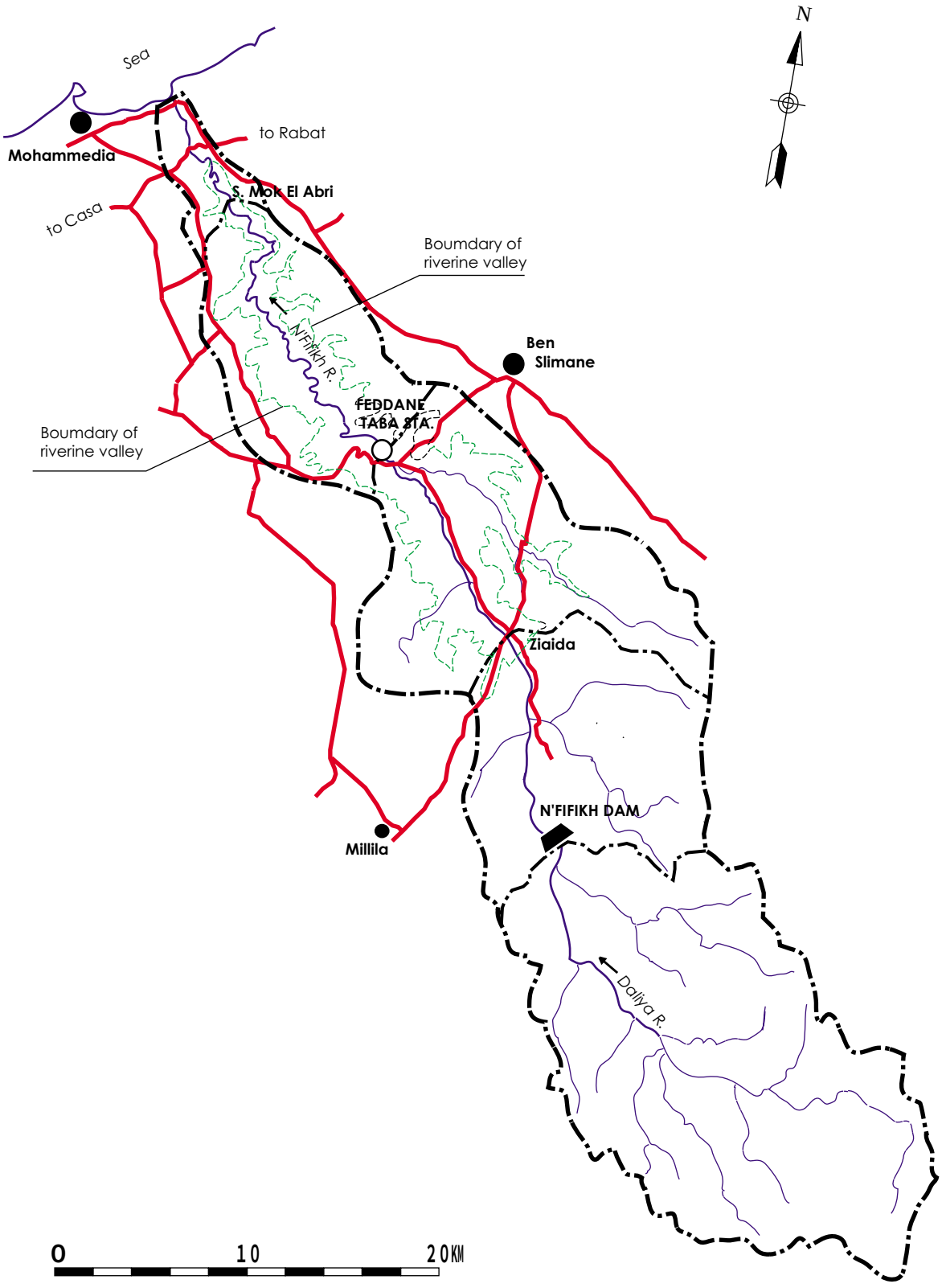
Feasibility Study on Water Resources Development in
Rural Area in the
Kingdom of Morocco
Final Report
Volume IV Supporting Report (2.A)
Feasibility Study
Supporting Report XI
Hydro-Meteorology and Hydro-Geology

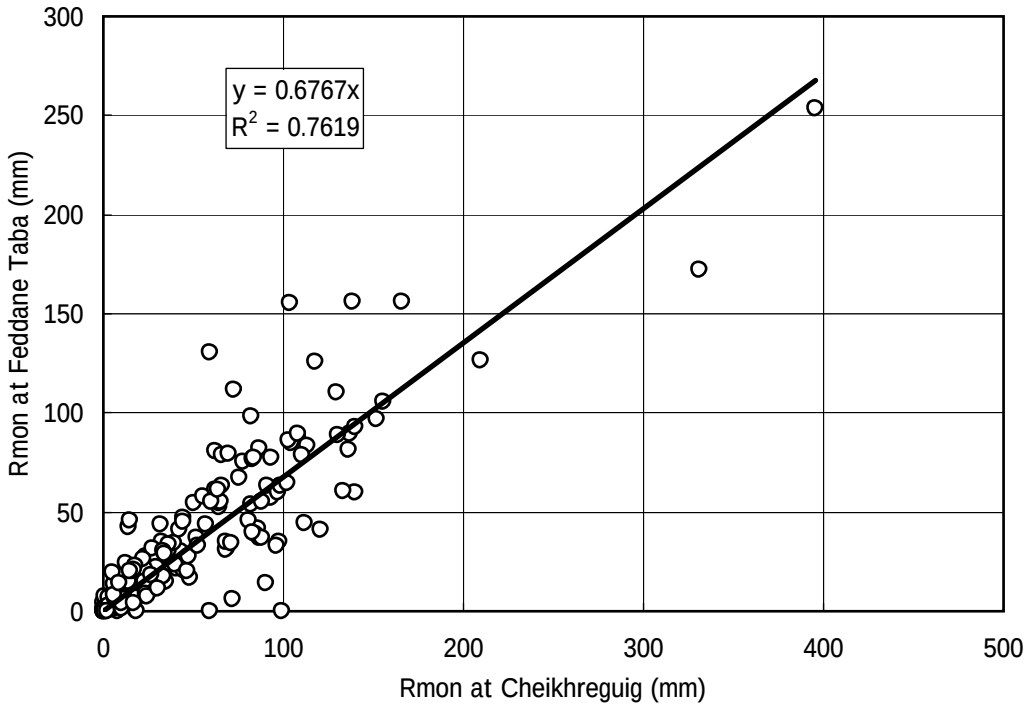
Figures

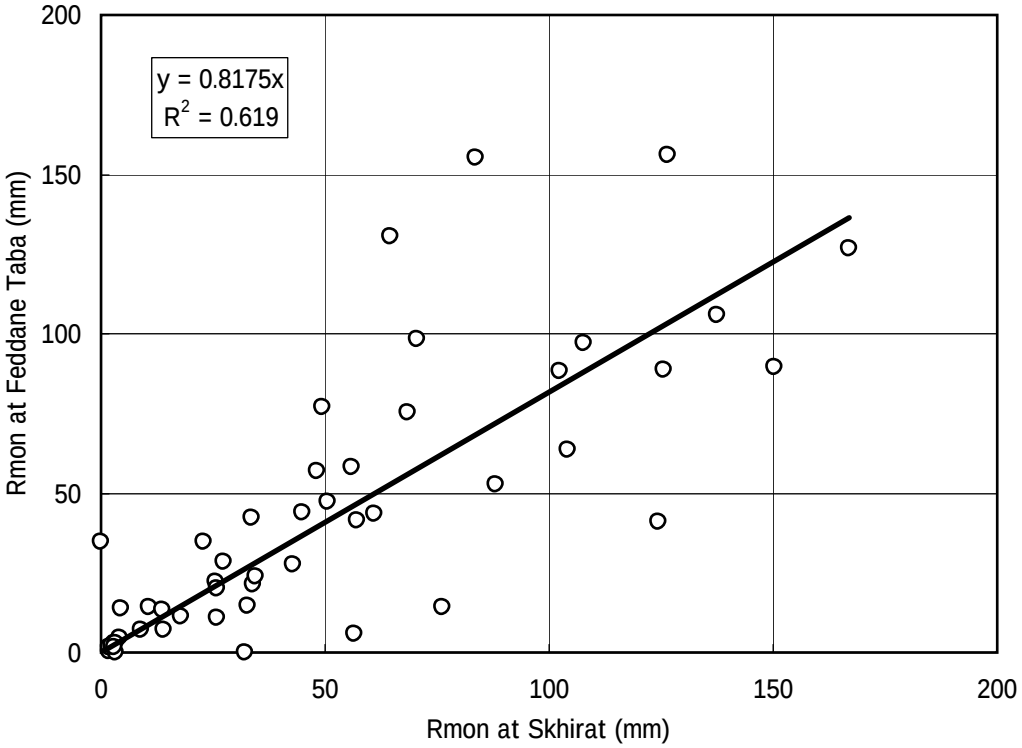


FEASIBILITY STUDY ON
WATER RESOURCES DEVELOPMENT
IN RURAL AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure XI2.1.1
General Location Map:
N'Fifikh River Basin



