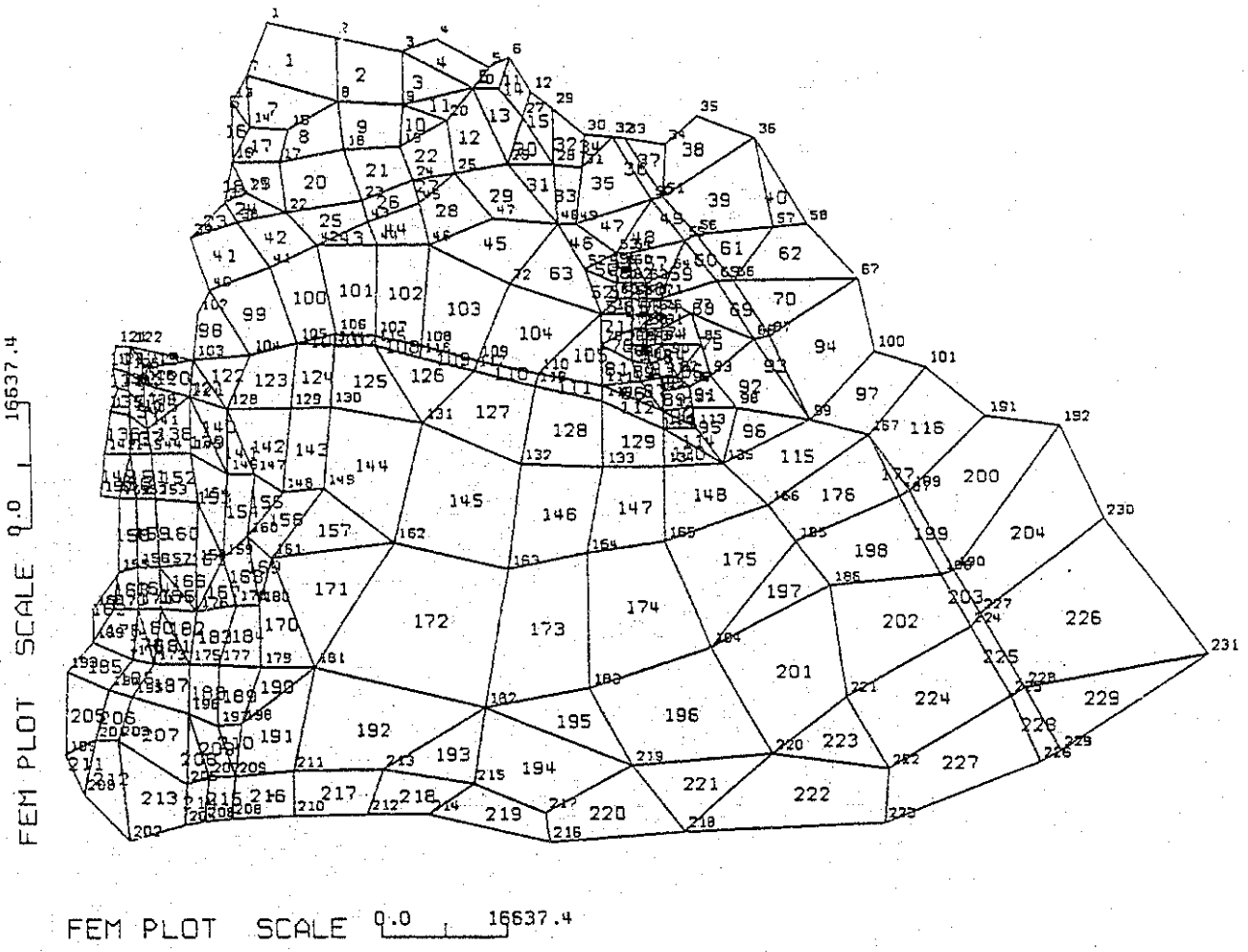




Fig.3.25
Water Salinity (E.C) Map of B4

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY




Boundary Condition

Specified Head

| Node | Head (EL m) |
|---|---|
| 7 | 937.5 |
| 13 | 950.0 |
| 16 | 1000.0 |
| 37 | 1030.0 |
| 39 | 1000.0 |
| 40 | 950.0 |
| 102 | 950.0 |
| 103 | 945.8 |
| 121 | 965.0 |
| 122 | 960.0 |
| 124 | 975.0 |
| 136 | 962.7 |
| 142 | 1171.2 |
| 150 | 1202.5 |
| 151 | 1131.6 |
| 155 | 1052.5 |
| 168 | 1152.5 |
| 169 | 1068.7 |
| 193 | 1102.5 |
| 199 | 1272.5 |
| 200 | 1272.5 |
| 202 | 1302.5 |

Specified Flow

| Node | Flow (m3/day) |
|---|---|
| 4 | -600 |
| 5 | -600 |
| 6 | -600 |
| 12 | -600 |
| 29 | -600 |
| 30 | -600 |
| 32 | -500 |
| 33 | -500 |
| 34 | -600 |
| 35 | -600 |
| 58 | -700 |
| 67 | -700 |
| 100 | -2600 |
| 101 | -2600 |
| 191 | -880 |
| 192 | -880 |
| 230 | -550 |

Fig.3.26 FEM Simulation Mesh of Lower Ajlun (A1-6) Aquifer System

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

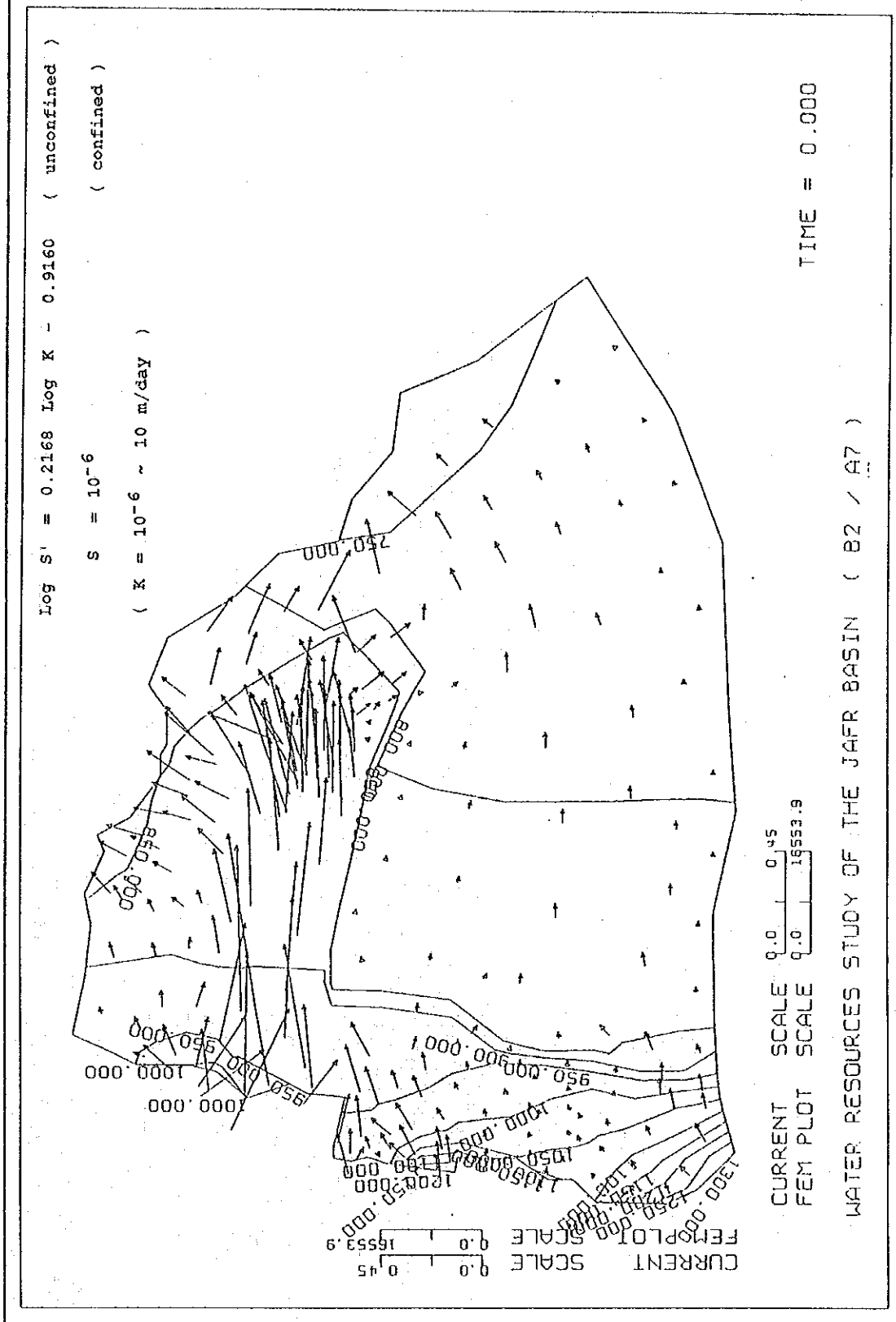
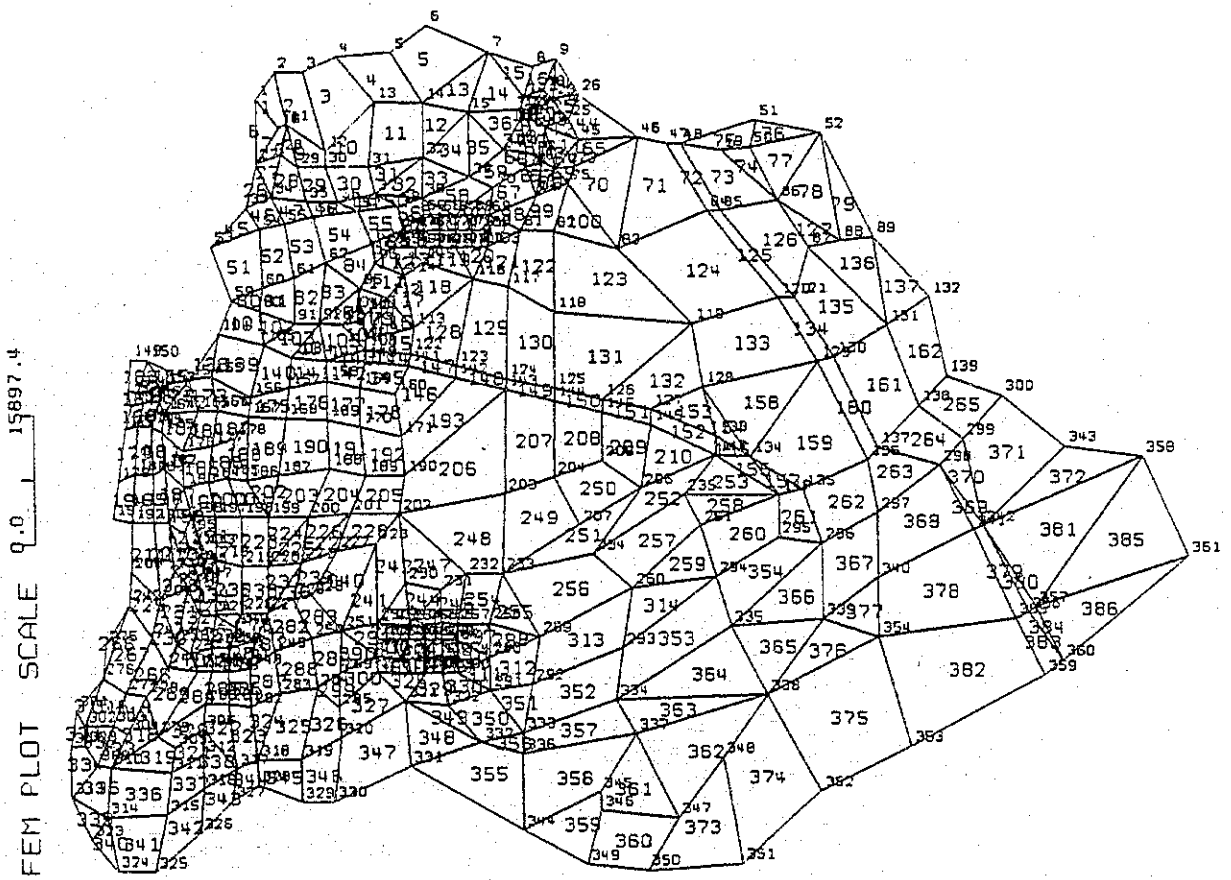



Fig. 3.27 Calibrated Piezometric Surface and Computed Regional Flow Vector of Lower Ajlun (A1-6).

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY




Boundary Condition

Specified Head

| Node | Head (EL m) |
|---|---|
| 1 | 1120.0 |
| 27 | 1120.0 |
| 33 | 1120.0 |
| 53 | 1140.0 |
| 59 | 1160.0 |
| 104 | 1190.0 |
| 149 | 1450.0 |
| 150 | 1420.0 |
| 151 | 1440.0 |
| 154 | 1310.0 |
| 161 | 1440.0 |
| 172 | 1440.0 |
| 179 | 1460.0 |
| 191 | 1500.0 |
| 192 | 1420.0 |
| 208 | 1480.0 |
| 242 | 1480.0 |
| 275 | 1500.0 |
| 276 | 1470.0 |
| 301 | 1500.0 |
| 307 | 1500.0 |
| 313 | 1500.0 |
| 323 | 1500.0 |
| 324 | 1500.0 |

Specified Flow

| Node | Flow (m3/day) |
|---|---|
| 7 | -1800 |
| 8 | -2400 |
| 9 | -2400 |
| 26 | -2400 |
| 46 | -2400 |
| 47 | -1200 |
| 48 | -1200 |
| 49 | -2200 |
| 51 | -2400 |
| 52 | -2400 |
| 89 | -4000 |
| 132 | -4800 |
| 139 | -5600 |
| 300 | -5600 |
| 343 | -4800 |
| 358 | -4800 |

FEM PLOT SCALE 0.0 15897.4

AMMAN / WADI SIR ( B2/A7 )
FEM MESH

Fig.3.28 FEM Simulation Mesh of Amman - Wadi Sir (B2/A7) Aquifer System

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.3.29 Calibrated Piezometric Surface and Computed Regional Flow Vector of Amman - Wadi Sir (B2/A7)

THE HASHEMITE KINGDOM OF JORDAN

**WATER RESOURCES STUDY OF THE JAFR BASIN**

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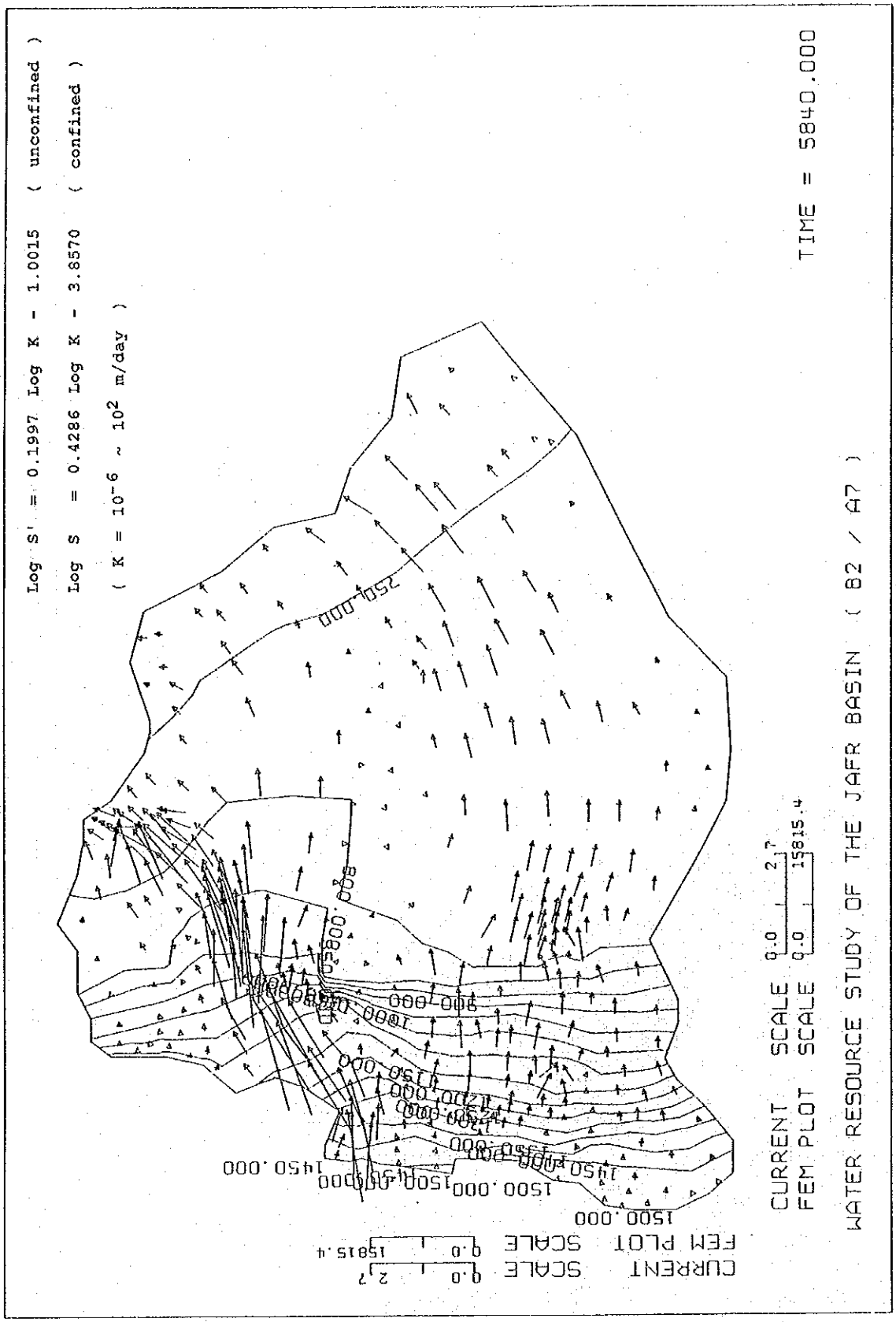


Fig.3.30 Calibrated Piezometric Surface of B2/A7 by the Year 1988

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

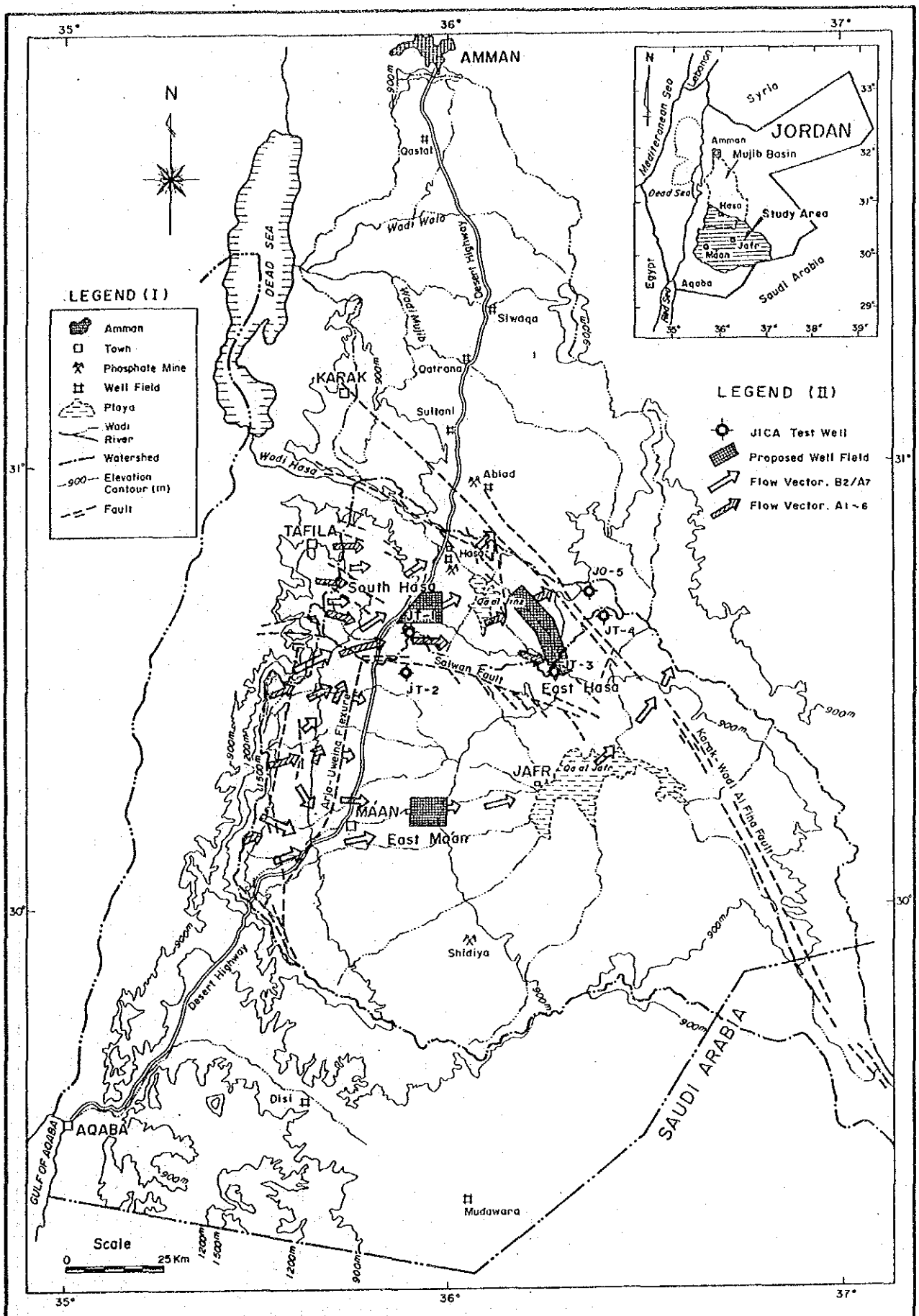


Fig. 3.31 Proposed Well Field in the Simulation Model

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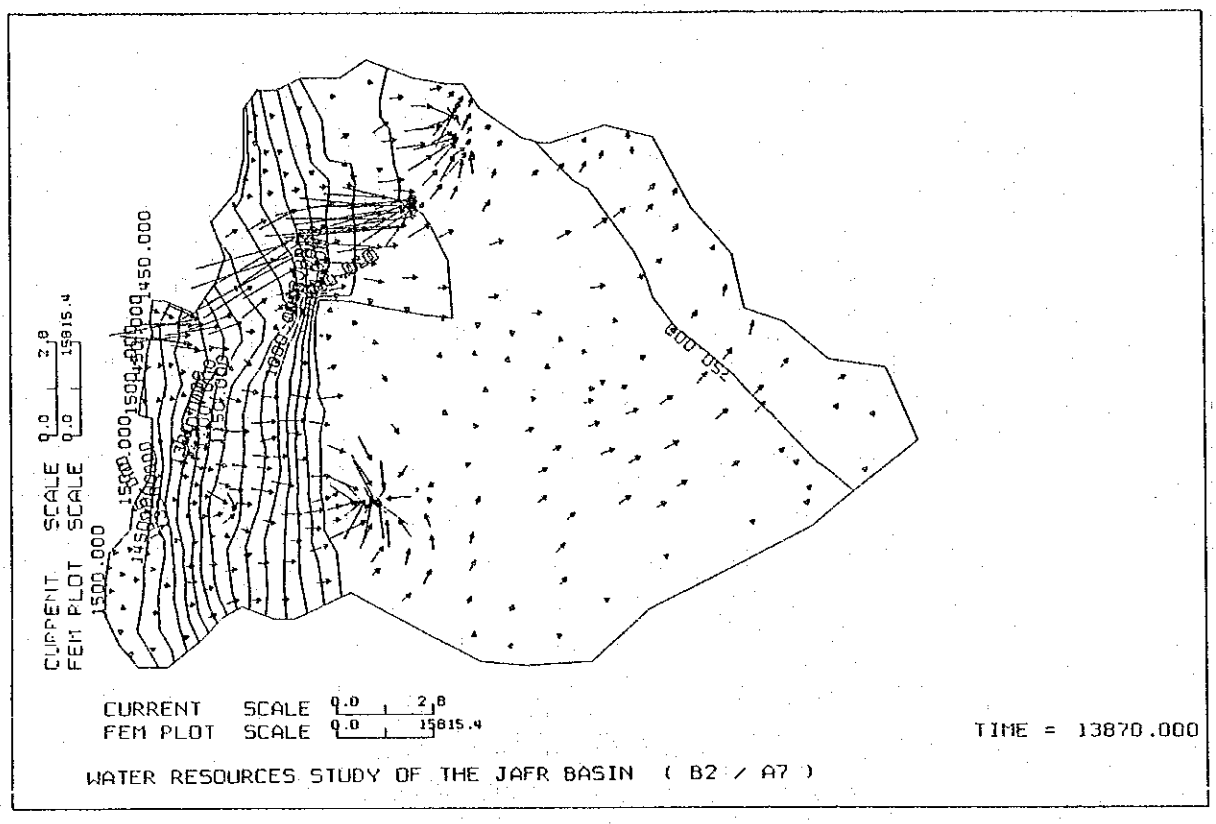
WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY



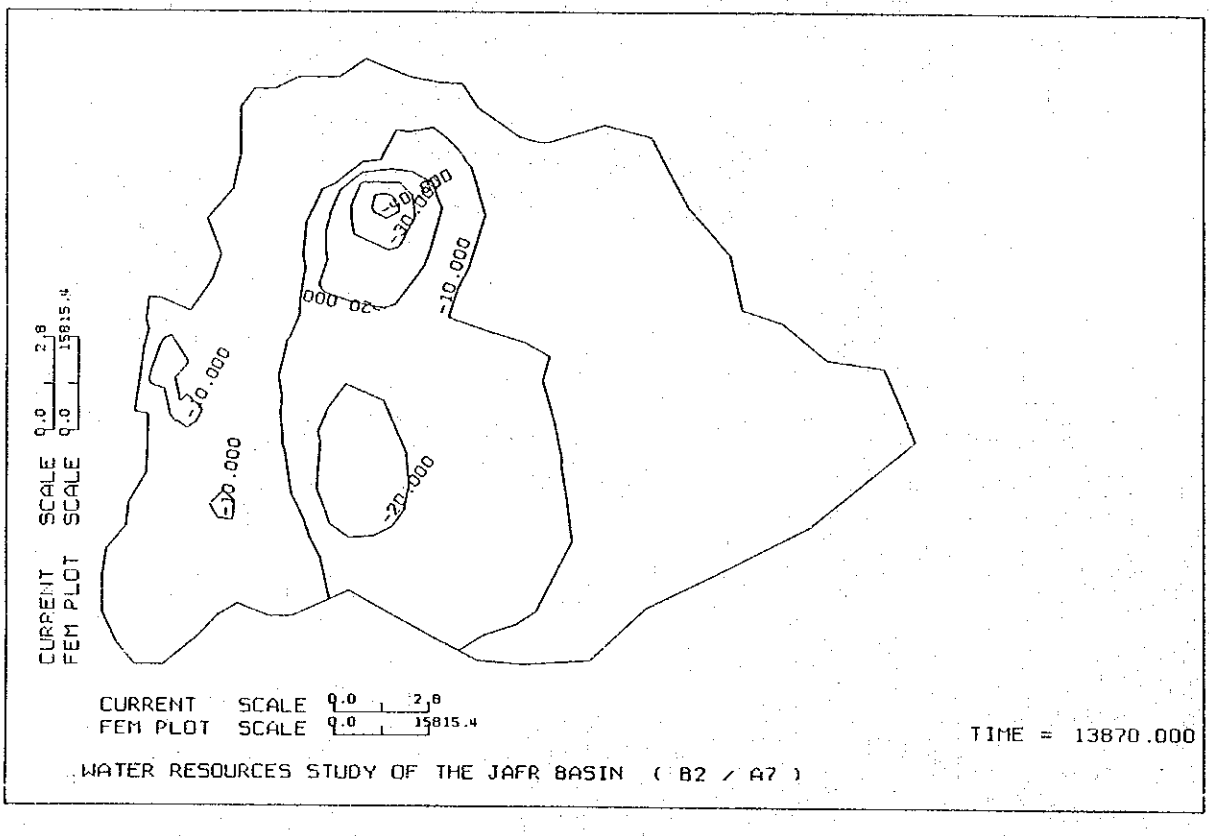
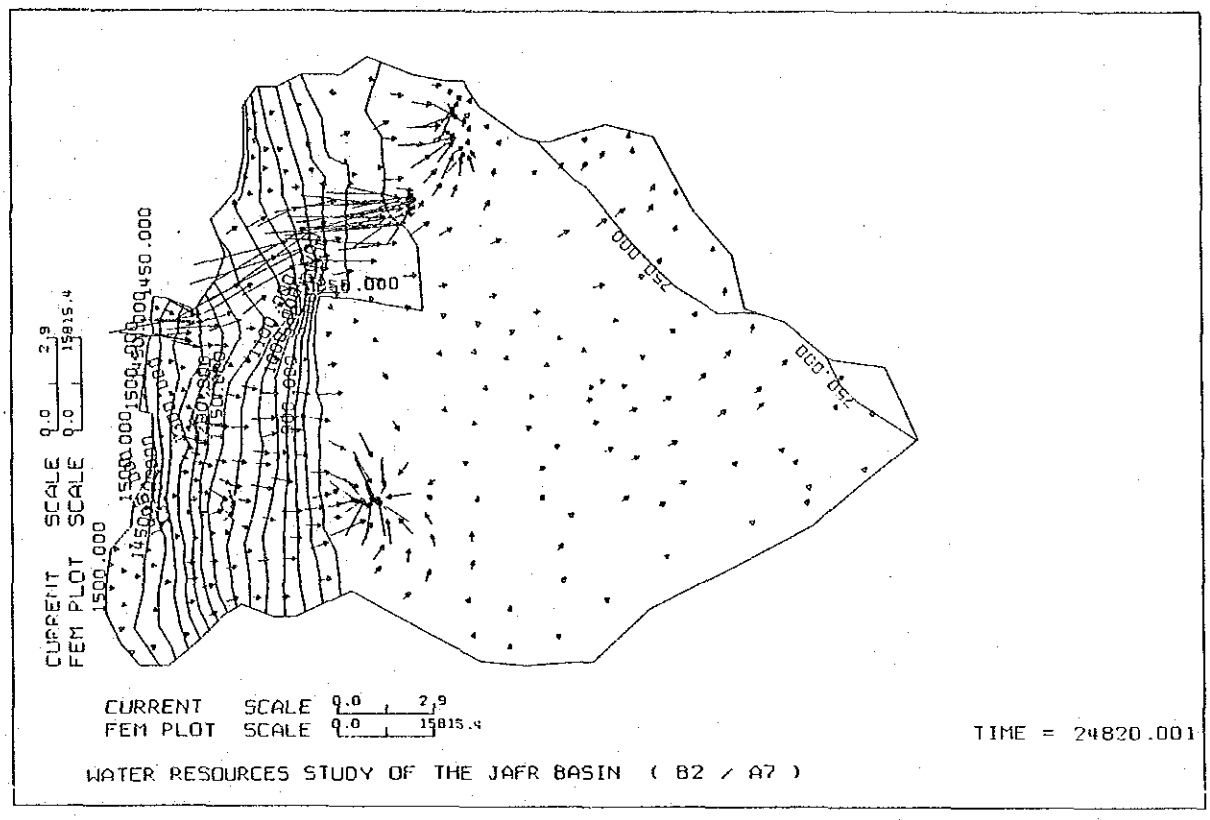