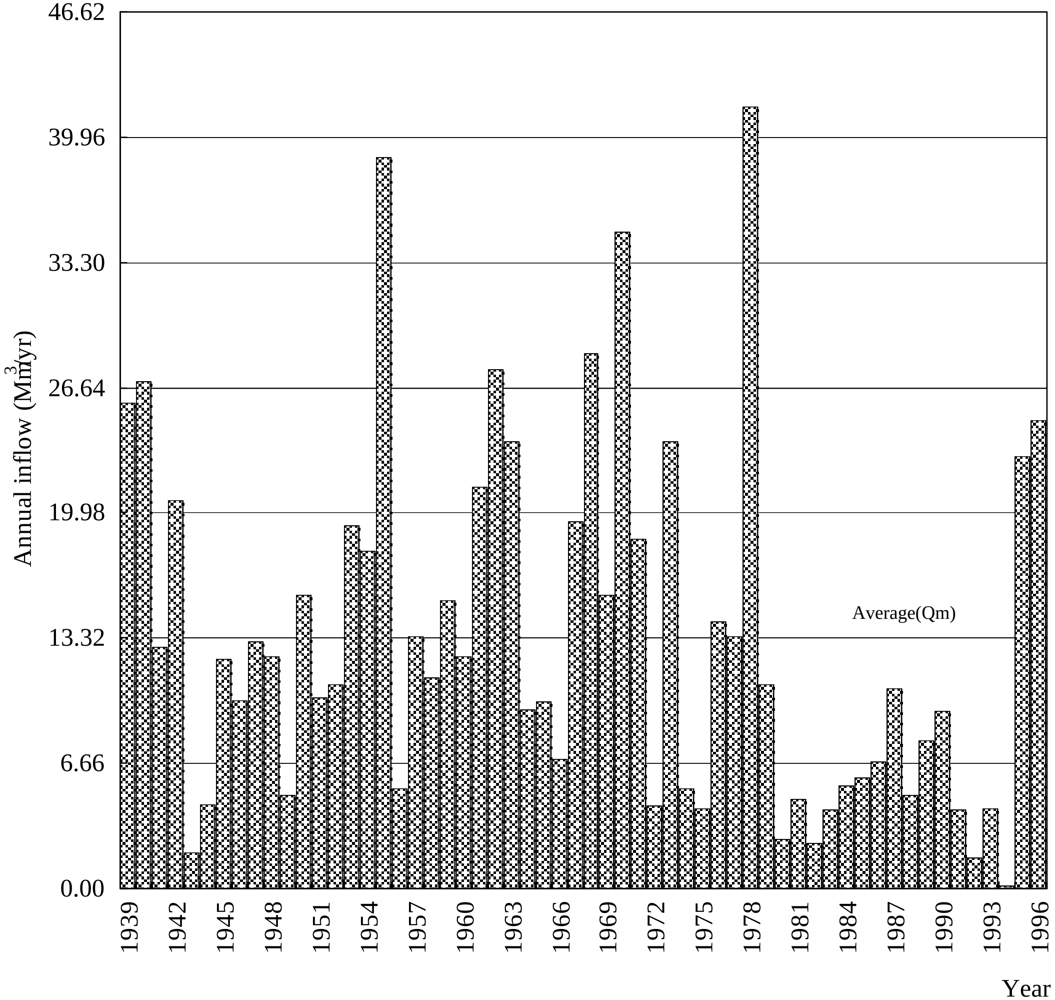


FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI2.3.1** **Correlation of Monthly Rainfall**
JAPAN INTERNATIONAL COOPERATION AGENCY	XIF-2

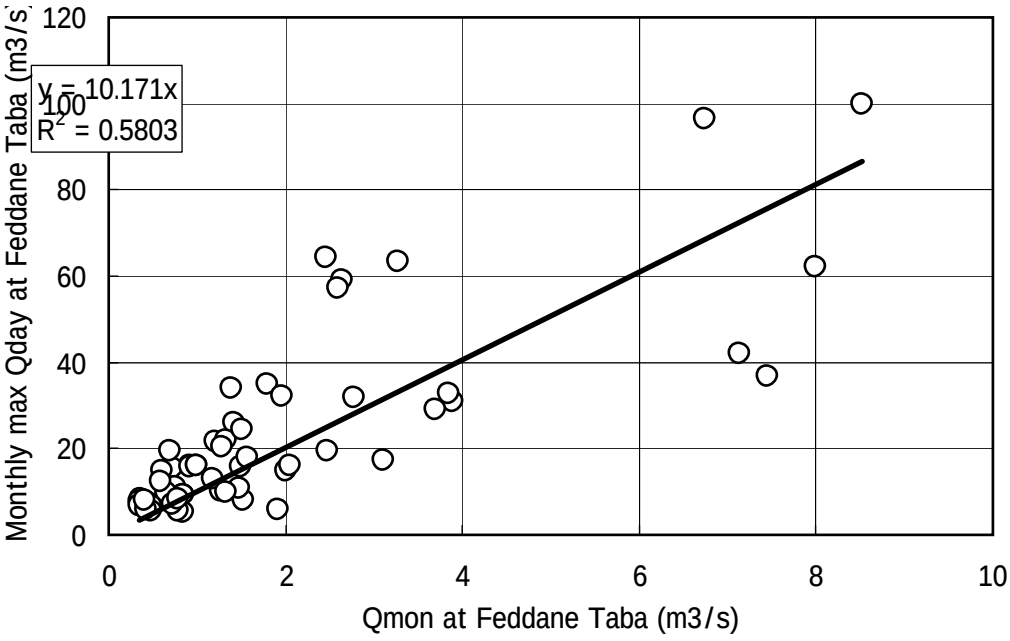
FEASIBILITY STUDY ON
WATER RESOURCES DEVELOPMENT
IN RURAL AREA

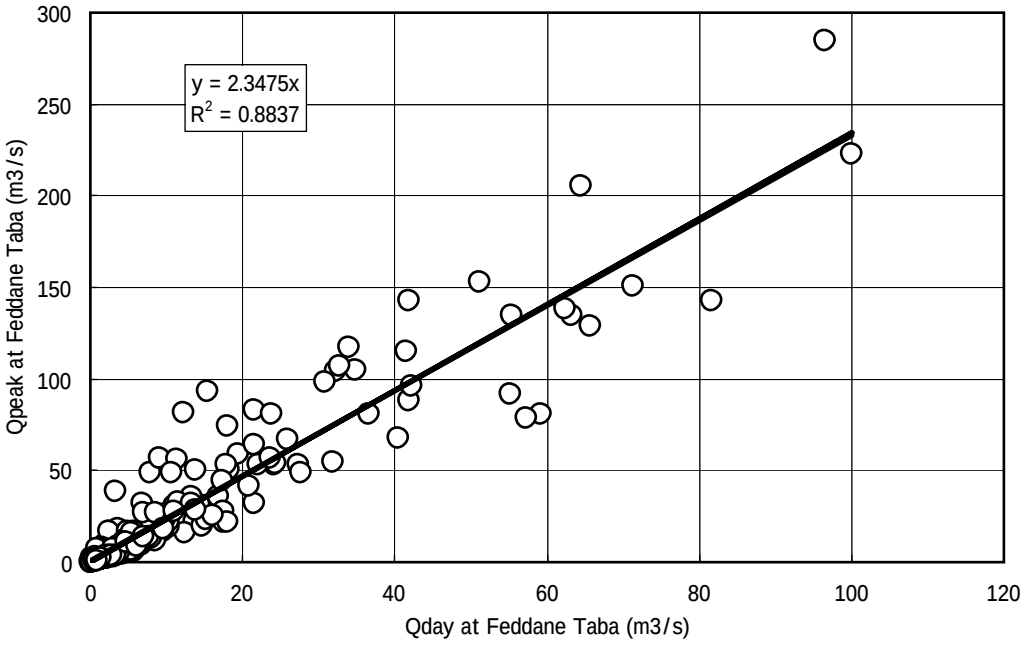
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure XI2.4.1
Annual Inflow: N'Fifikh Dam



Ratio to Qm	Total years	Frequency (yrs)	Frequency (%)
		1	2
3.0	1		
		2	3
2.5	3		
		3	5
2.0	6		
		7	12
1.5	13		
		10	17
1.0	23		
		17	29
0.5	40		
		18	31
0.0	58		





FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI2.4.2** **Discharge Correlation: Qmon, Qday, Qpeak**
JAPAN INTERNATIONAL COOPERATION AGENCY	XIF-4