Fig.3.32 Predicted Piezometric Surface of B2/A7 Aquifer; After 20 Years Pumping

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY



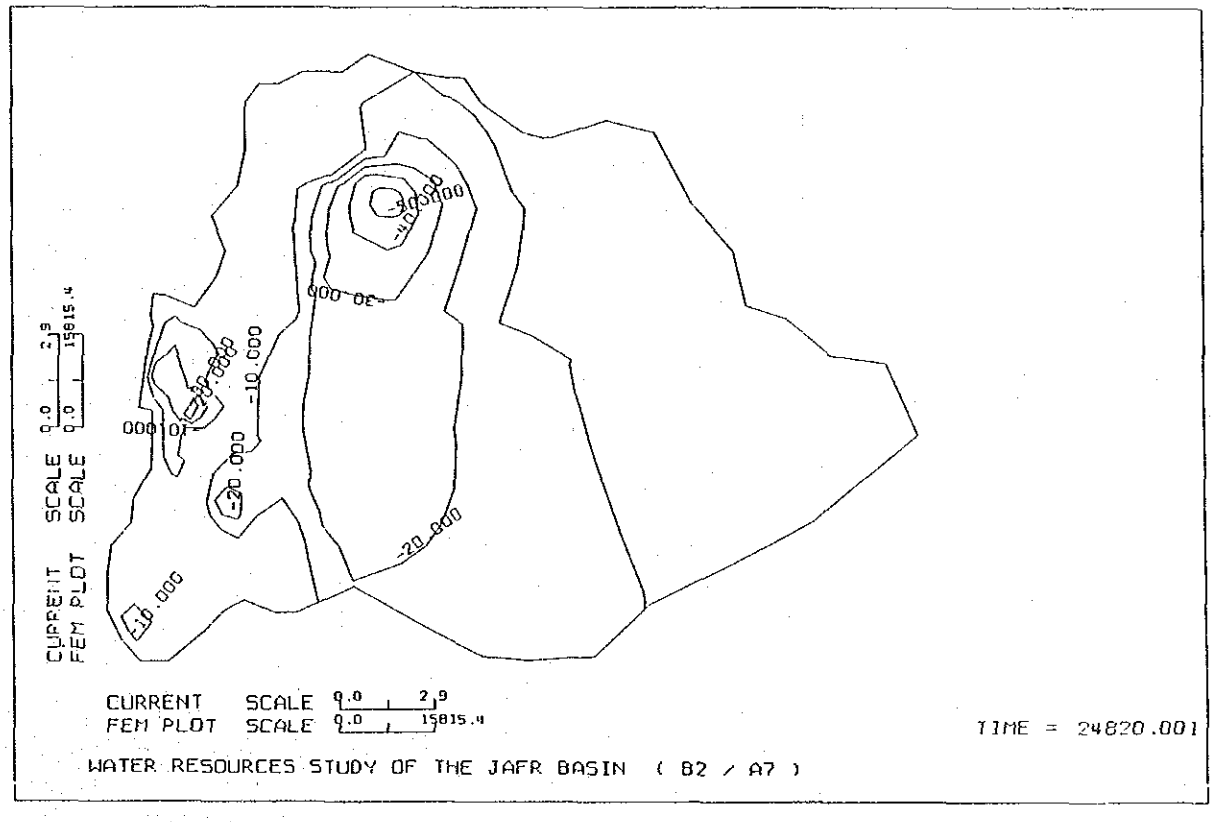
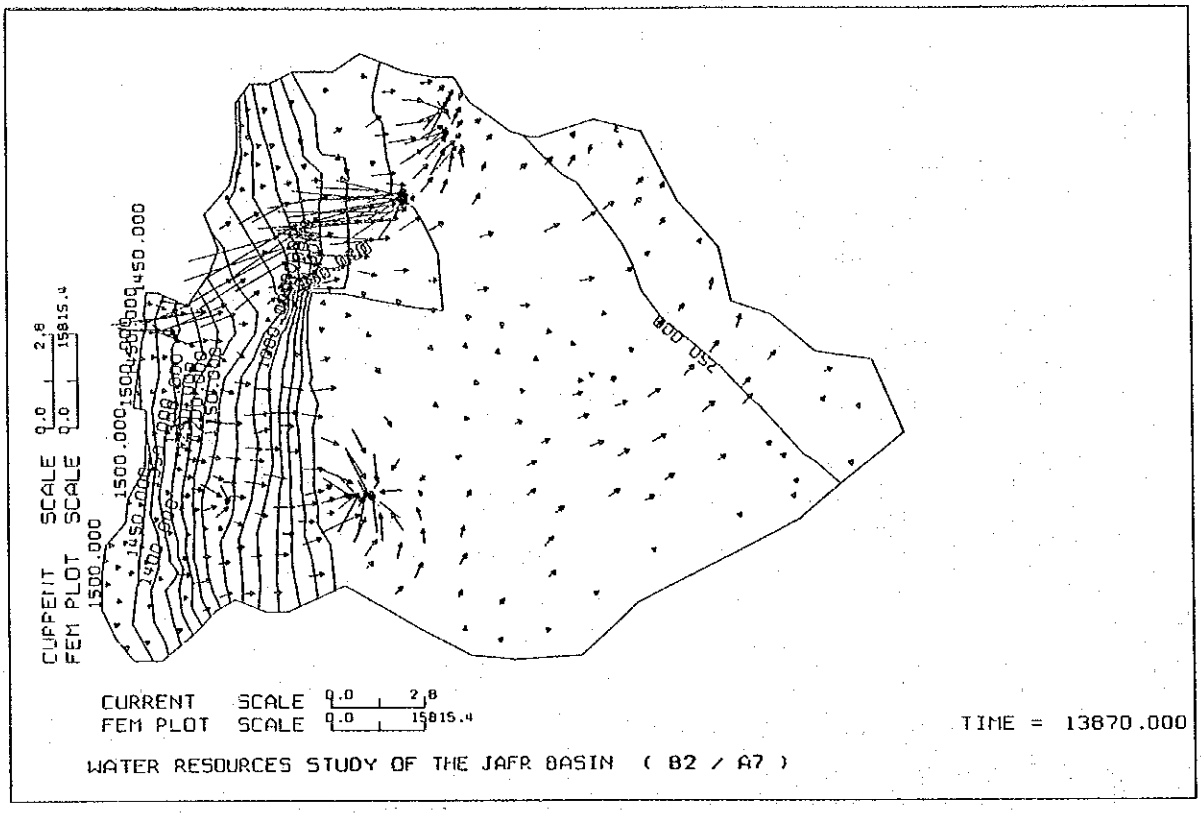




Fig.3.33 Predicted Piezometric Surface of B2/A7 Aquifer; After 50 Years Pumping

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY



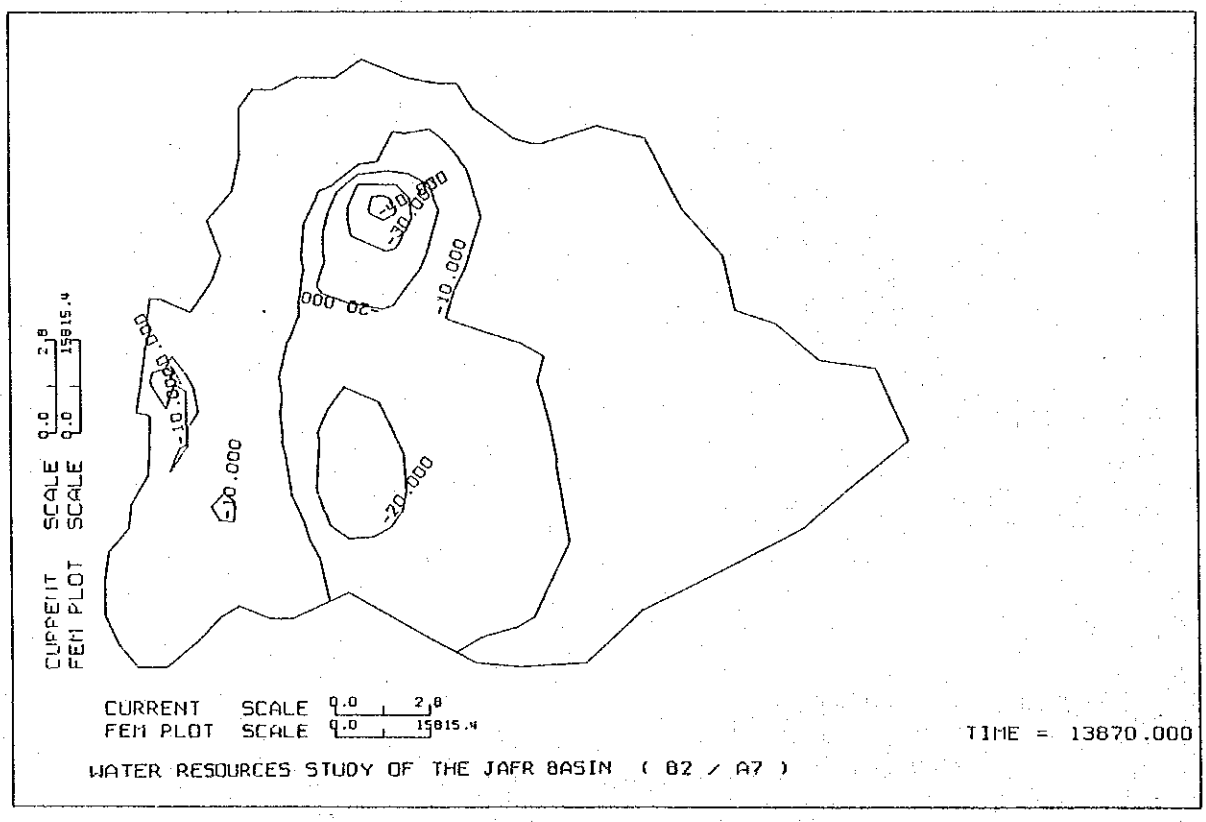
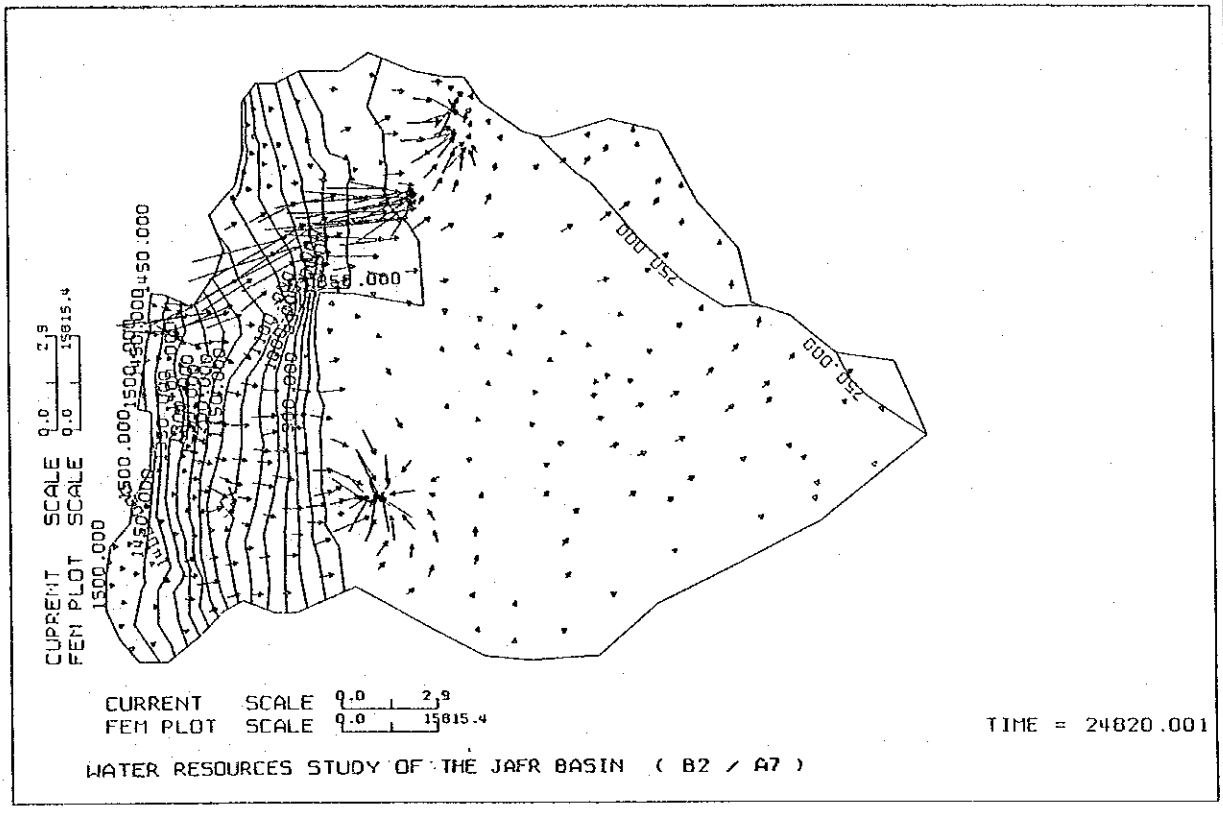




Fig.3.34 Predicted Piezometric Surface of B2/A7 with Groundwater Recharge Dam; After 20 Years Pumping and Recharging

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY



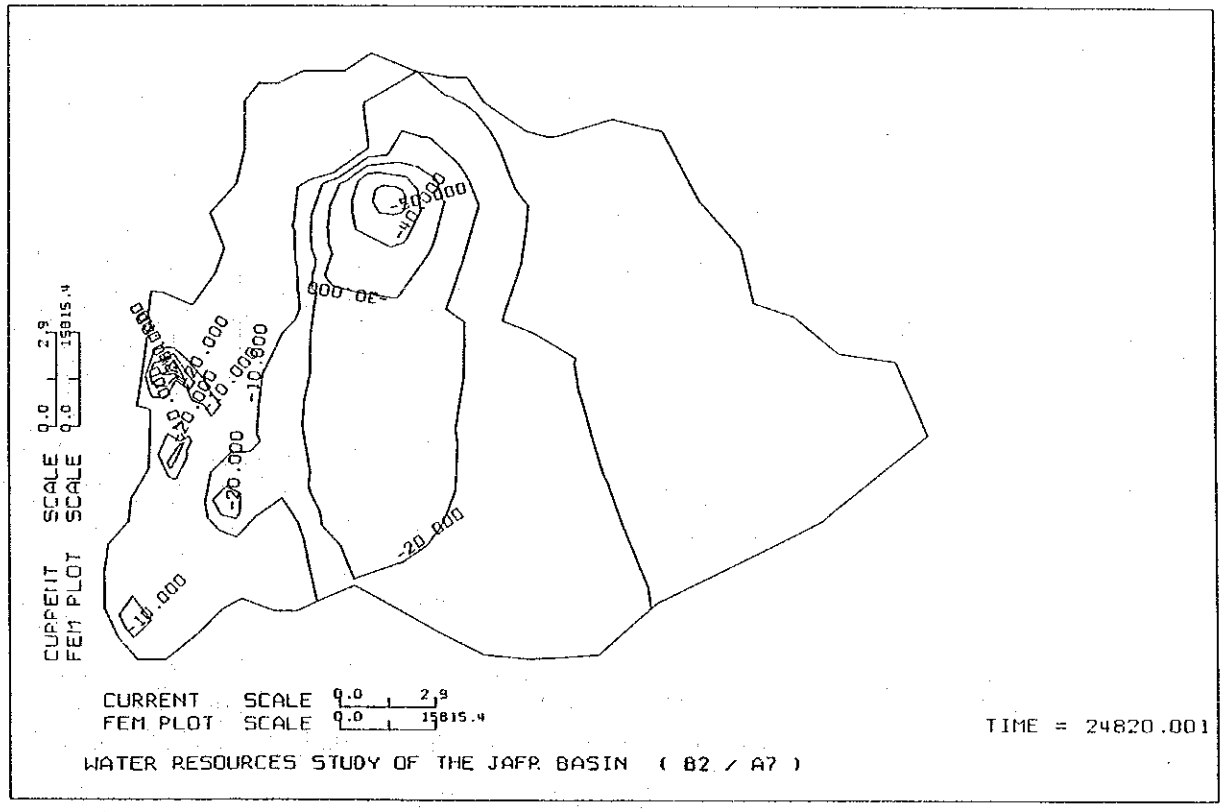
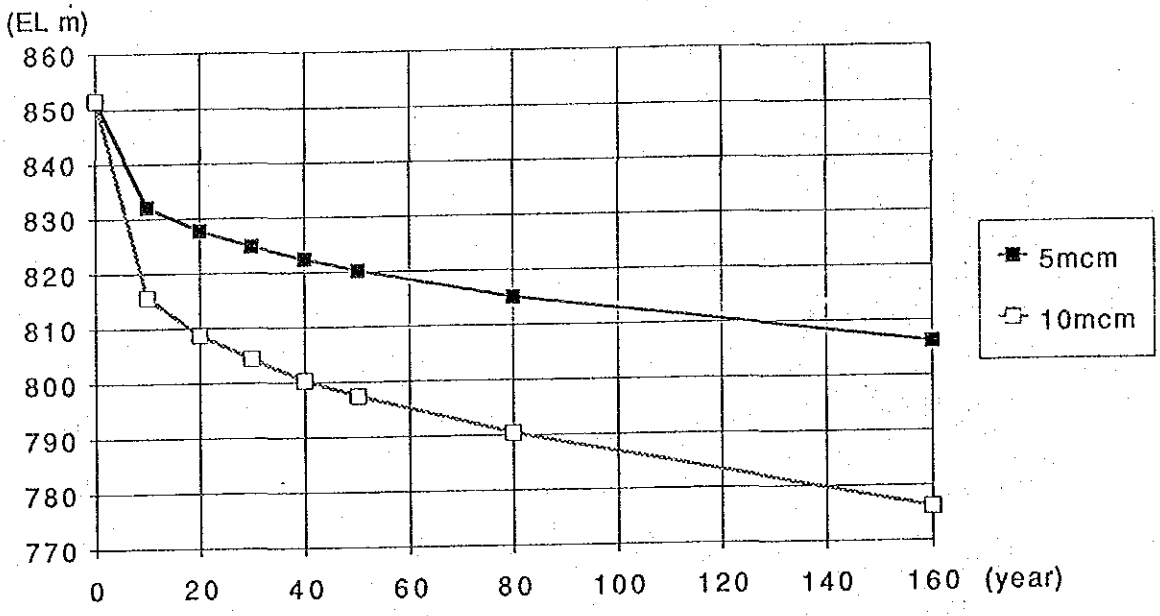




Fig.3.35 Predicted Piezometric Surface of B2/A7 with Groundwater Recharge Dam; After 50 Years Pumping and Recharging