JAPAN INTERNATIONAL COOPERATION AGENCY

FEASIBILITY STUDY ON
WATER RESOURCES DEVELOPMENT
IN RURAL AREA

Figure XI2.4.3
Probability Analysis By Gumbel Method

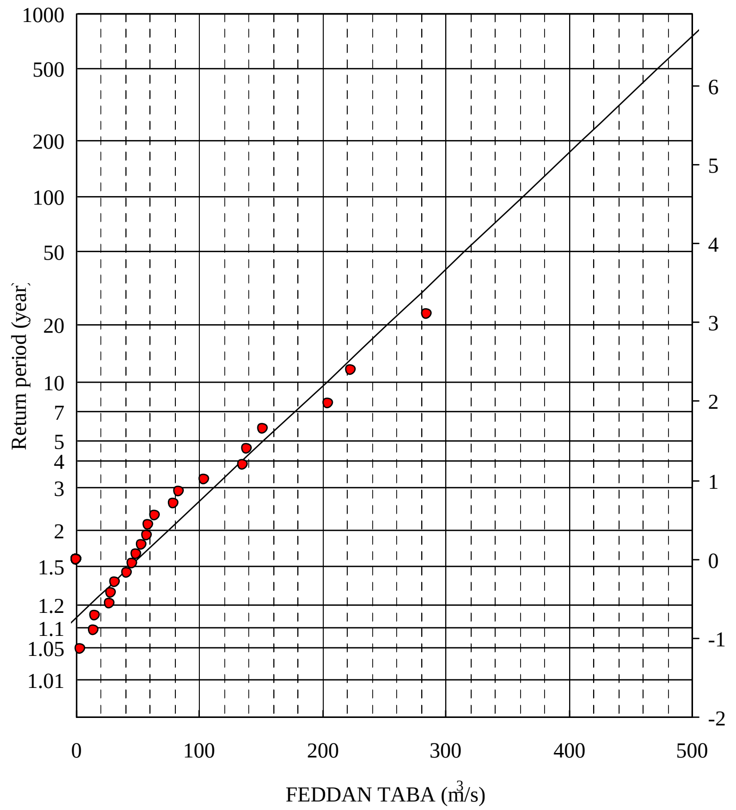
Mean = 85.90 mm

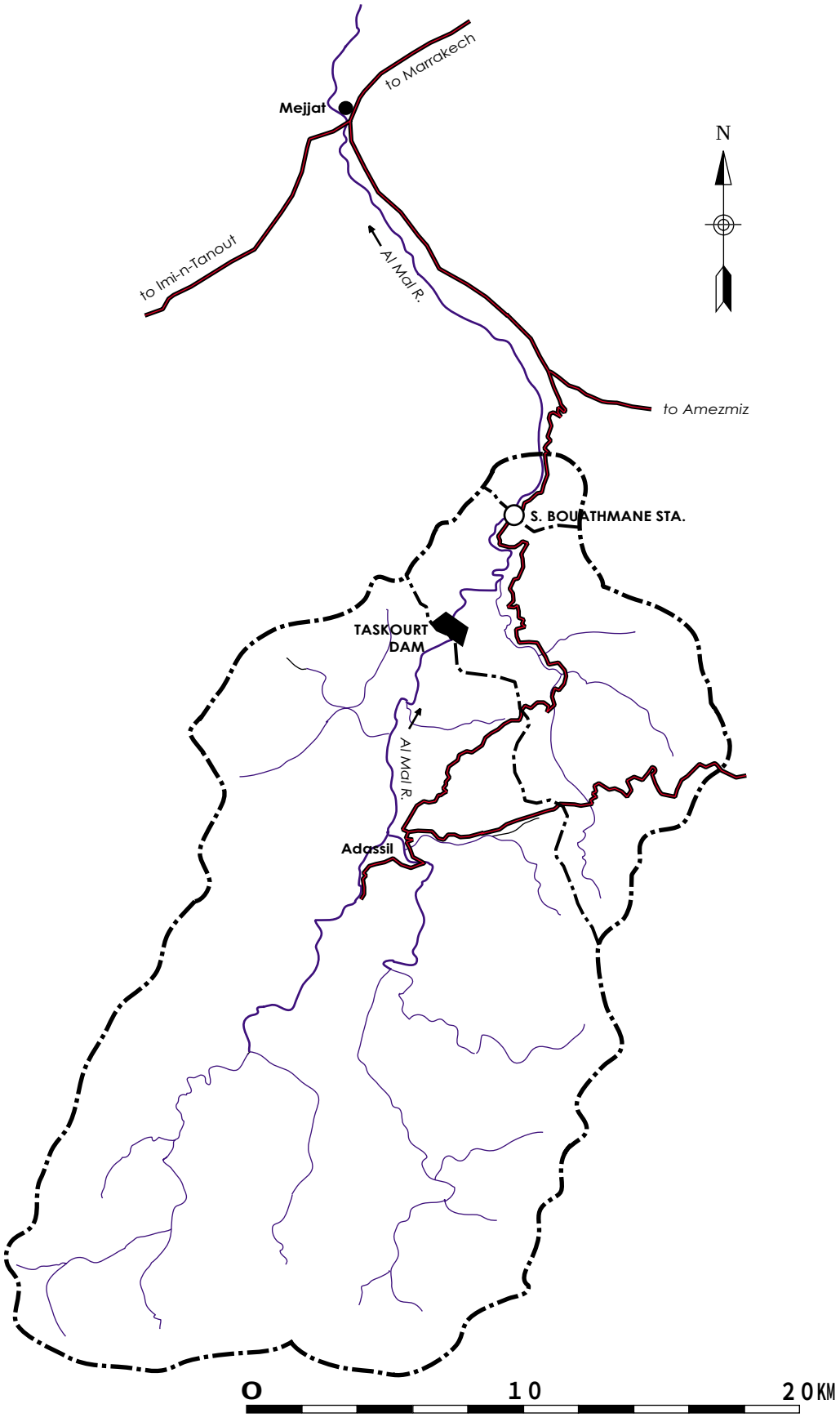
Observed data arranged in the order of magnitude		
Year	FEDDANE TABA (m^3/s)	Return period (year)
1977/78	285.0	32.27
1996/97	223.0	13.26
1984/85	205.0	10.29
1978/79	151.0	4.94
1995/96	138.0	4.17
1987/88	135.0	4.01
1986/87	104.0	2.75
1993/94	83.3	2.18
1989/90	79.0	2.08
1990/91	64.1	1.80
1985/86	58.7	1.71
1975/76	56.9	1.68
1988/89	52.9	1.62
1979/80	48.8	1.56
1976/77	45.1	1.52
1981/82	41.4	1.47
1991/92	31.2	1.36
1980/81	28.3	1.34
1983/84	26.7	1.32
1982/83	14.7	1.23
1992/93	14.3	1.22
1994/95	3.4	1.16

Calculation results	
Return period (year)	FEDDANE TABA (m^3/s)
1000	519.2
500	472.1
250	425.0
200	409.8
100	362.5
50	315.1
30	280.0
25	267.3
20	251.8
15	231.7
10	202.9
5	152.0
4	134.7
3	111.4
2	75.0
1.500	43.7
1.333	27.9
1.250	17.8
1.111	-6.5
1.071	-17.7
1.053	-24.2
1.042	-29.1
1.034	-33.3
1.020	-42.9
1.010	-53.7
1.005	-63.2
1.004	-66.0
1.002	-74.0
1.001	-81.1