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

South Hasa




East Ma'an

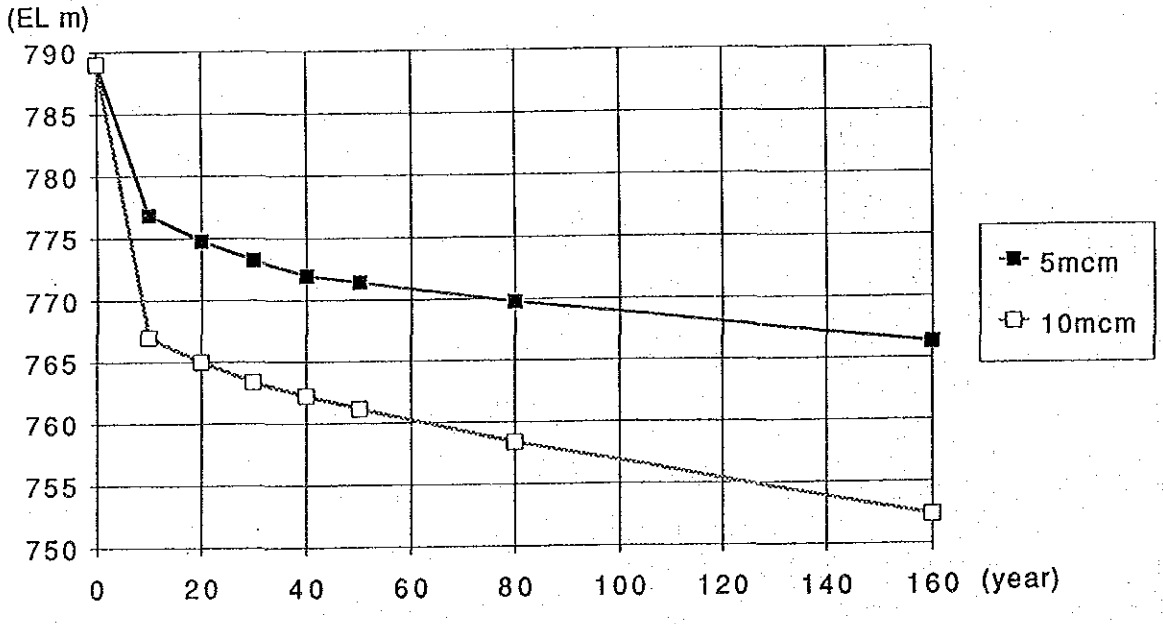



Fig.3.36 Estimated Drawdown in Representative Wellfields

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

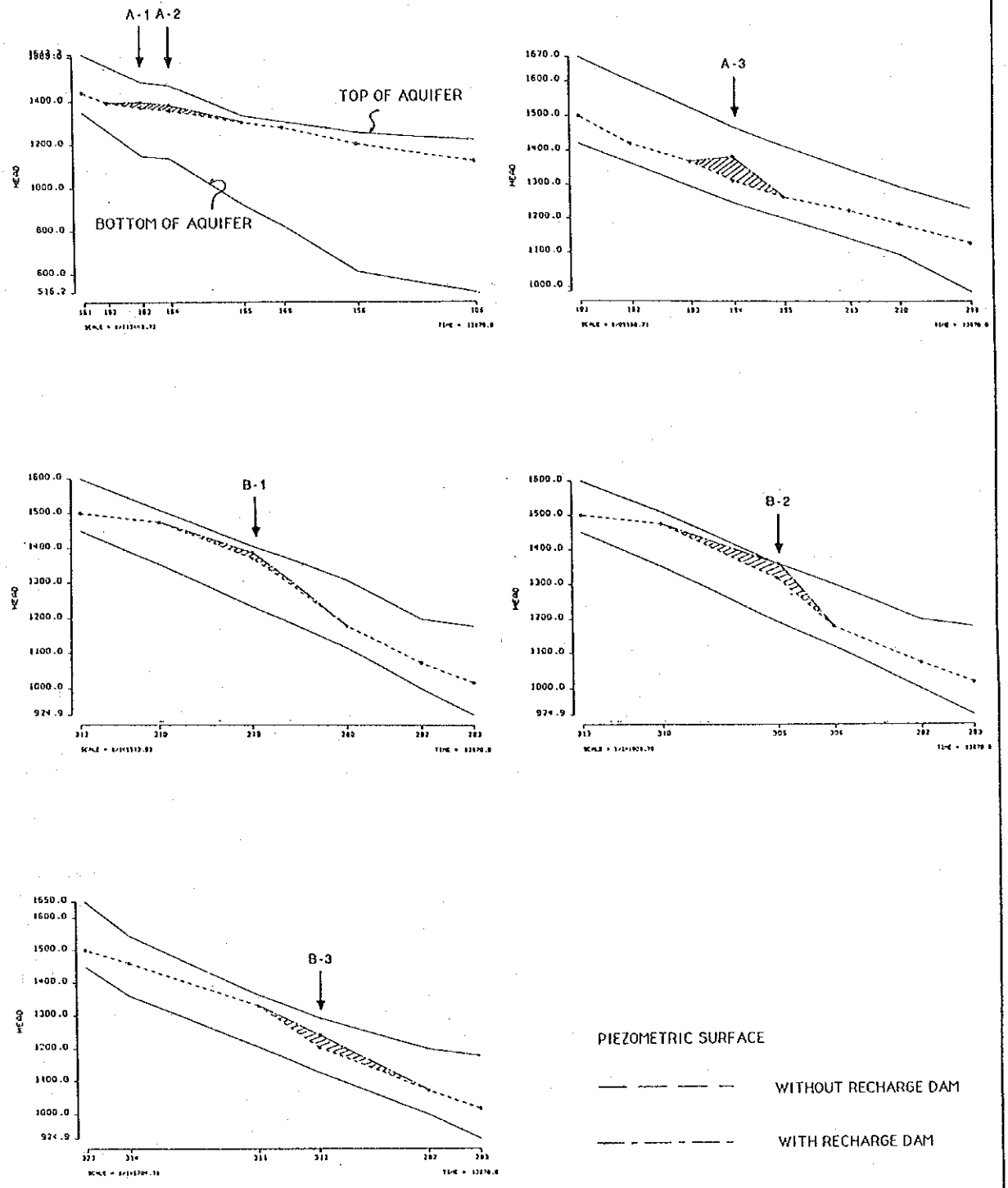



Fig.3.37 Estimated Change in Piezometric Surface by Recharge Dams

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

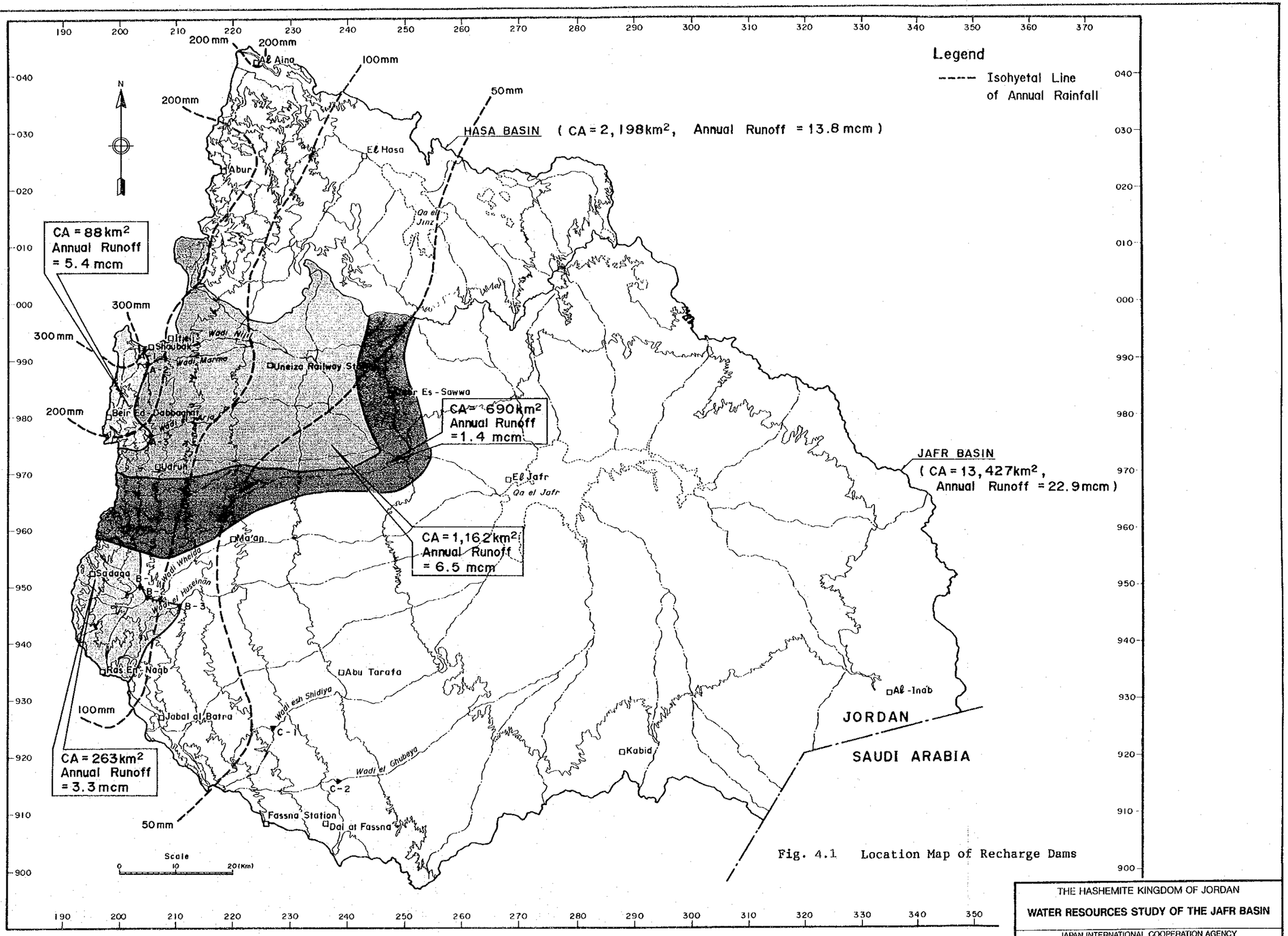



Fig. 4.1 Location Map of Recharge Dams

THE HASHEMITE KINGDOM OF JORDAN
**WATER RESOURCES STUDY OF THE JAFR BASIN**
JAPAN INTERNATIONAL COOPERATION AGENCY

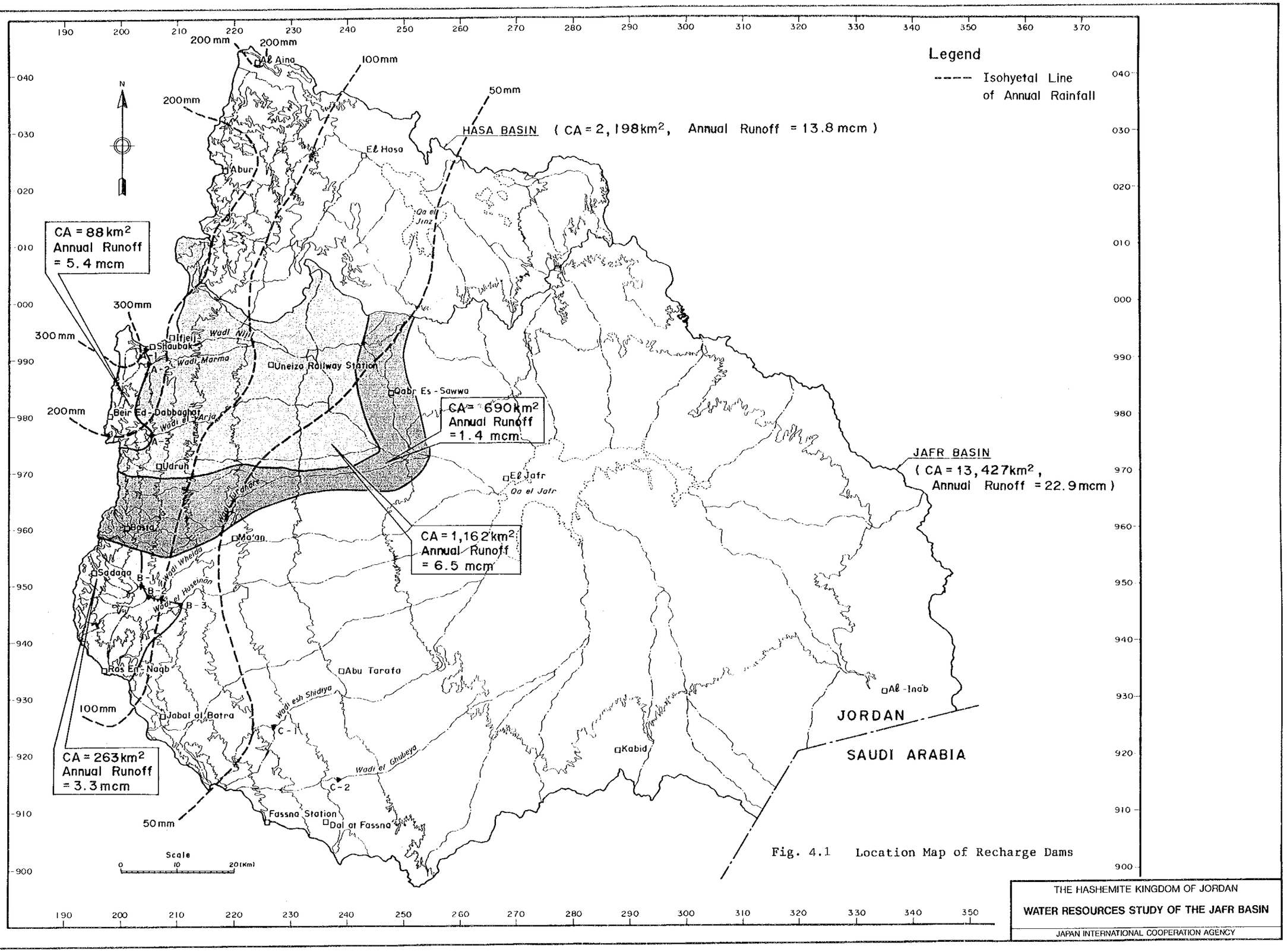



Fig. 4.1 Location Map of Recharge Dams

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