PROBABILITY ANALYSIS BY GUMBEL METHOD

FEDDANE TABA

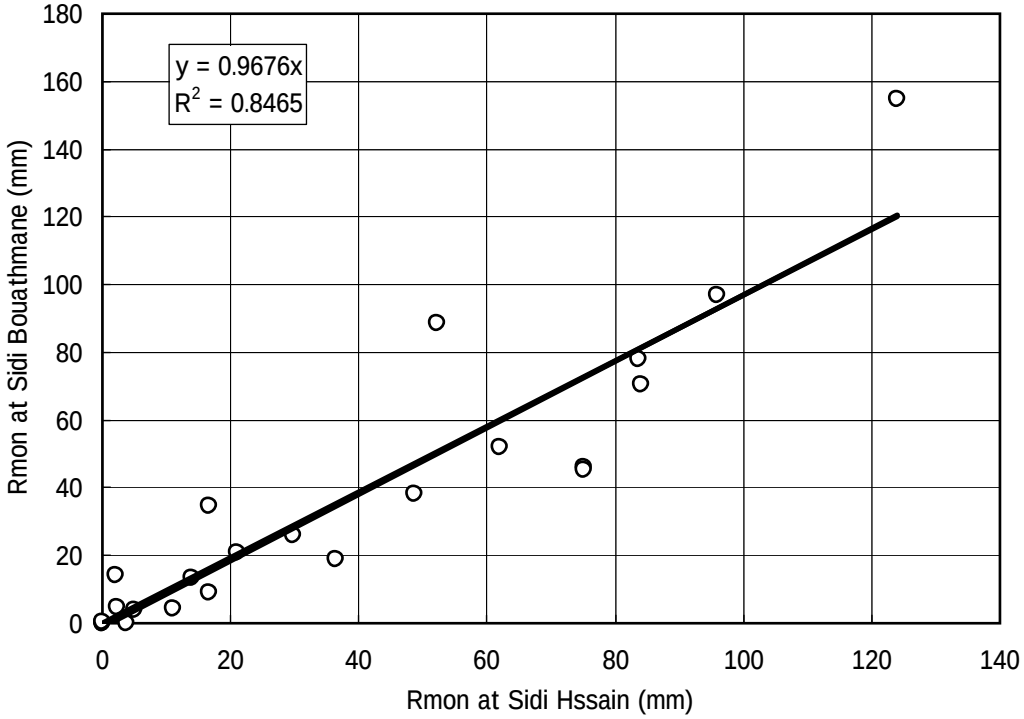


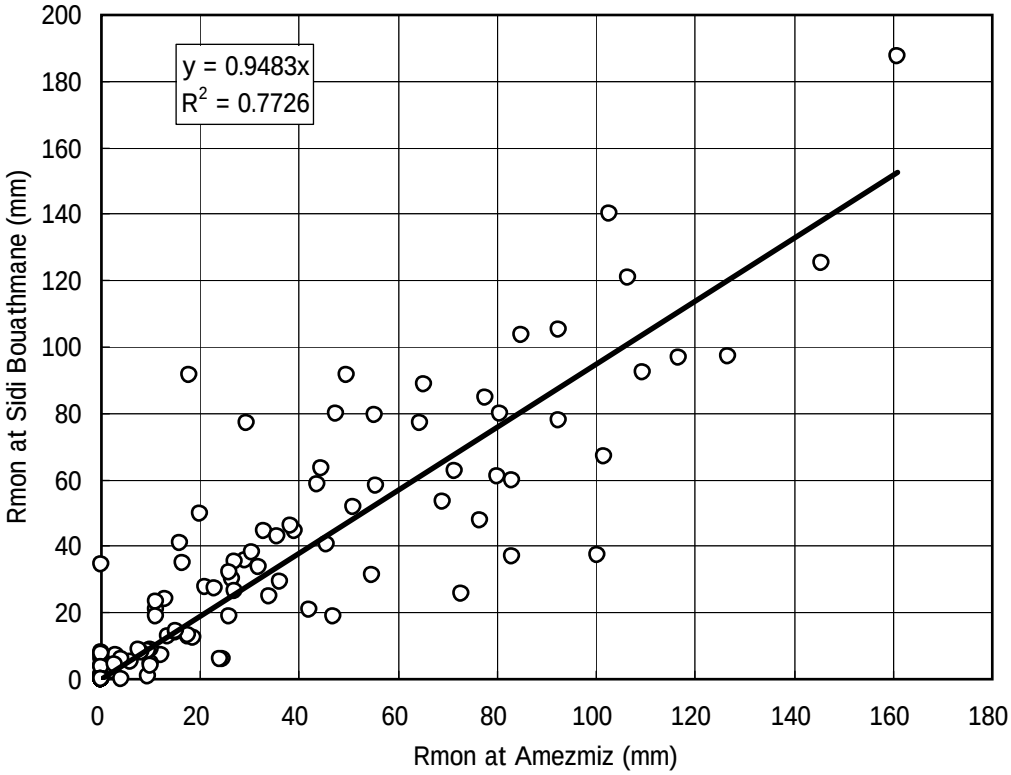


FEASIBILITY STUDY ON
WATER RESOURCES DEVELOPMENT
IN RURAL AREA

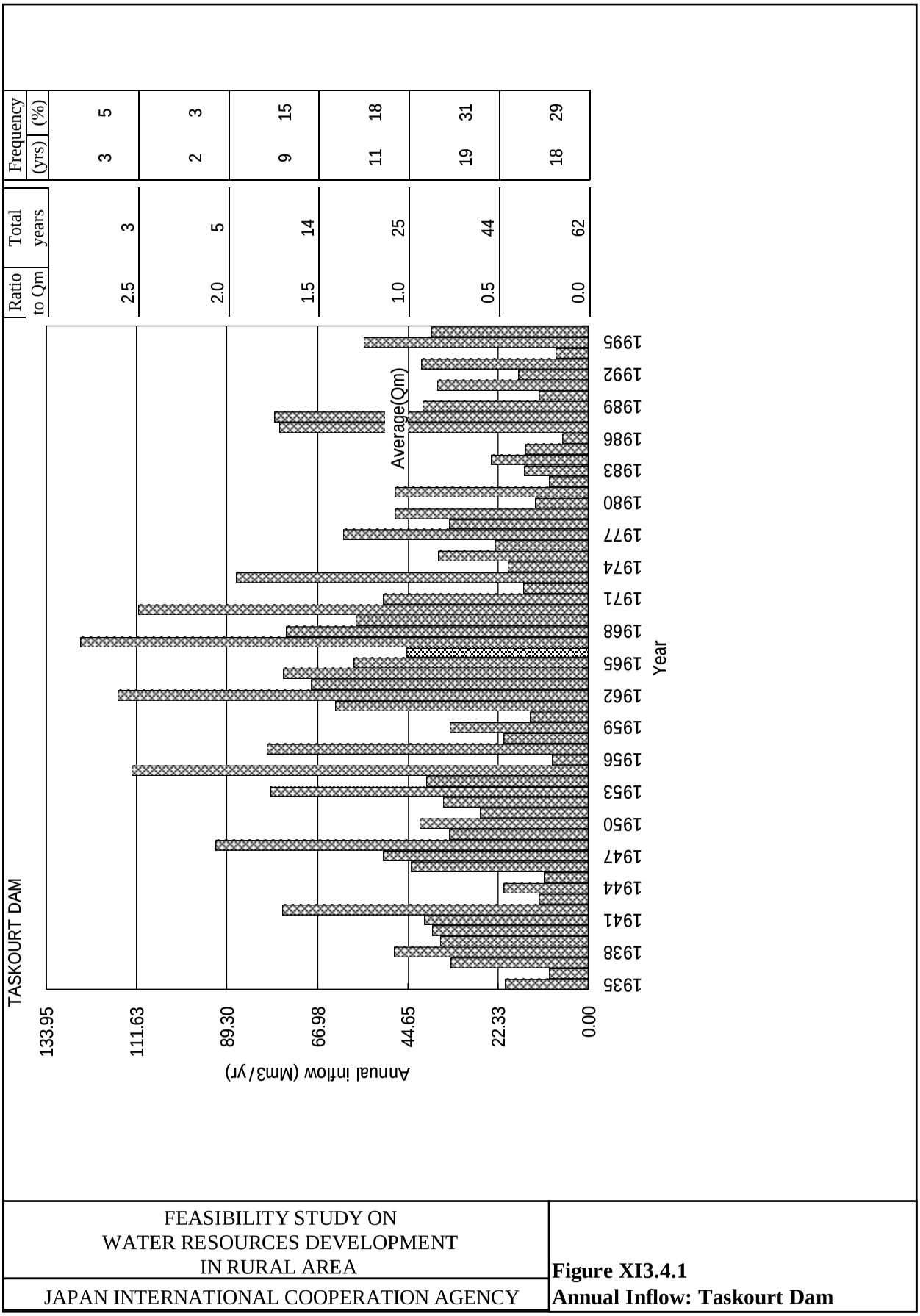
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure XI3.1.1
General Location Map:
Asif Al Mal River Basin





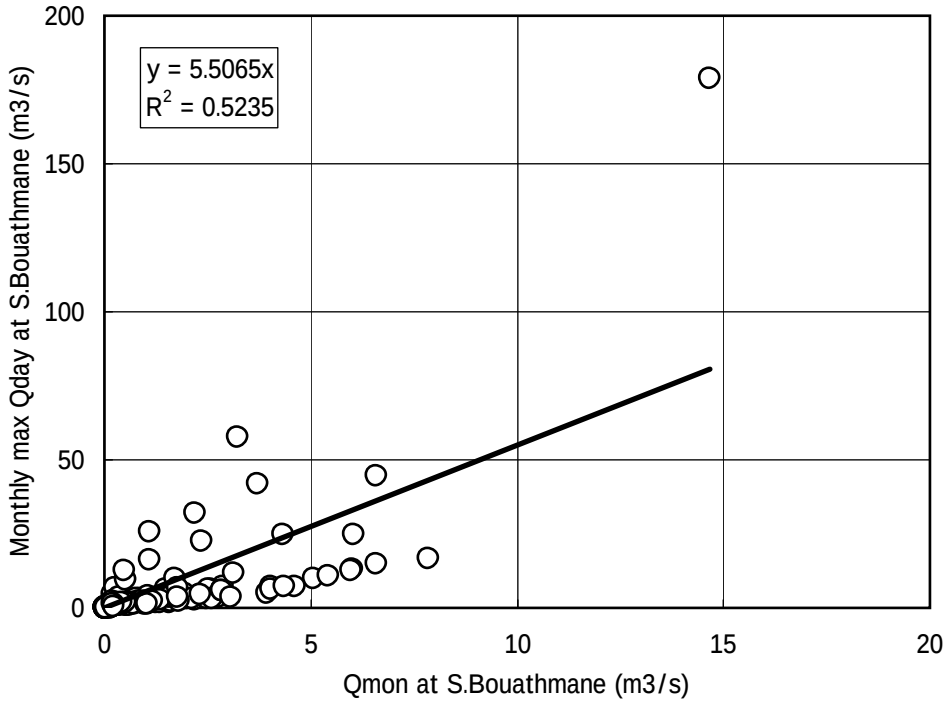
FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI3.3.1** **Correlation of Monthly Rainfall**
JAPAN INTERNATIONAL COOPERATION AGENCY	XII-7

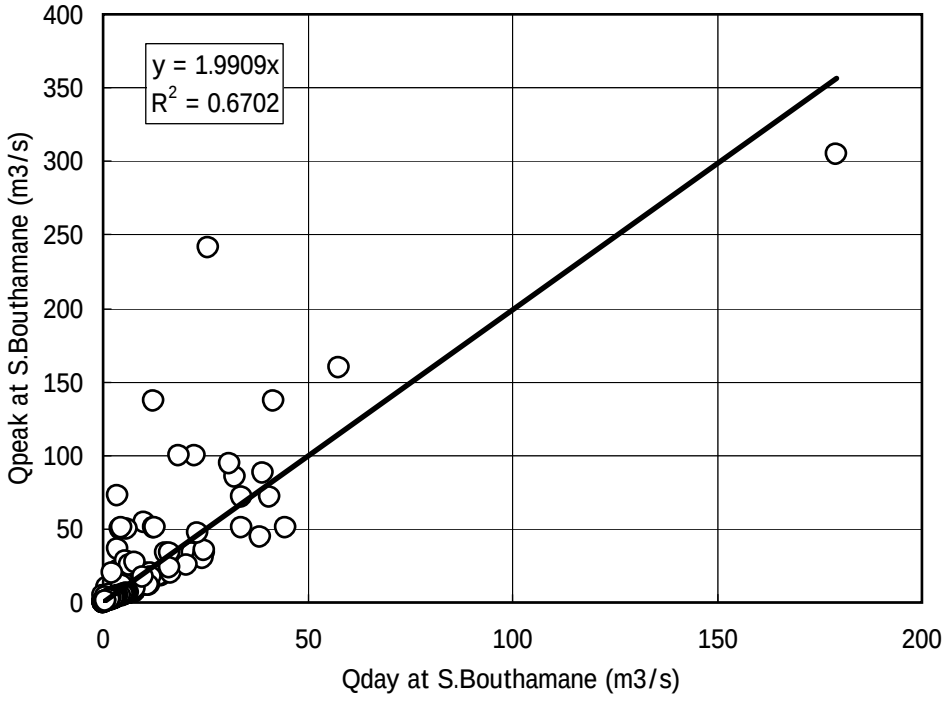


FEASIBILITY STUDY ON
WATER RESOURCES DEVELOPMENT
IN RURAL AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure XI3.4.1
Annual Inflow: Taskourt Dam





FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI3.4.2** **Discharge Correlation: Qmon, Qday, Qpeak**
JAPAN INTERNATIONAL COOPERATION AGENCY	

FEASIBILITY STUDY ON
WATER RESOURCES DEVELOPMENT
IN RURAL AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

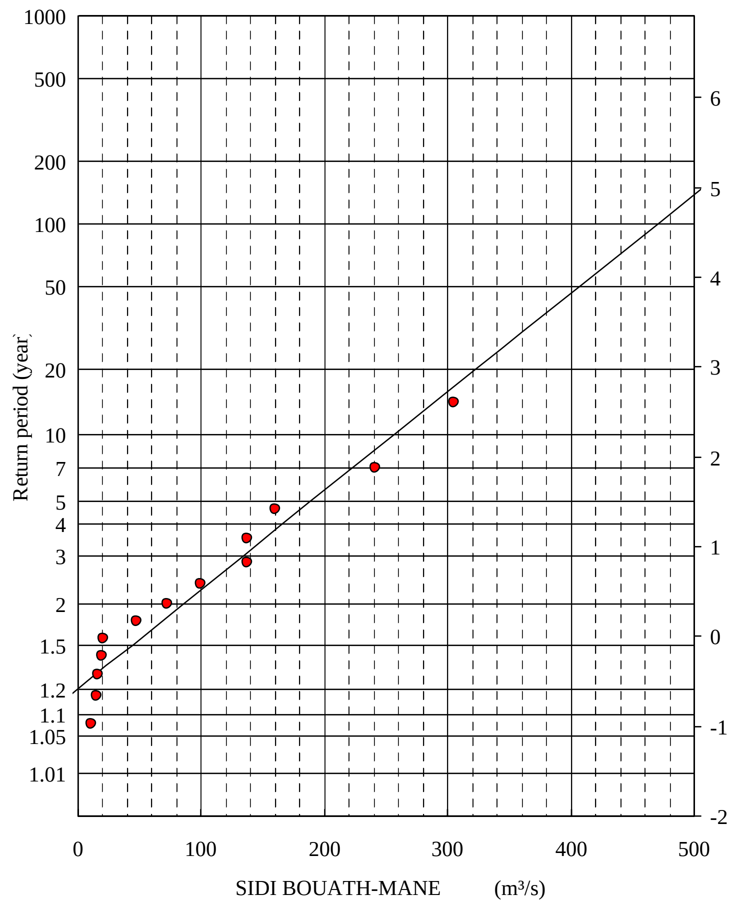
Figure XI3.4.3
Probability Anlaysis by Gumbel Method