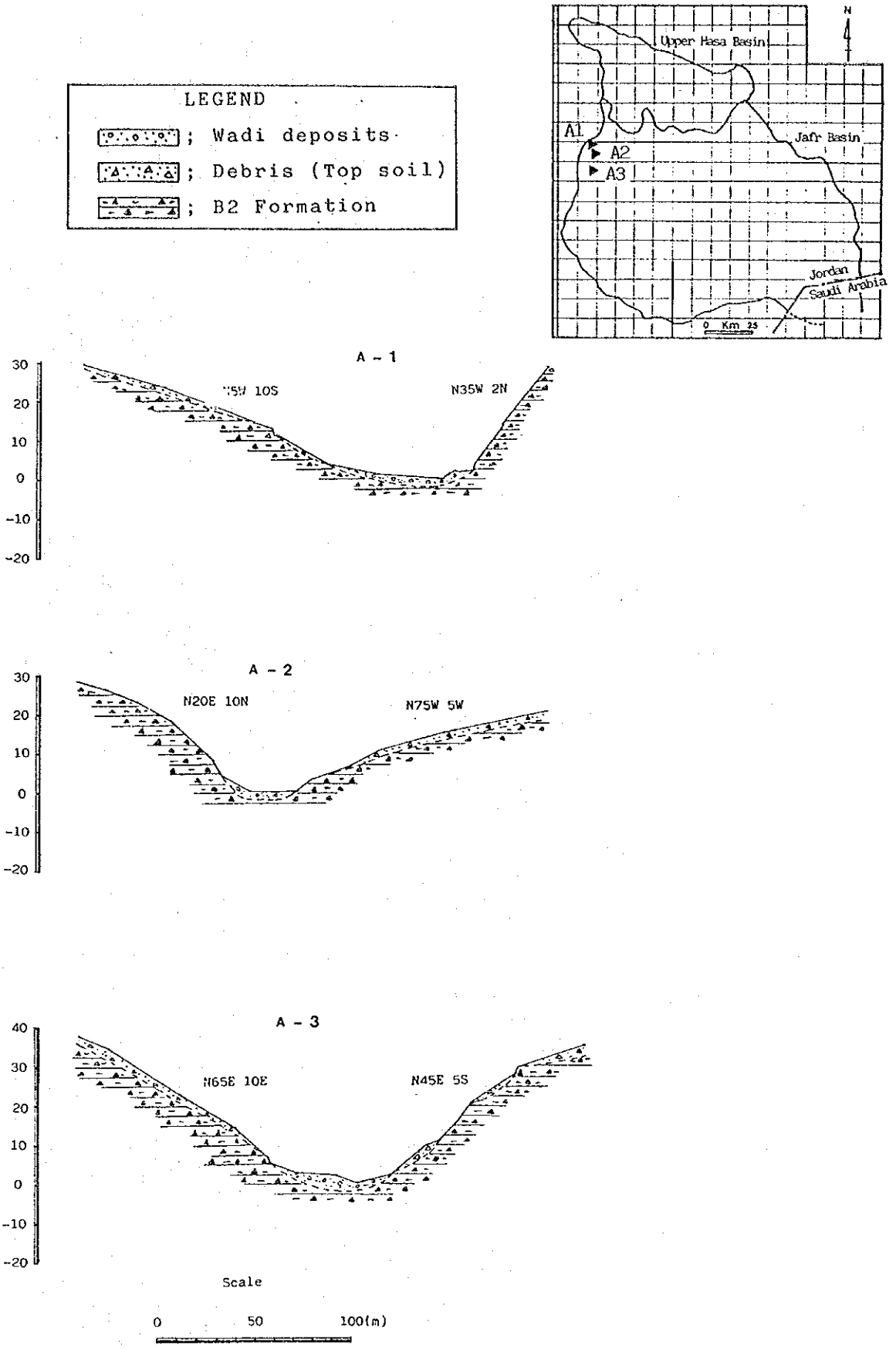



Fig. 4.2

Geological Profile Along Dam Axis in Group A

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

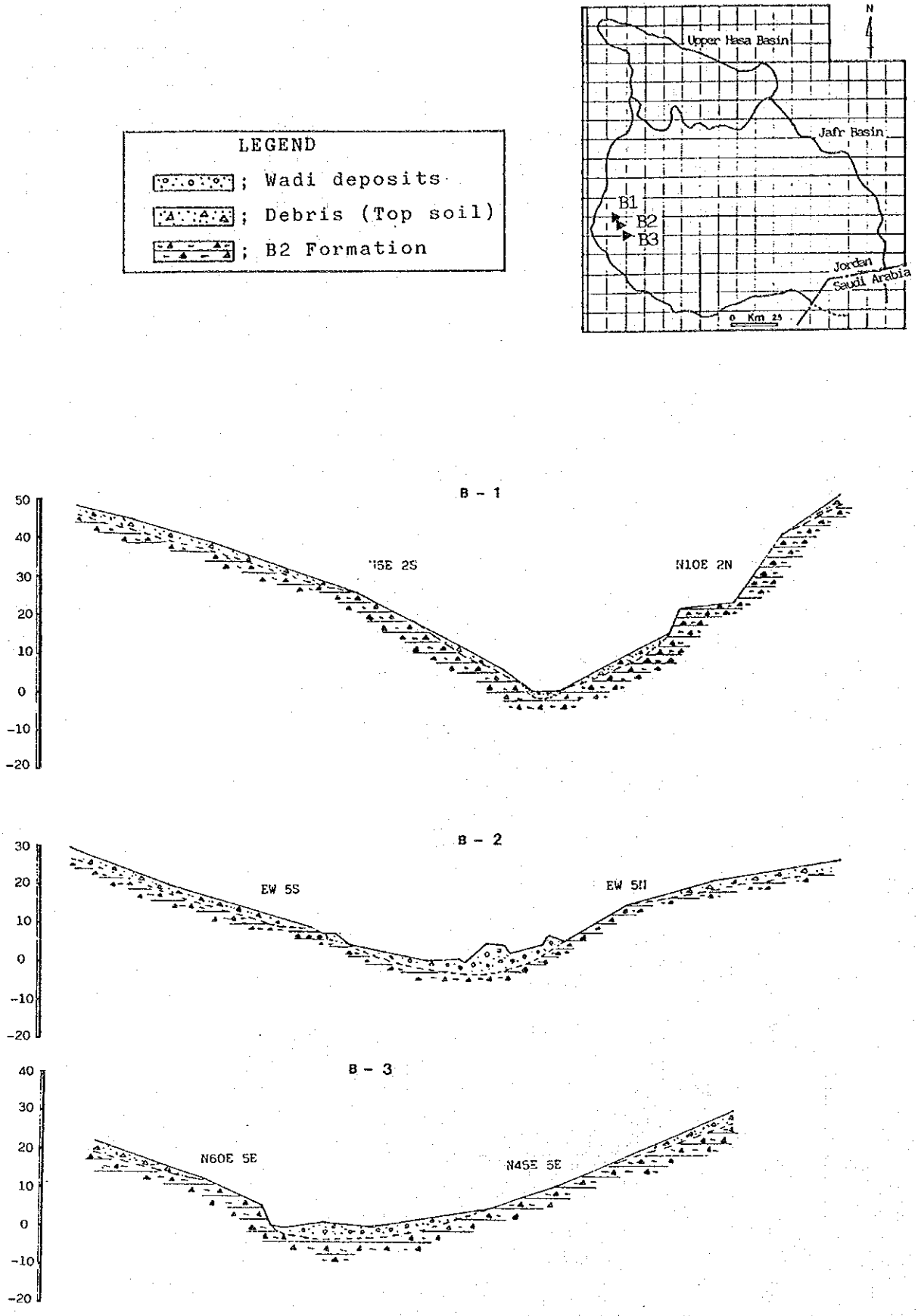



Fig. 4.3

Geological Profile Along Dam Axis in Group B

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

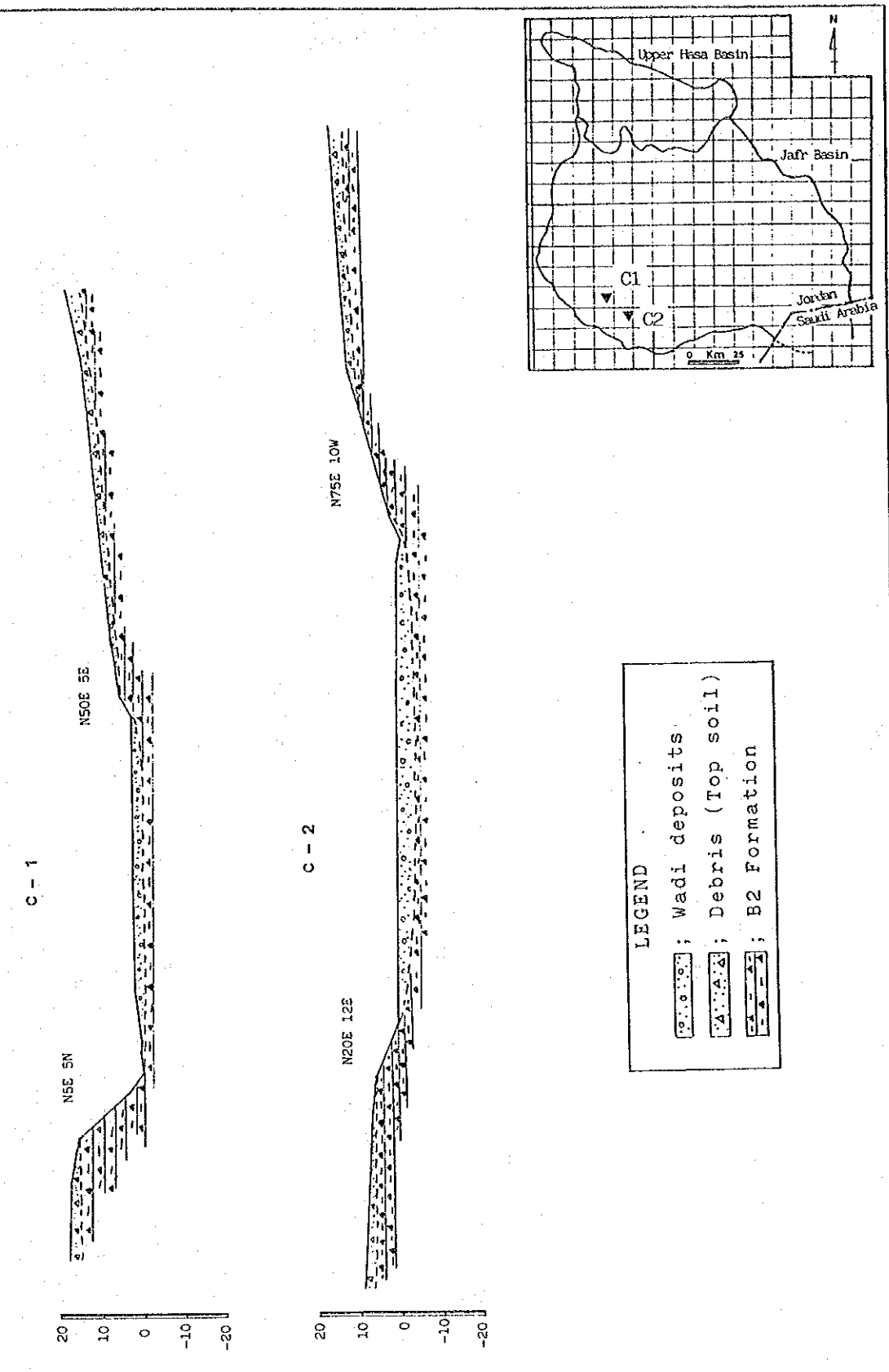



Fig. 4.4

Geological Profile Along Dam Axis in Group C

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

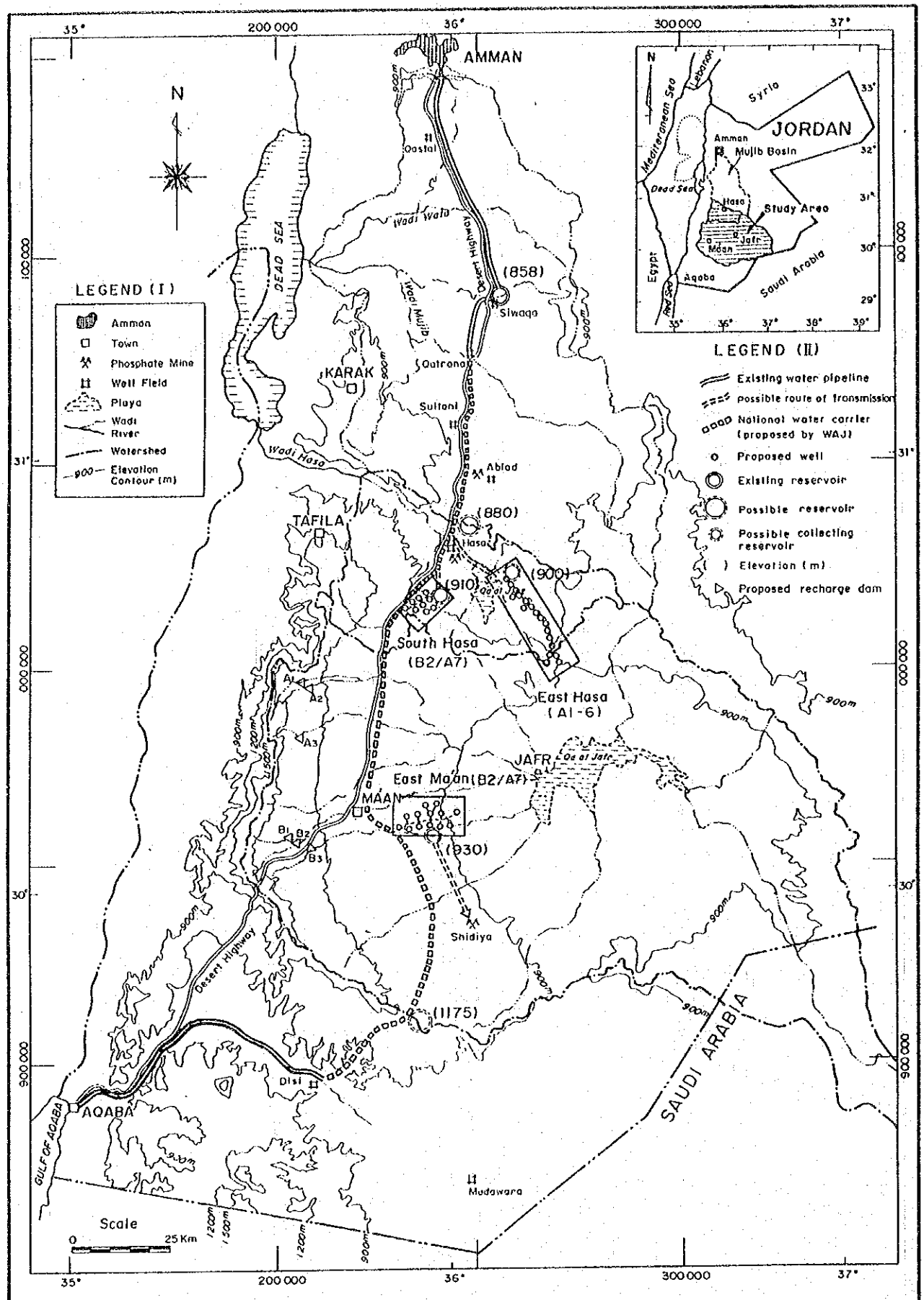



Fig.4.5
Development Alternatives

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

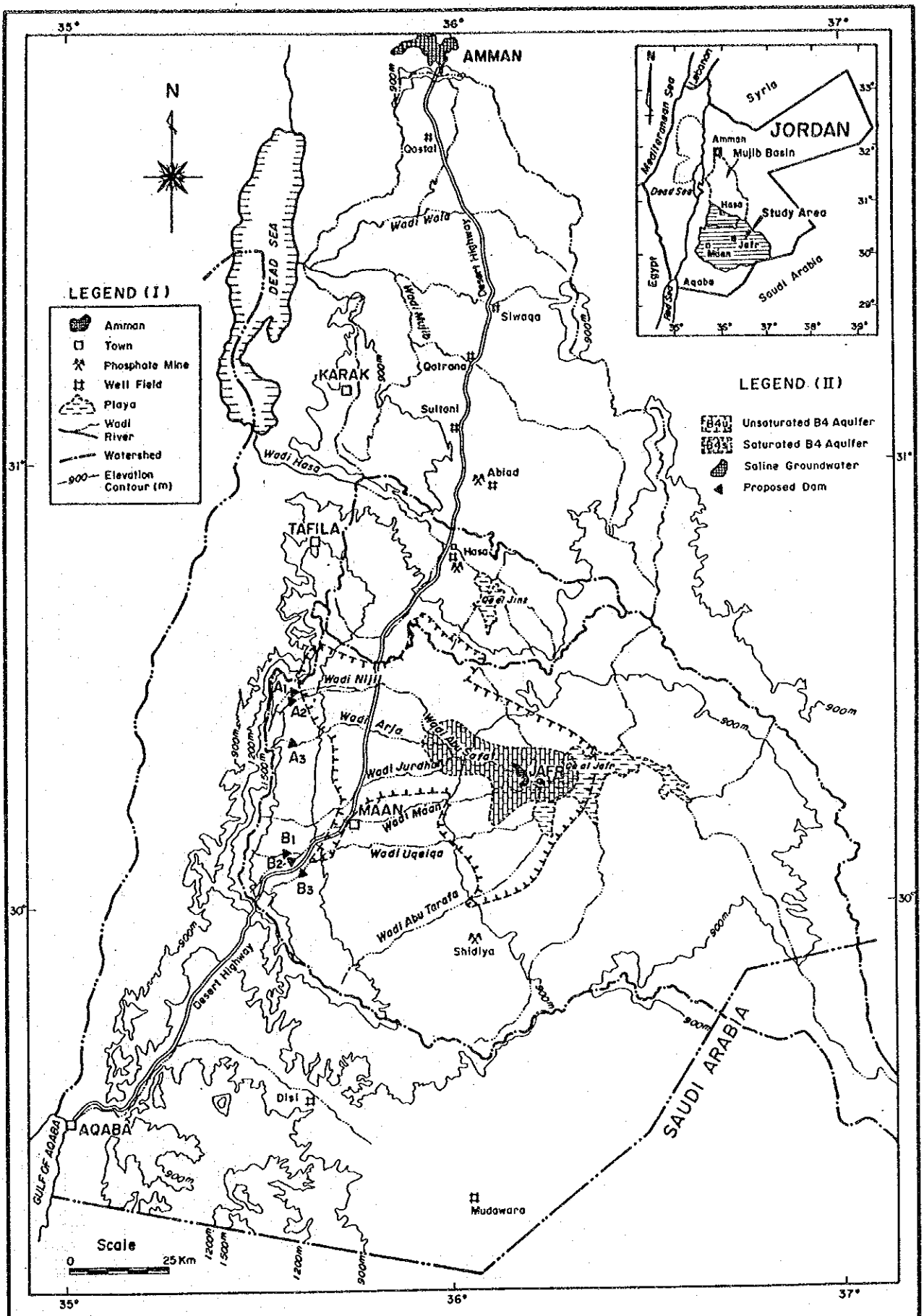
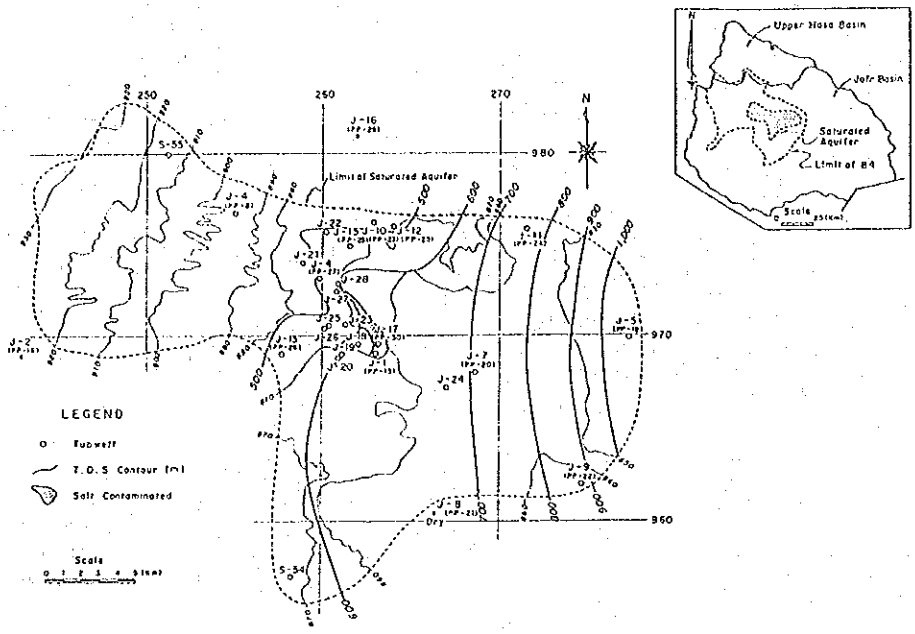
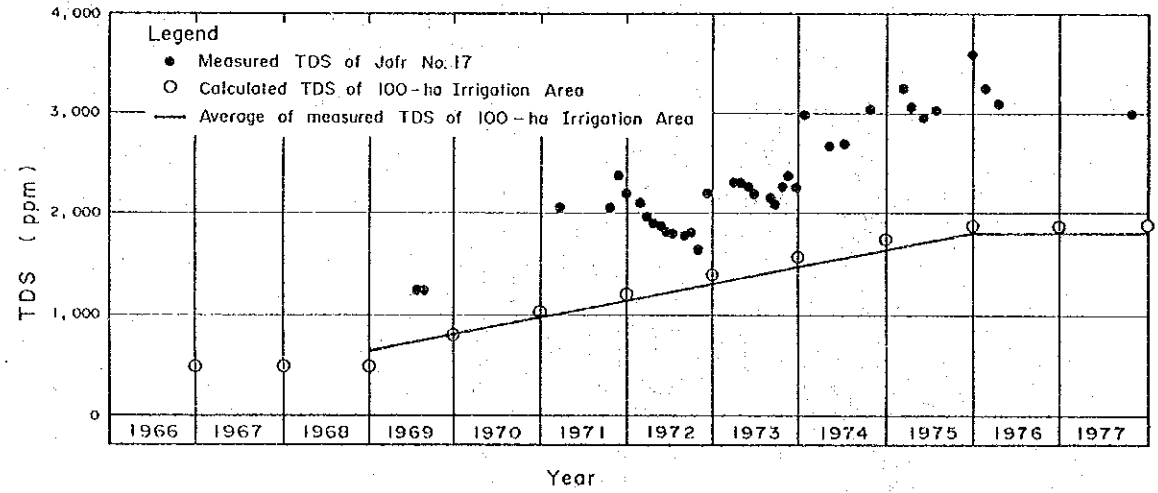