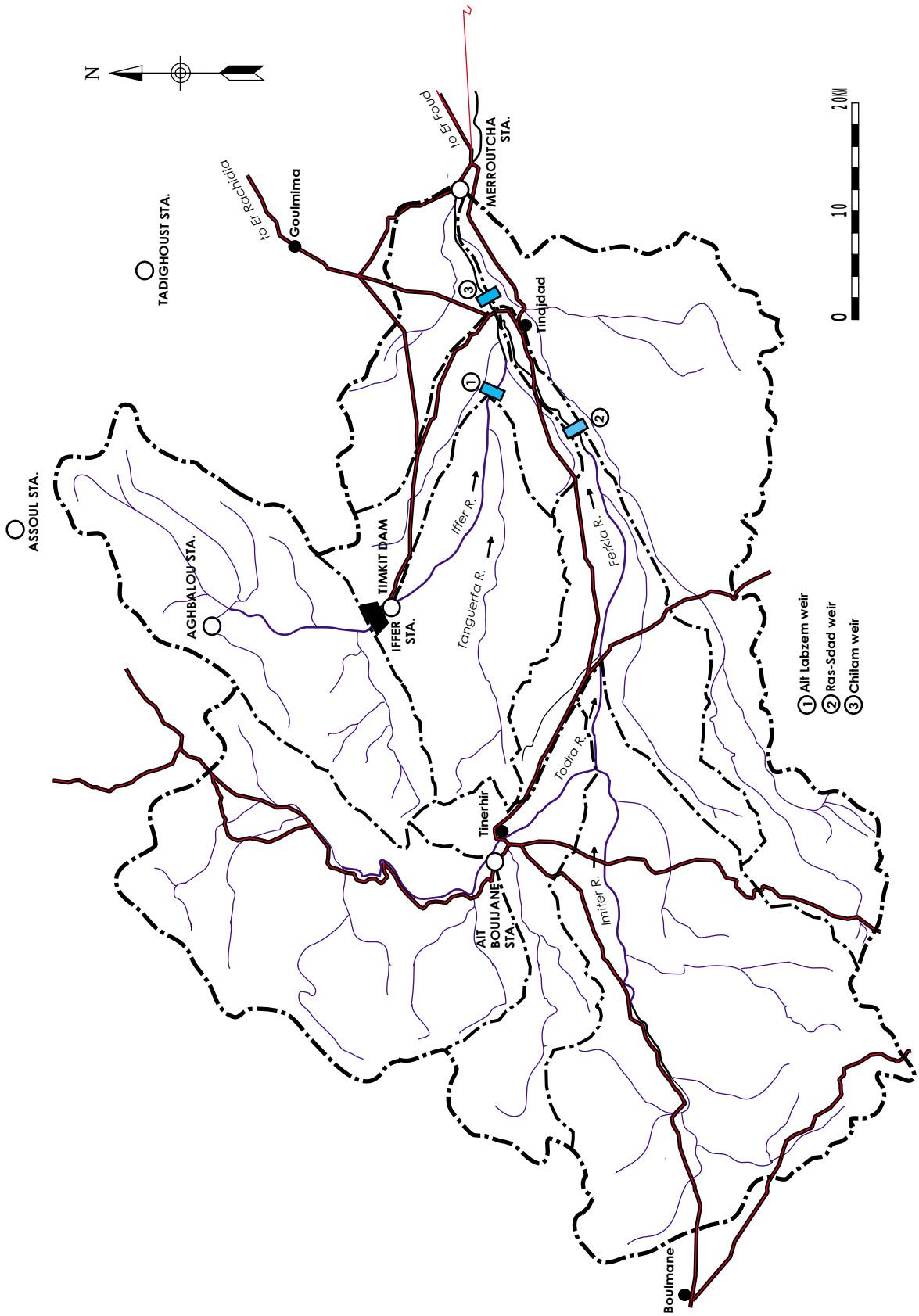
Mean = 98.66 mm

Observed data arranged in the order of magnitude		
Year	SIDI BOUATH-MANE (m³/s)	Return period (year)
1988/89	305.0	16.60
1990/91	241.0	8.47
1987/88	160.0	3.79
1989/90	137.0	3.06
1986/87	137.0	3.06
1985/86	100.0	2.23
1984/85	72.5	1.81
1991/92	47.3	1.53
1994/95	20.4	1.32
1995/96	19.5	1.31
1993/94	16.6	1.29
1996/97	15.4	1.28
1992/93	10.9	1.26

Calculation results	
Return period (year)	SIDI BOUATH-MANE (m³/s)
1000	680.0
500	617.0
250	553.9
200	533.6
100	470.4
50	407.0
30	360.0
25	343.1
20	322.4
15	295.5
10	257.0
5	188.8
4	165.8
3	134.6
2	85.9
1.500	44.1
1.333	22.9
1.250	9.4
1.111	-23.2
1.071	-38.1
1.053	-46.8
1.042	-53.3
1.034	-58.9
1.020	-71.7
1.010	-86.3
1.005	-98.9
1.004	-102.6
1.002	-113.3
1.001	-122.9

PROBABILITY ANALYSIS BY GUMBEL METHOD

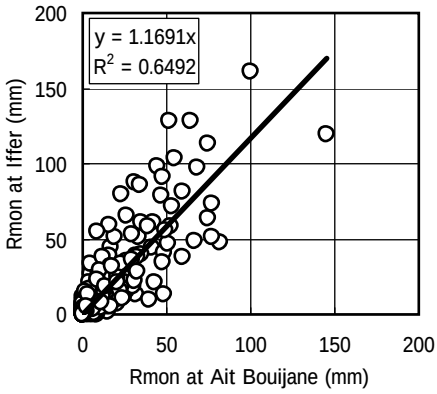


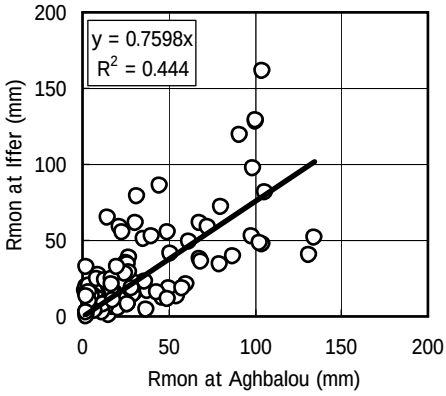


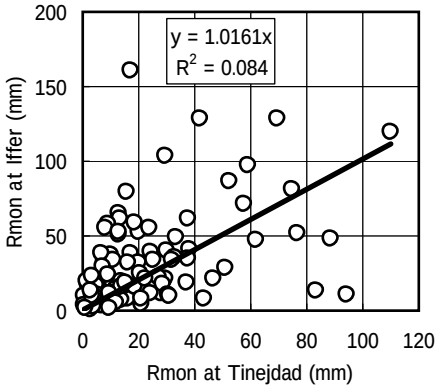
FEASIBILITY STUDY ON
WATER RESOURCES DEVELOPMENT
IN RURAL AREA

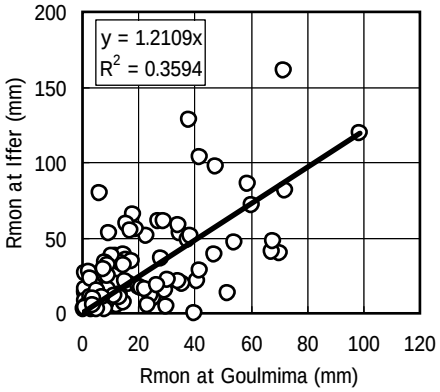
JAPAN INTERNATIONAL COOPERATION AGENCY

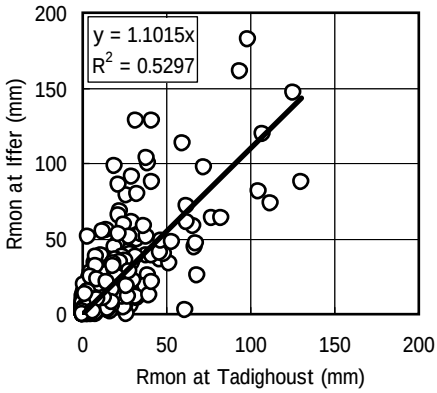
Figure XI4.1.1
General Location Map:
Ifer/Ferkla River Basin

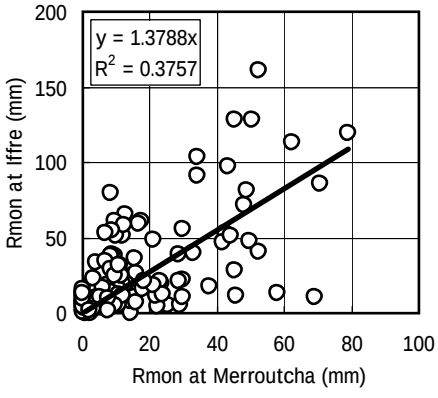




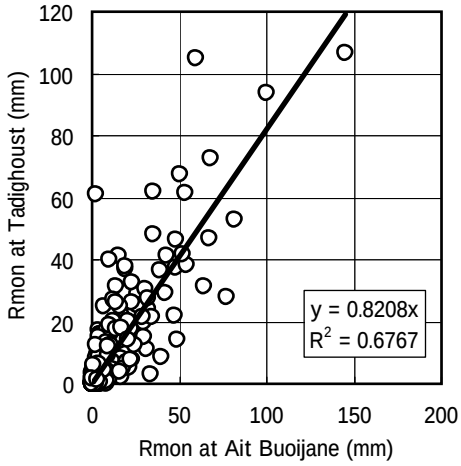


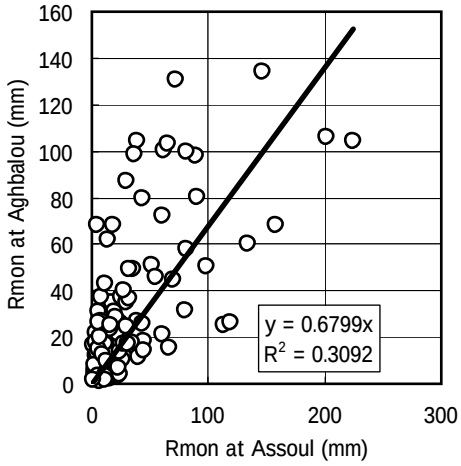


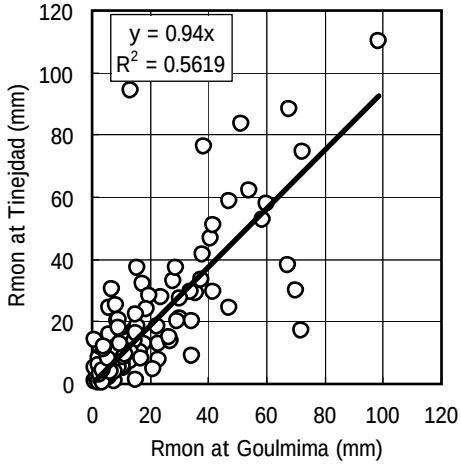


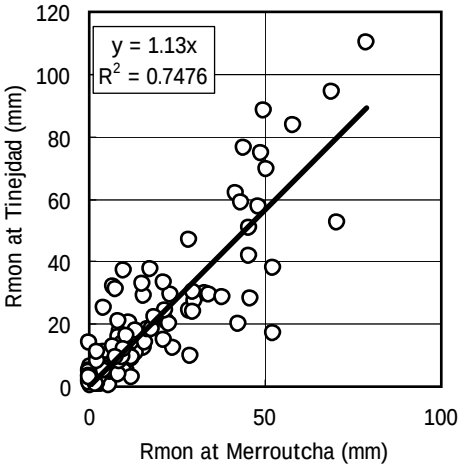


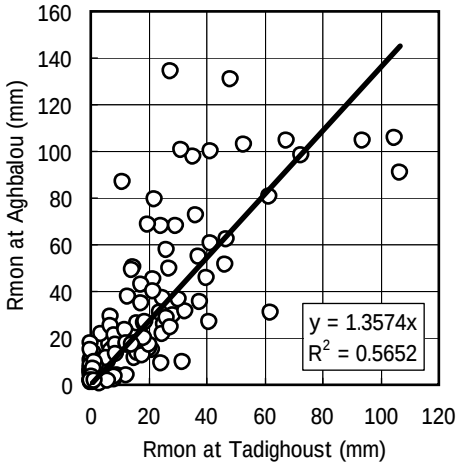
FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.3.1(1/2)** **Correlation of Monthly Rainfall**
JAPAN INTERNATIONAL COOPERATION AGENCY	

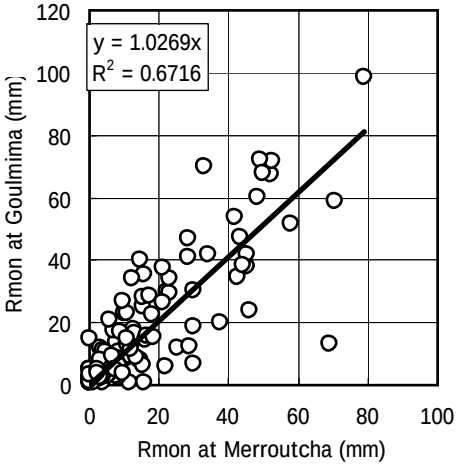




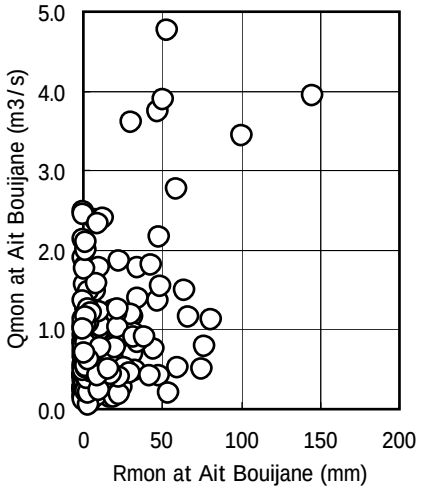


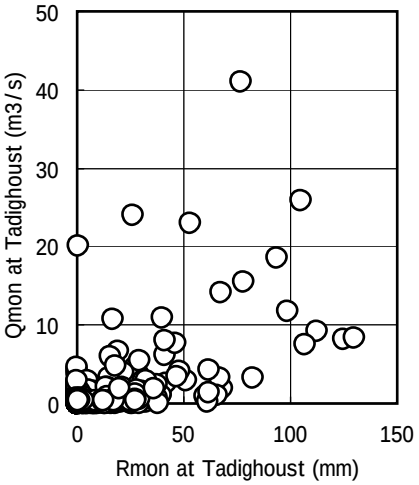


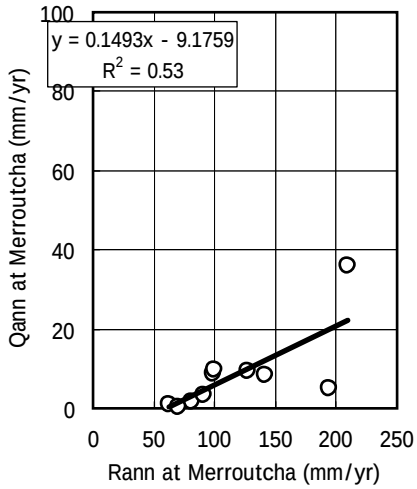


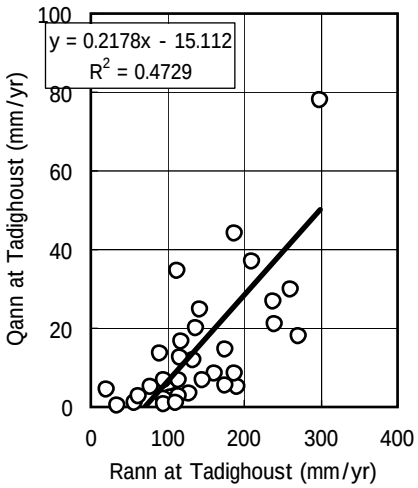


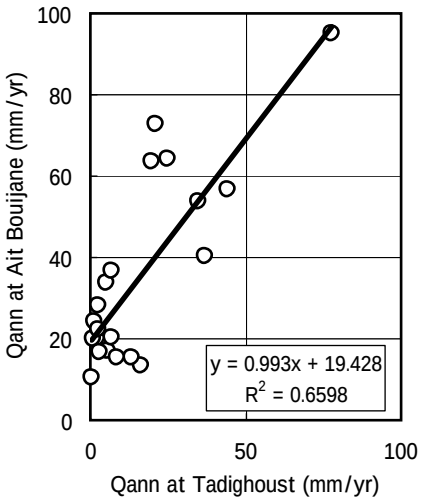
FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.3.1(2/2)** **Correlation of Monthly Rainfall**
JAPAN INTERNATIONAL COOPERATION AGENCY	