Fig. 5.1
Location of Salinity-Accumulated Area in Rijam (B4) Aquifer

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY



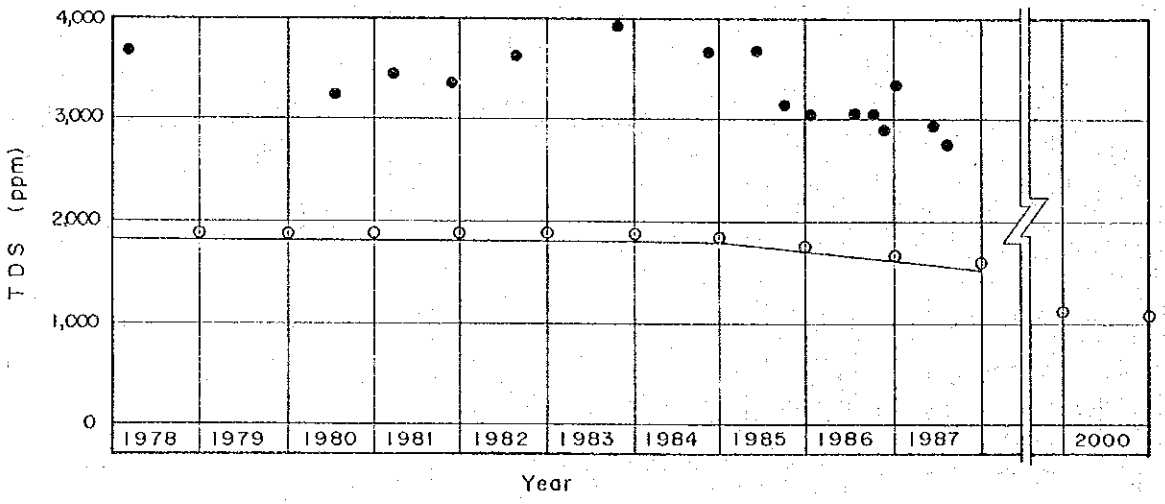
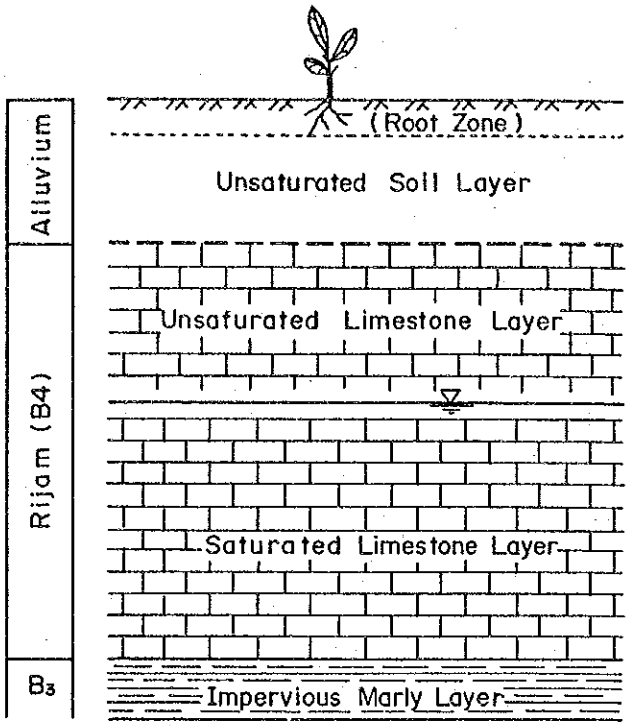




Fig. 5.2 Location of Salinity-Accumulated Area and Measured and Calculated TDS Values