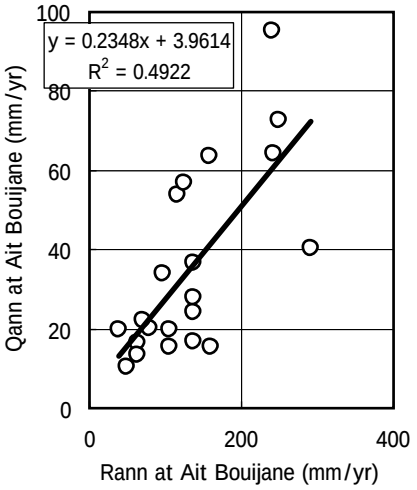




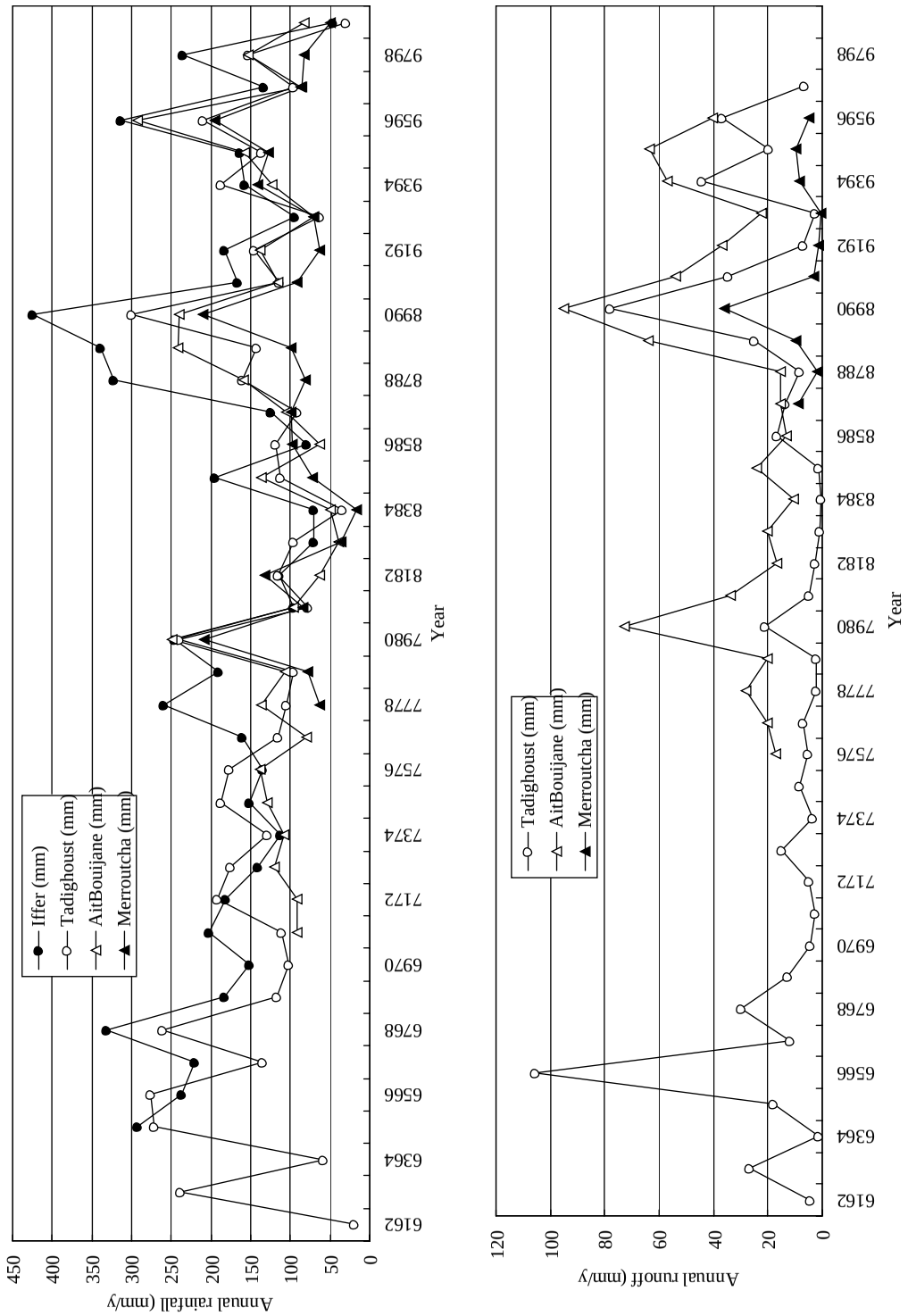




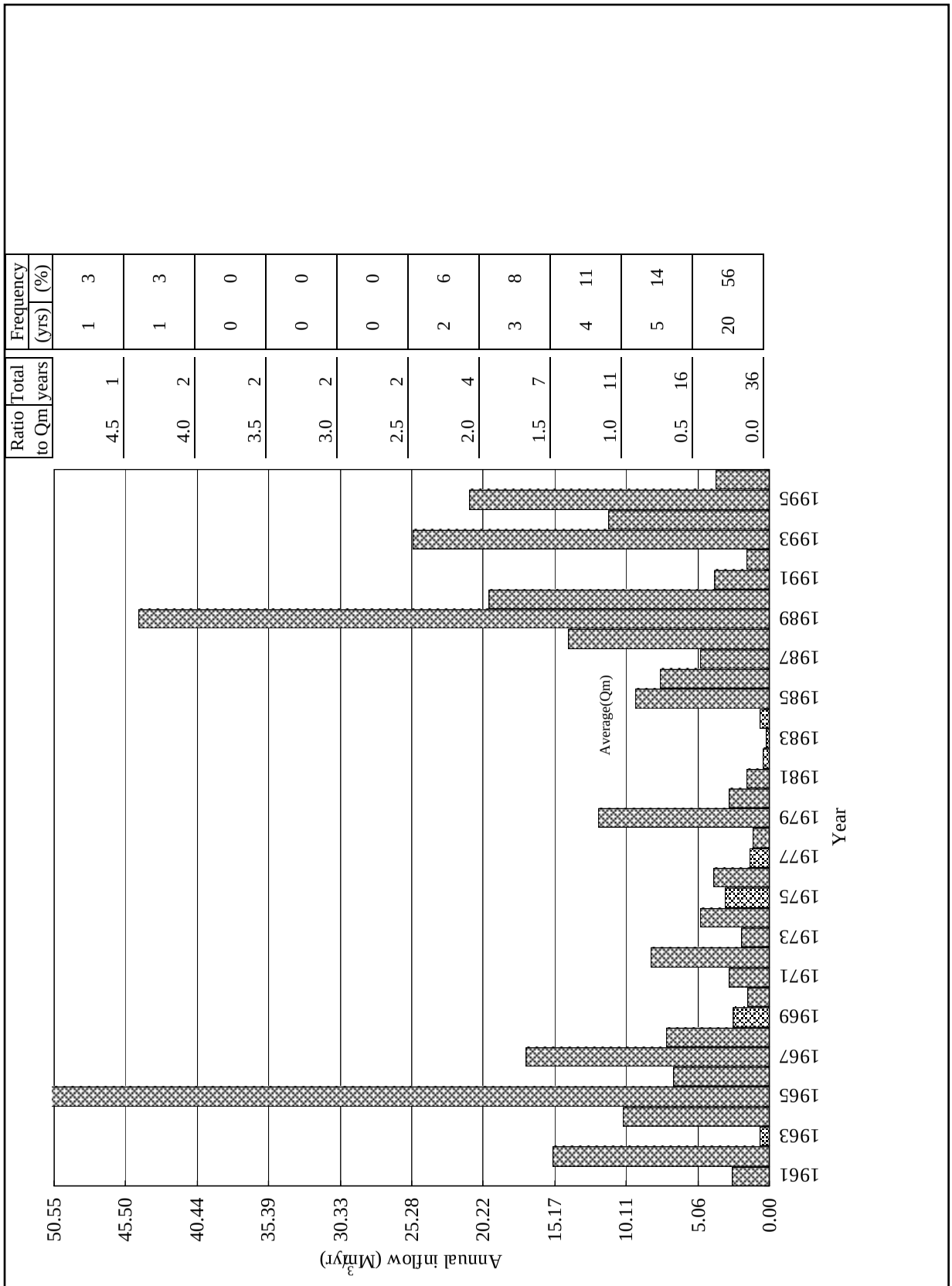




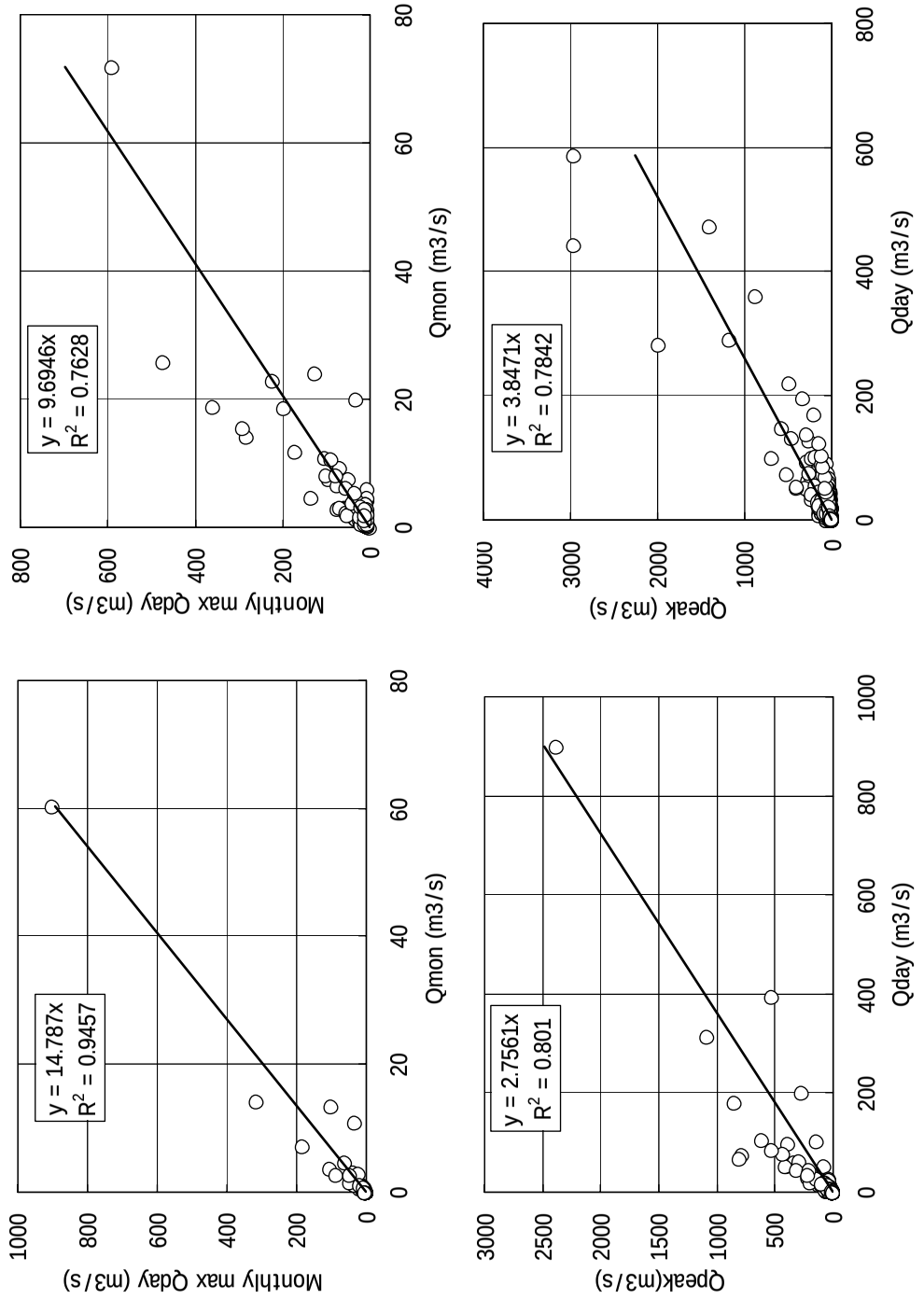
FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.4.1** **Correlation Ait Bouijane, Tadighoust and Merroutcha Stations**
JAPAN INTERNATIONAL COOPERATION AGENCY	



FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.4.2** **Comarison of Historical Rainfall and Runoff Records**
JAPAN INTERNATIONAL COOPERATION AGENCY	



FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.4.3** **Annual Inflow: Timkit Dam**
JAPAN INTERNATIONAL COOPERATION AGENCY	



FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.4.4** **Discharge Correlation: Qmon, Qday, Qpeak**
JAPAN INTERNATIONAL COOPERATION AGENCY	