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY



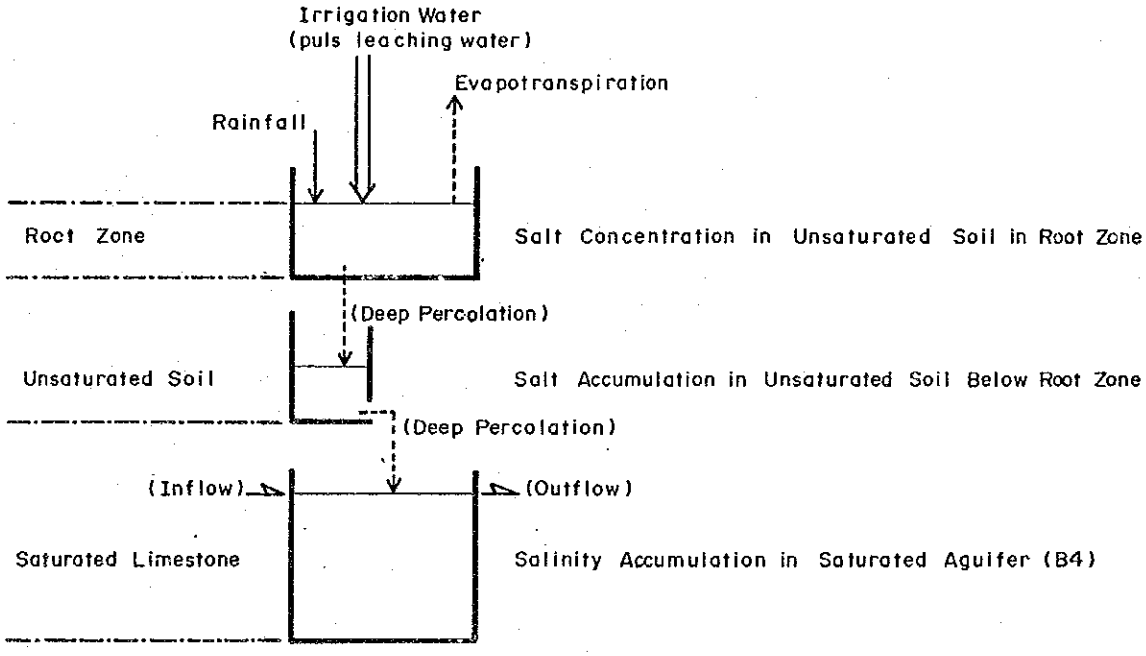




Fig. 5.3 Schematics of Salt Accumulation in Rijam (B4) Aquifer

THE HASHEMITE KINGDOM OF JORDAN
WATER RESOURCES STUDY OF THE JAFR BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

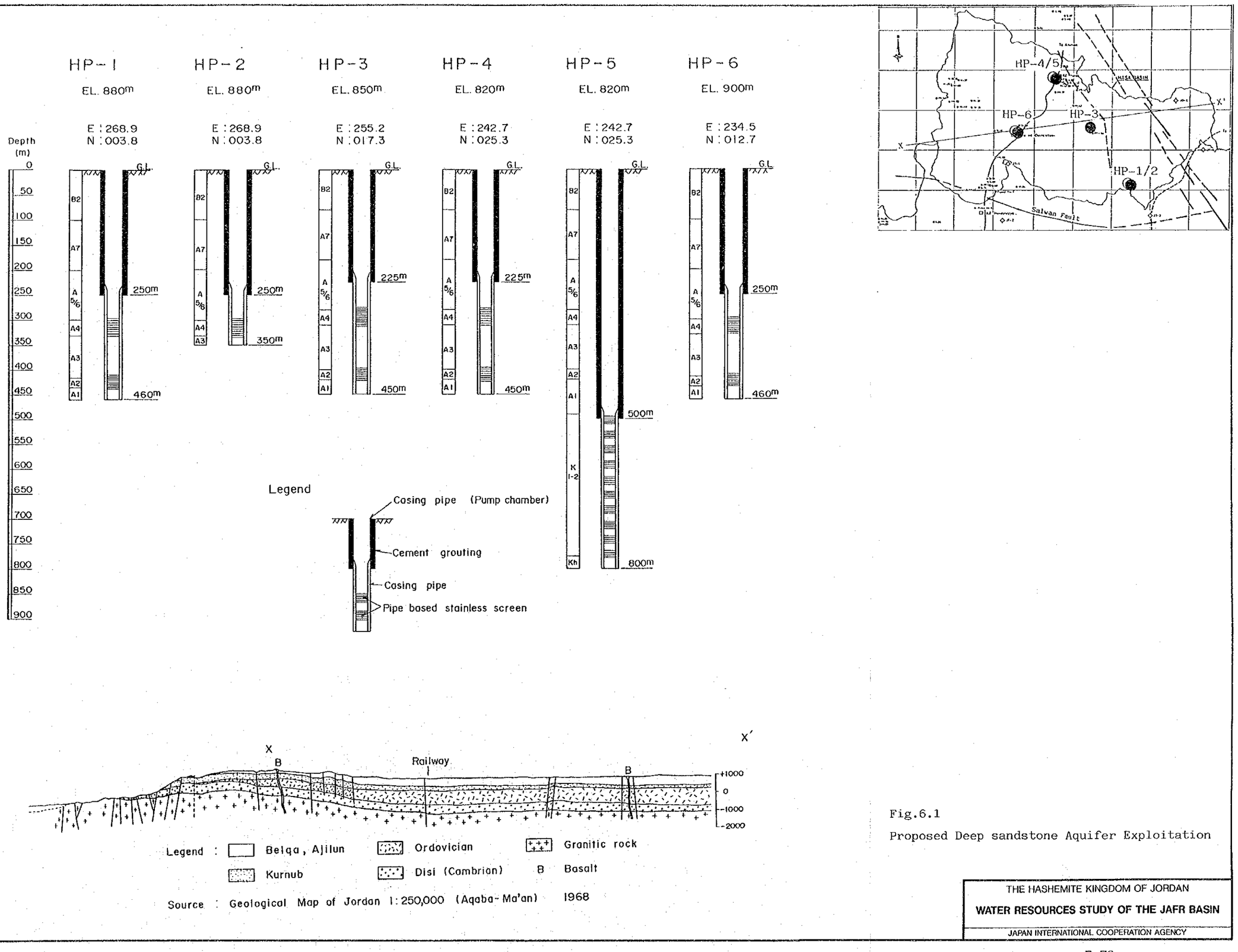


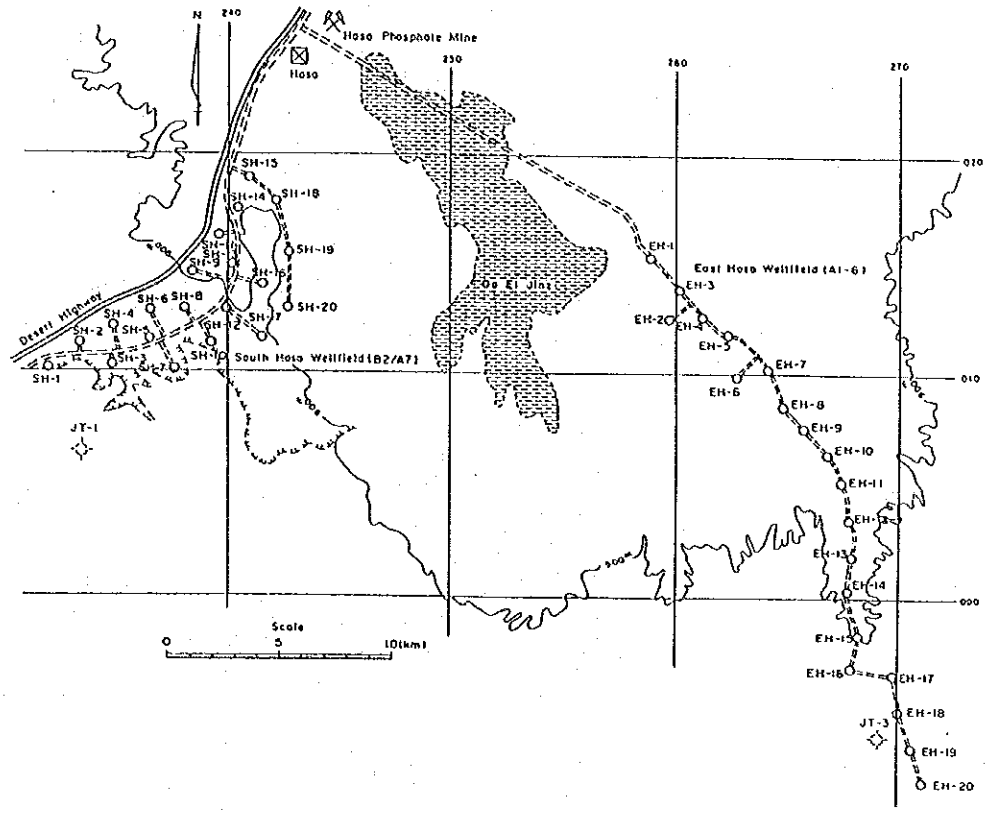

Fig.6.1

Proposed Deep sandstone Aquifer Exploitation

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY



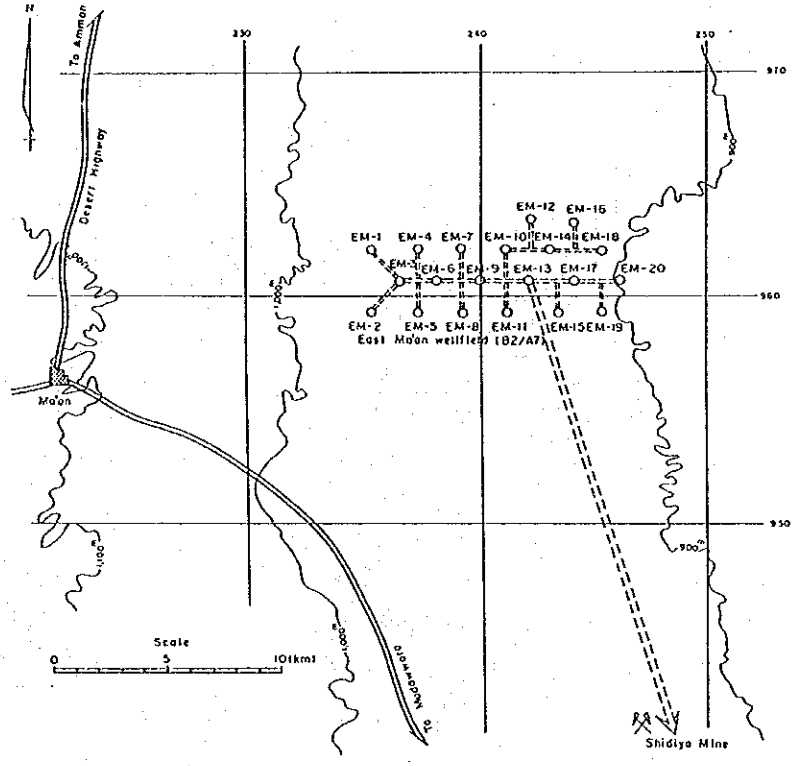




Fig. 6.2

Preliminary Design of Proposed Wellfields

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

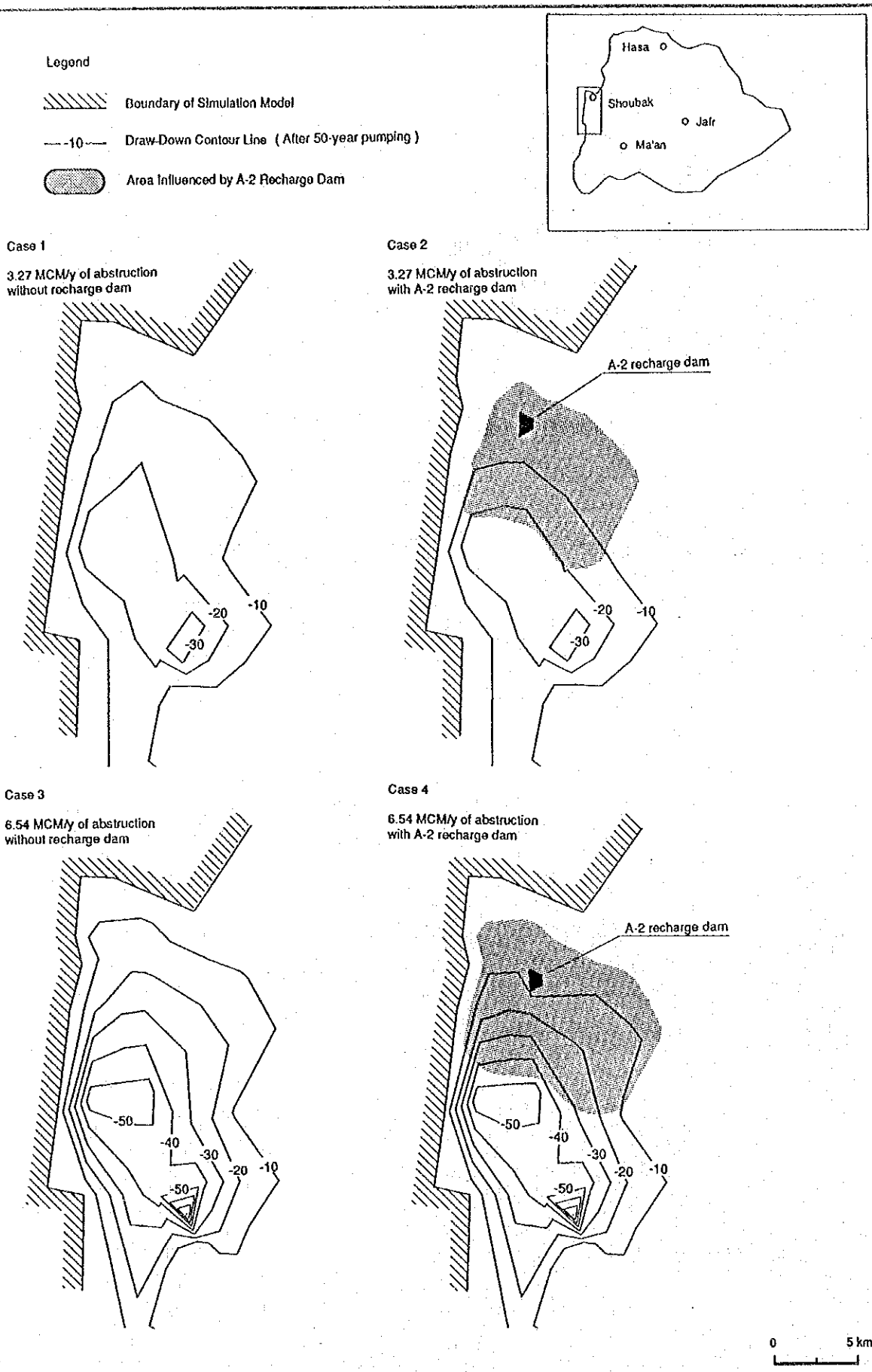



Fig.6. 3 Area Affected by the A-2 Recharge Dam

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Legend

Profile A : —○—
Node 161-162-163-164-165-166-167

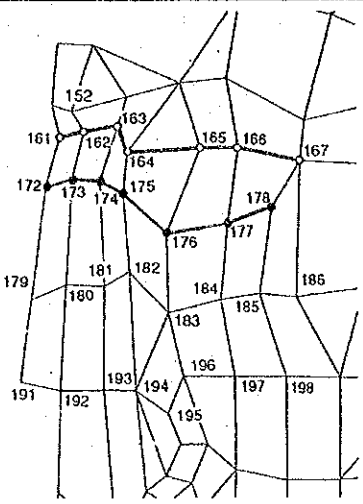
Profile B : —●—
Node 172-173-174-175-176-177-178

Case 1 — 3.27 MCM/y of abstruction without recharge dam

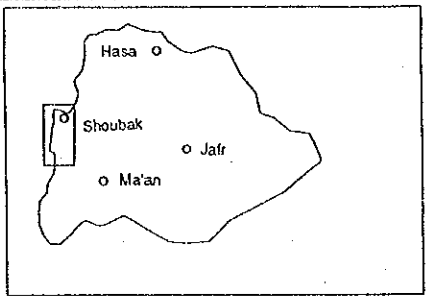
Case 2 — 3.27 MCM/y of abstruction with A-2 recharge dam

Case 3 — 6.54 MCM/y of abstruction without recharge dam

Case 4 — 6.54 MCM/y of abstruction with A-2 recharge dam

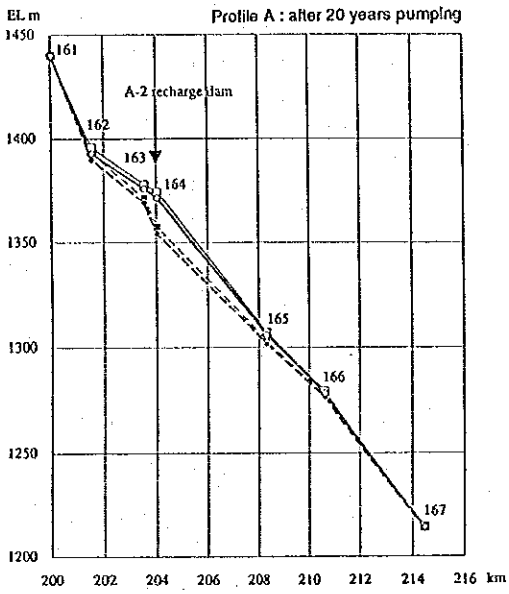


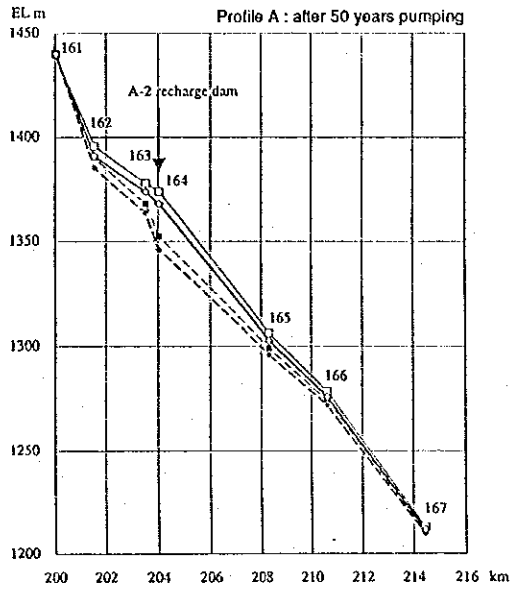

FEM Simulation Mesh aound the Shoubak Well Field

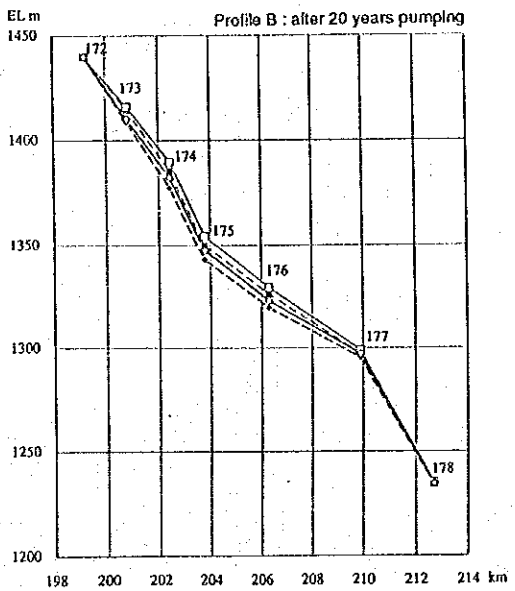



Note :

Distance is shown by longitude of Palestinian Grid



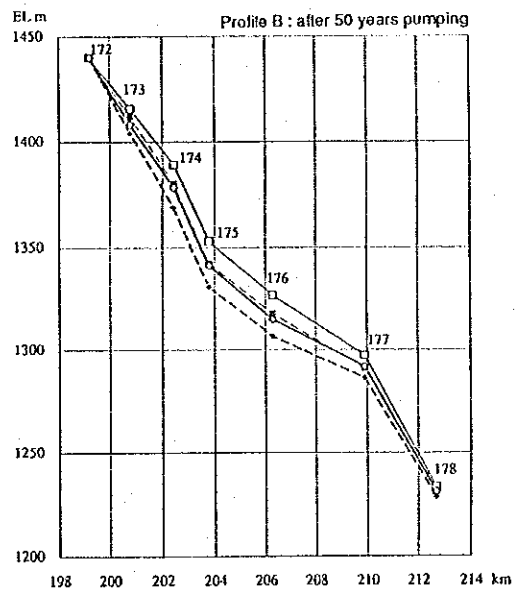




Fig.6. 4

Profile of Piezometric Surface in the Shoubak Area (1/2)

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Legend

Profile C :
Node 179-180-181-182-183-184-185-186

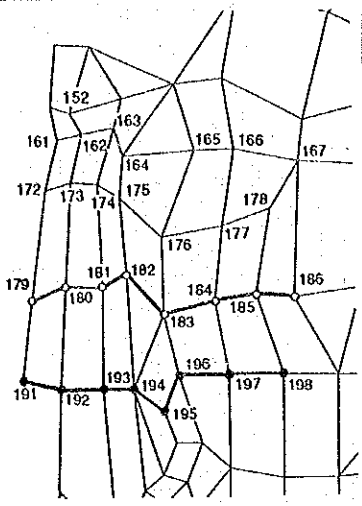
Profile D :
Node 191-192-193-194-195-196-197-198

Case 1 — 3.27 MCM/y of abstruction without recharge dam

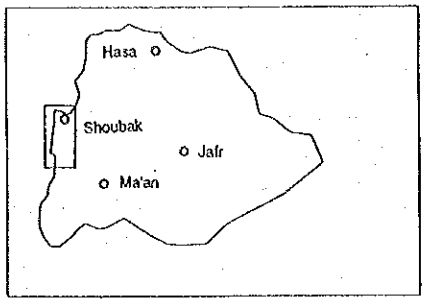
Case 2 — 3.27 MCM/y of abstruction with A-2 recharge dam

Case 3 — 6.54 MCM/y of abstruction without recharge dam

Case 4 — 6.54 MCM/y of abstruction with A-2 recharge dam

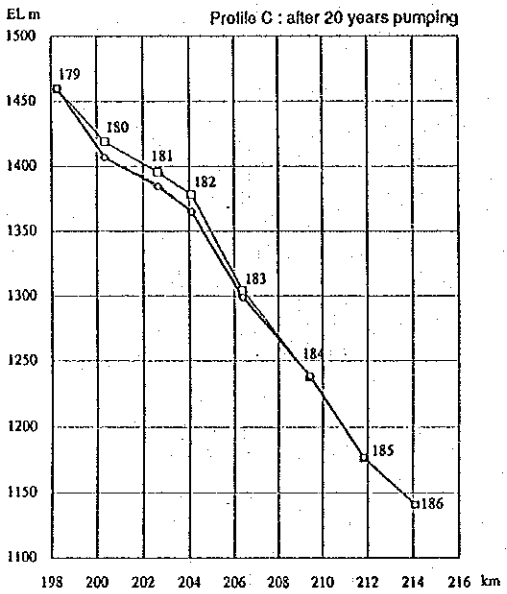


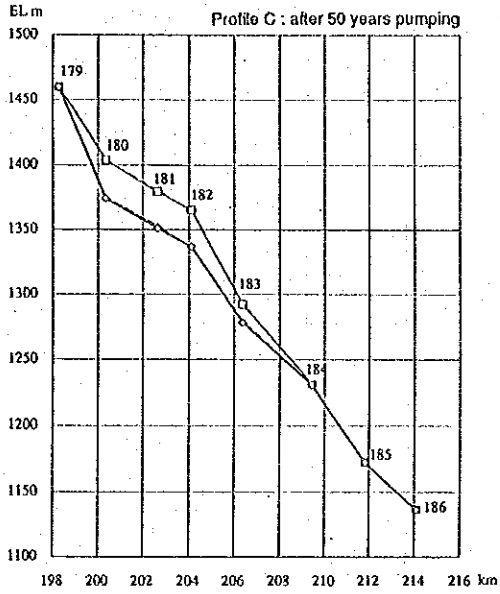

FEM Simulation Mesh aound the Shoubak Well Field

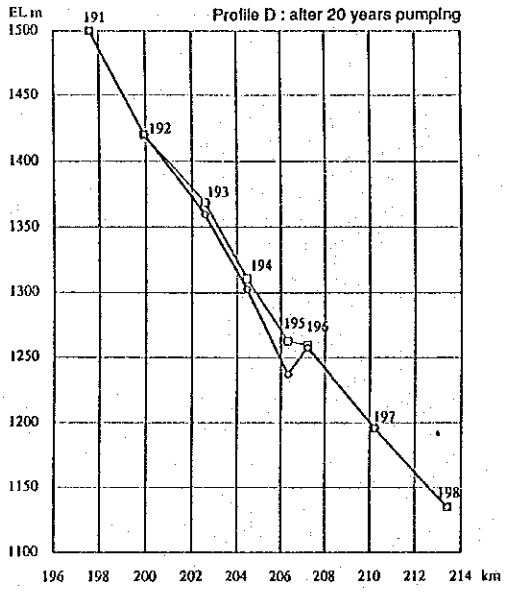



Note :

Distance is shown by longitude of Palestinian Grid



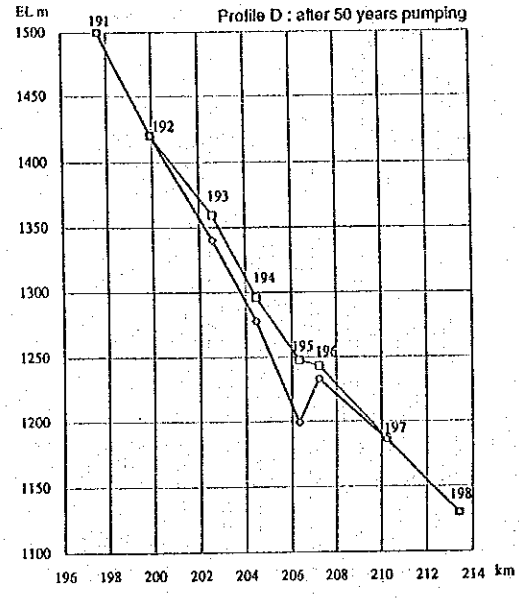




Fig.6. 5

Profile of Piezometric Surface in the shoubak Area

(2/2)

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

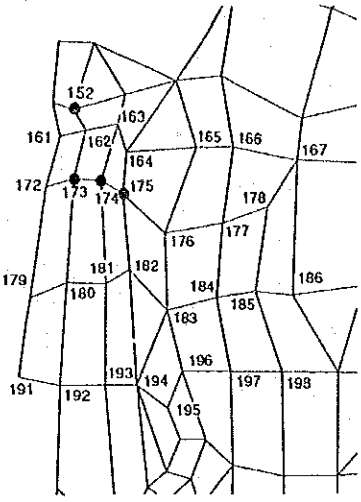
JAPAN INTERNATIONAL COOPERATION AGENCY

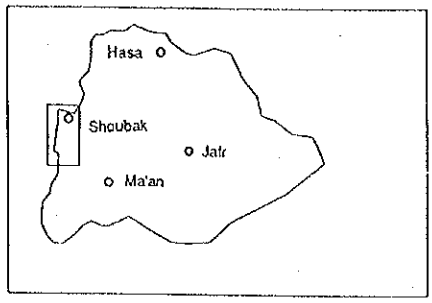
Case 1 — 3.27 MCM/y of abstruction without recharge dam

Case 2 — 3.27 MCM/y of abstruction with A-2 recharge dam

Case 3 — 6.54 MCM/y of abstruction without recharge dam

Case 4 — 6.54 MCM/y of abstruction with A-2 recharge dam

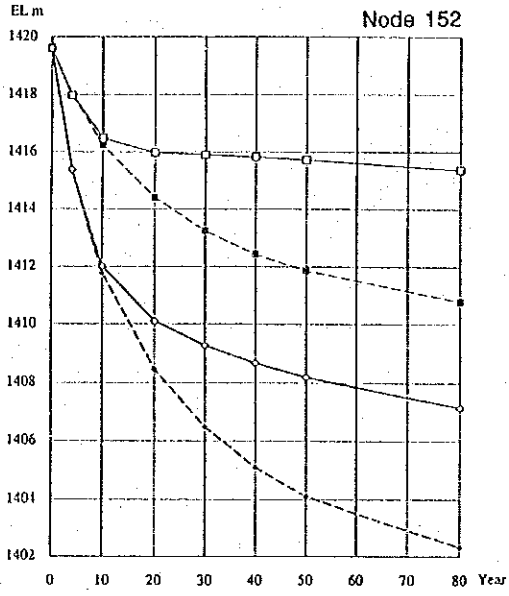


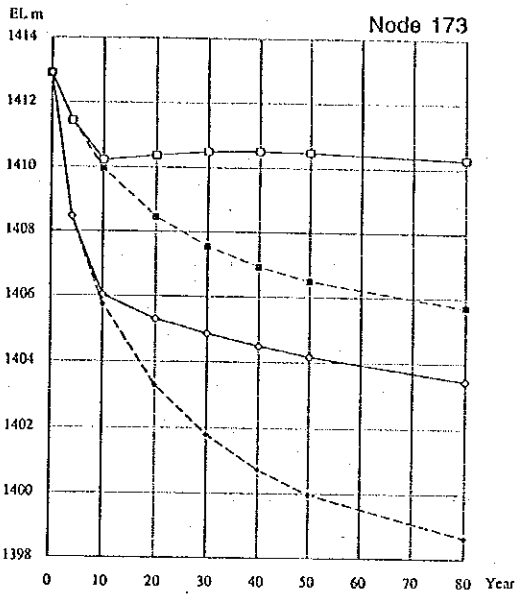



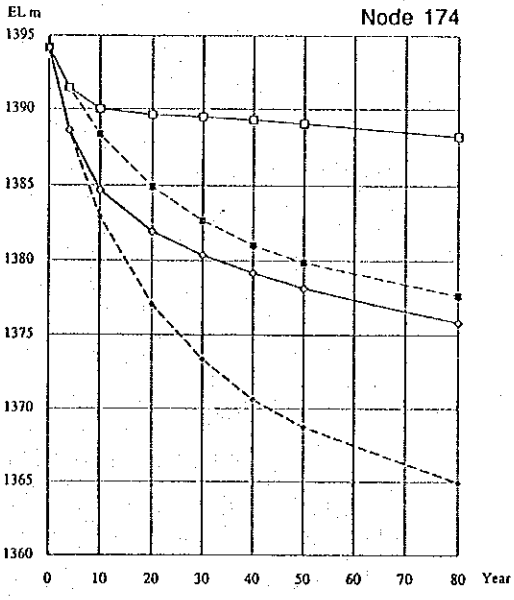

Note :

A-2 recharge dam is assumed to be constructed after 5 years.

FEM Simulation Mesh aound the Shoubak Well Field



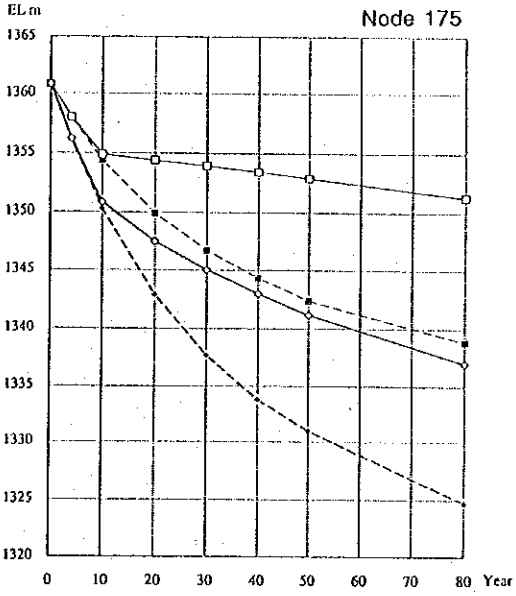




Fig.6. 6

Predicted Piezometric Levels for the Mesh Nodes in the Shoubak Area (1/3)

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

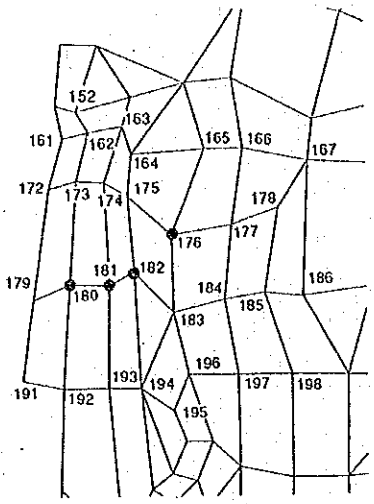
JAPAN INTERNATIONAL COOPERATION AGENCY

Case 1 — 3.27 MCM/y of abstruction without recharge dam

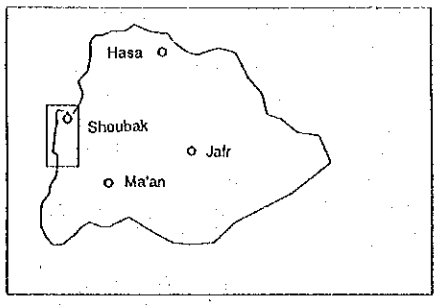
Case 2 — 3.27 MCM/y of abstruction with A-2 recharge dam

Case 3 — 6.54 MCM/y of abstruction without recharge dam

Case 4 — 6.54 MCM/y of abstruction with A-2 recharge dam

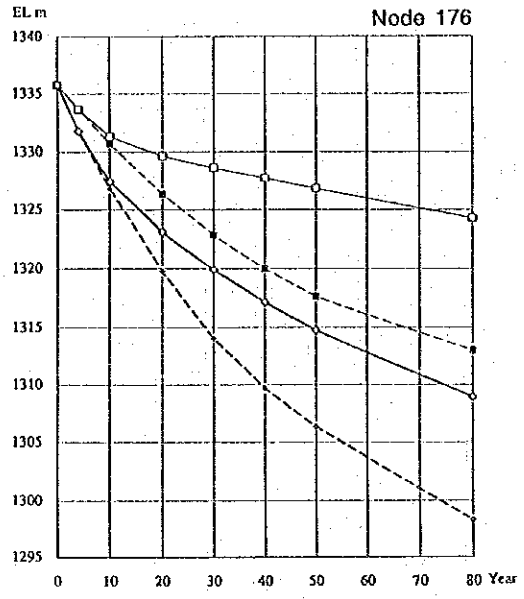


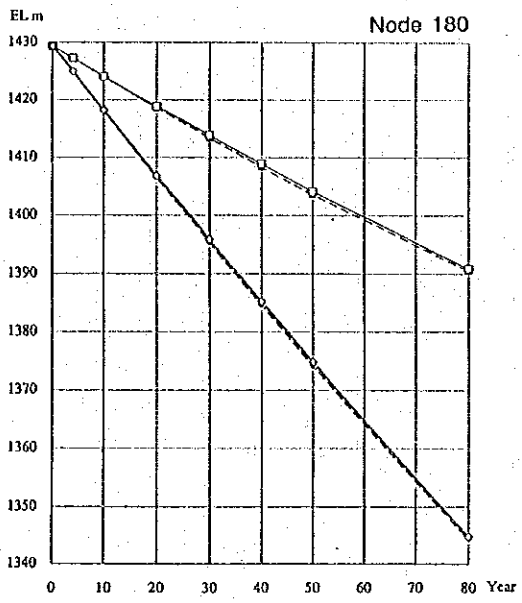

FEM Simulation Mesh aound the Shoubak Well Field

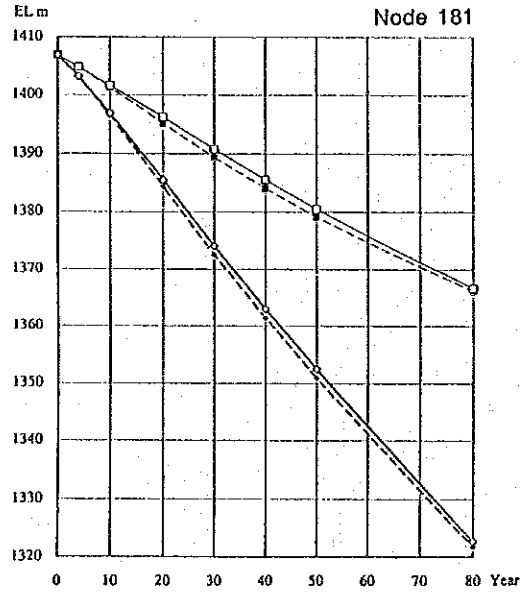



Note :

A-2 recharge dam is assumed to be constructed after 5 years.



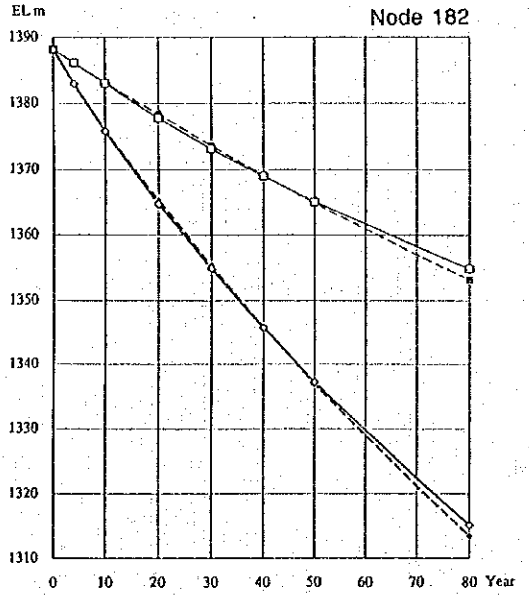




Fig.6. 7

Predicted Piezometric Levels for the Mesh Nodes in the Shoubak Area (2/3)

THE HASHEMITE KINGDOM OF JORDAN

WATER RESOURCES STUDY OF THE JAFR BASIN

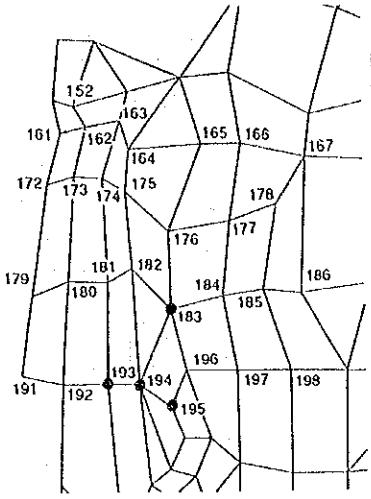
JAPAN INTERNATIONAL COOPERATION AGENCY

Case 1 — 3.27 MCM/y of abstruction without recharge dam

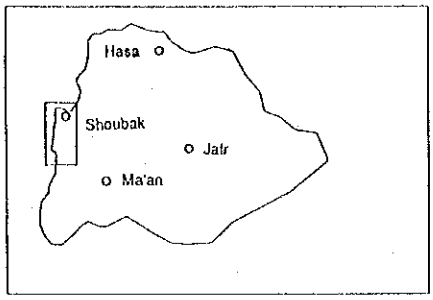
Case 2 — 3.27 MCM/y of abstruction with A-2 recharge dam

Case 3 — 6.54 MCM/y of abstruction without recharge dam

Case 4 — 6.54 MCM/y of abstruction with A-2 recharge dam

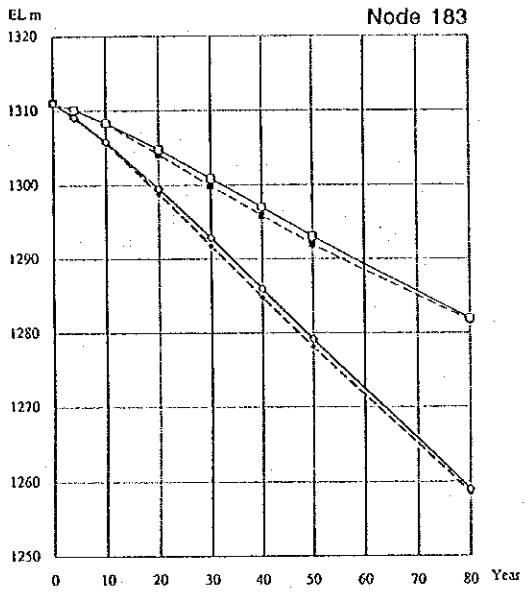


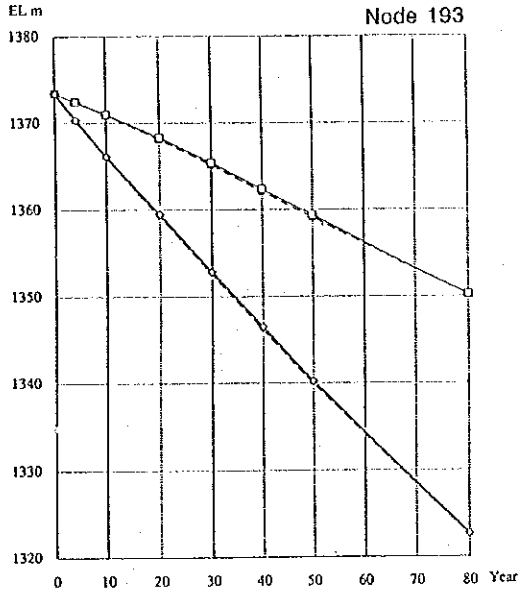

FEM Simulation Mesh aound the Shoubak Well Field

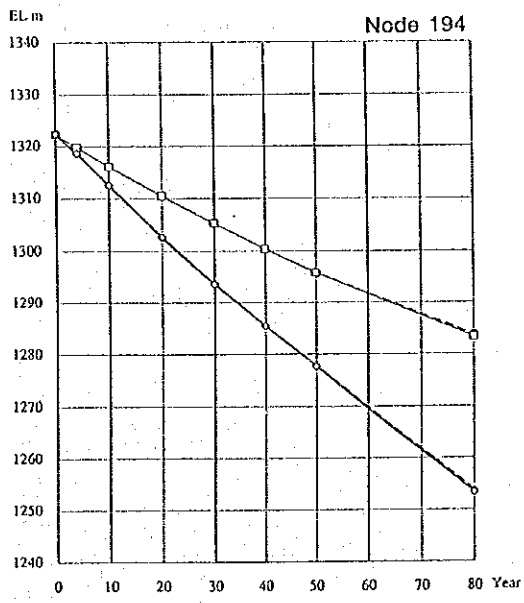



Note :

A-2 recharge dam is assumed to be constructed after 5 years.



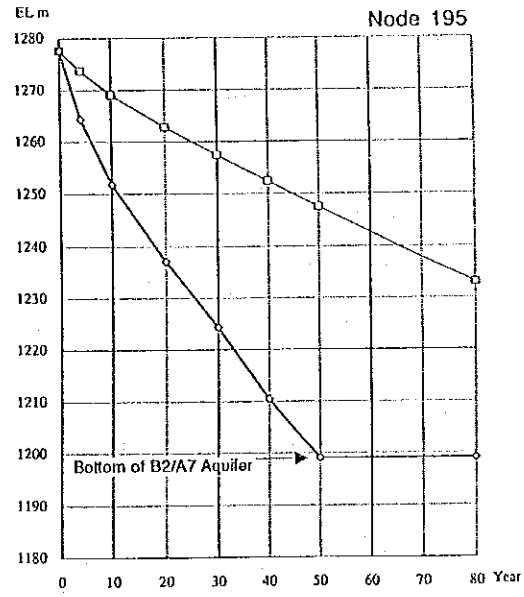




Fig.6. 8

Predicted Piezometric Levels for the Mesh Nodes in the Shoubak Area (3/3)

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