JAPAN INTERNATIONAL COOPERATION AGENCY

FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA

Figure XI4.4.5 Probability Analysis by Gumbel Method

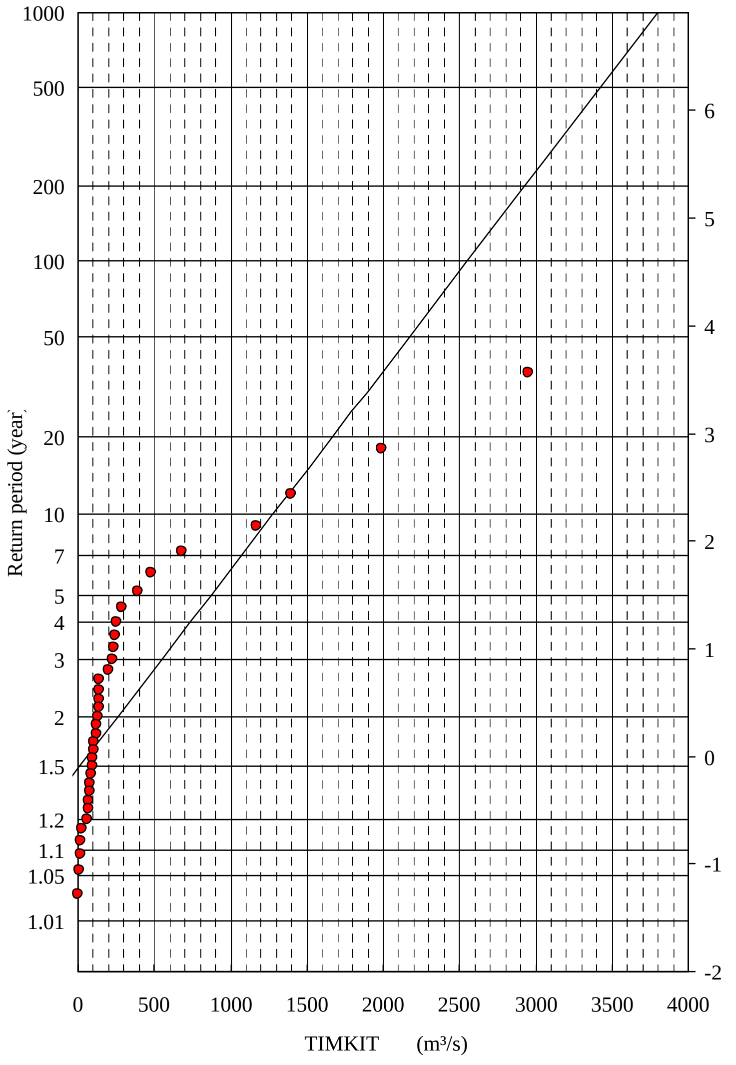
Mean = 352.80 mm

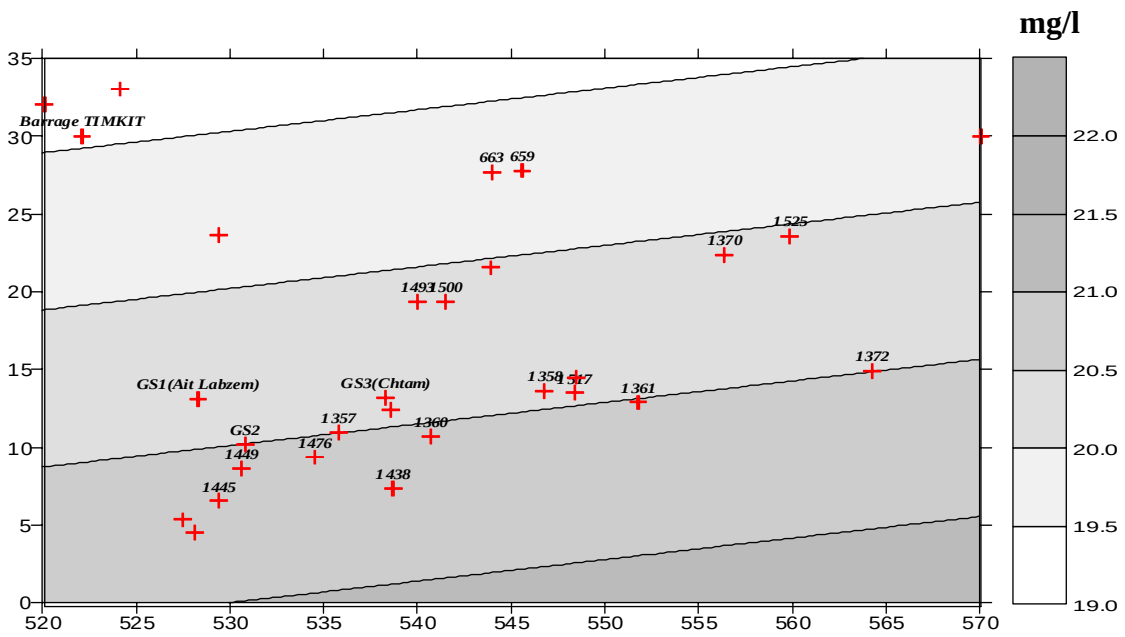
Observed data arranged in the order of magnitude		
Year	TIMKIT (m^3/s)	Return period (year)
1965/66	2950.0	209.56
1989/90	1990.0	35.93
1993/94	1400.0	12.41
1962/63	1170.0	8.29
1964/65	681.0	3.68
1995/96	480.0	2.71
1994/95	394.0	2.40
1979/80	292.0	2.09
1986/87	253.0	1.99
1974/75	242.0	1.96
1972/73	233.0	1.94
1990/91	230.0	1.93
1967/68	202.0	1.86
1978/79	140.0	1.73
1997/98	139.0	1.73
1992/93	138.0	1.73
1987/88	137.0	1.72
1988/89	129.0	1.71
1984/85	121.0	1.69
1991/92	118.0	1.69
1963/64	108.0	1.67
1971/72	103.0	1.66
1977/78	97.8	1.65
1985/86	97.5	1.65
1976/77	86.1	1.63
1961/62	79.0	1.61
1981/82	74.9	1.61
1970/71	66.8	1.59
1969/70	66.8	1.59
1975/76	59.2	1.58
1973/74	22.2	1.52
1966/67	21.5	1.52
1980/81	19.6	1.52
1968/69	6.0	1.49
1996/97	0.5	1.49

Calculation results	
Return period (year)	TIMKIT (m^3/s)
1000	3796.2
500	3421.1
250	3045.6
200	2924.7
100	2548.5
50	2170.8
30	1890.9
25	1790.4
20	1666.9
15	1506.6
10	1277.6
5	871.8
4	734.4
3	548.8
2	258.8
1.500	9.7
1.333	-116.4
1.250	-196.8
1.111	-390.7
1.071	-479.3
1.053	-531.6
1.042	-570.4
1.034	-603.6
1.020	-679.9
1.010	-766.5
1.005	-841.7
1.004	-863.9
1.002	-927.7
1.001	-984.7

PROBABILITY ANALYSIS BY GUMBEL METHOD

TIMKIT

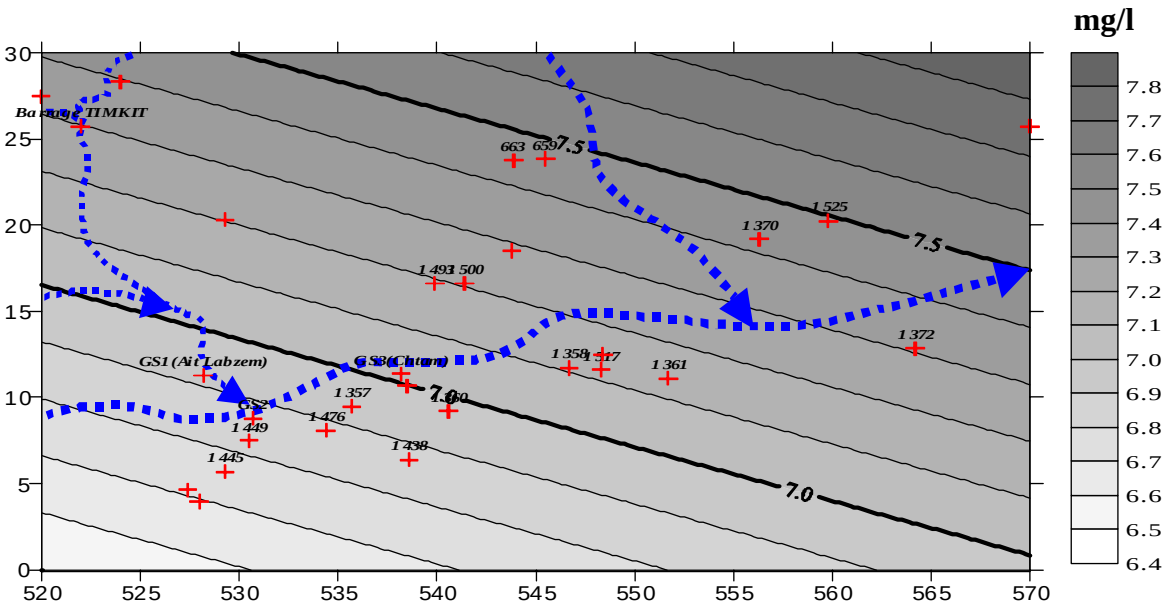




Legend

- Monitoring Well by DRH
- Observed Well in this study
- Observed at nearby the Well
- Oued Course
- Barrage Site

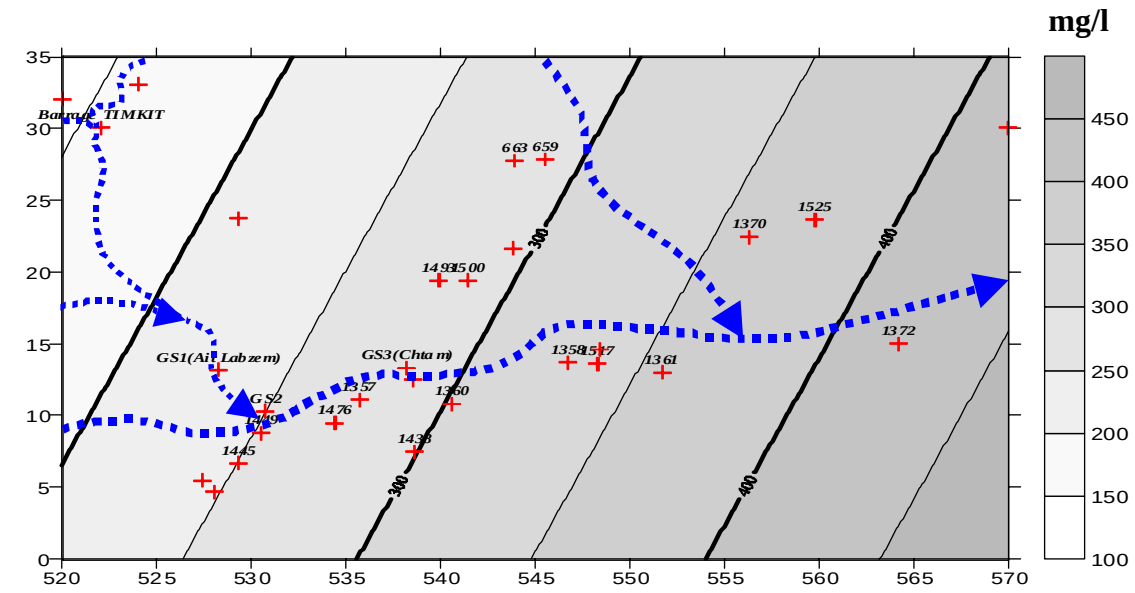
FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure XI4.7.1** **Contour of Temperature of Groundwater**



Legend

- Monitoring Well by DRH
- Observed Well in this study
- Observed at nearby the Well
- Oued Course
- Barrage Site

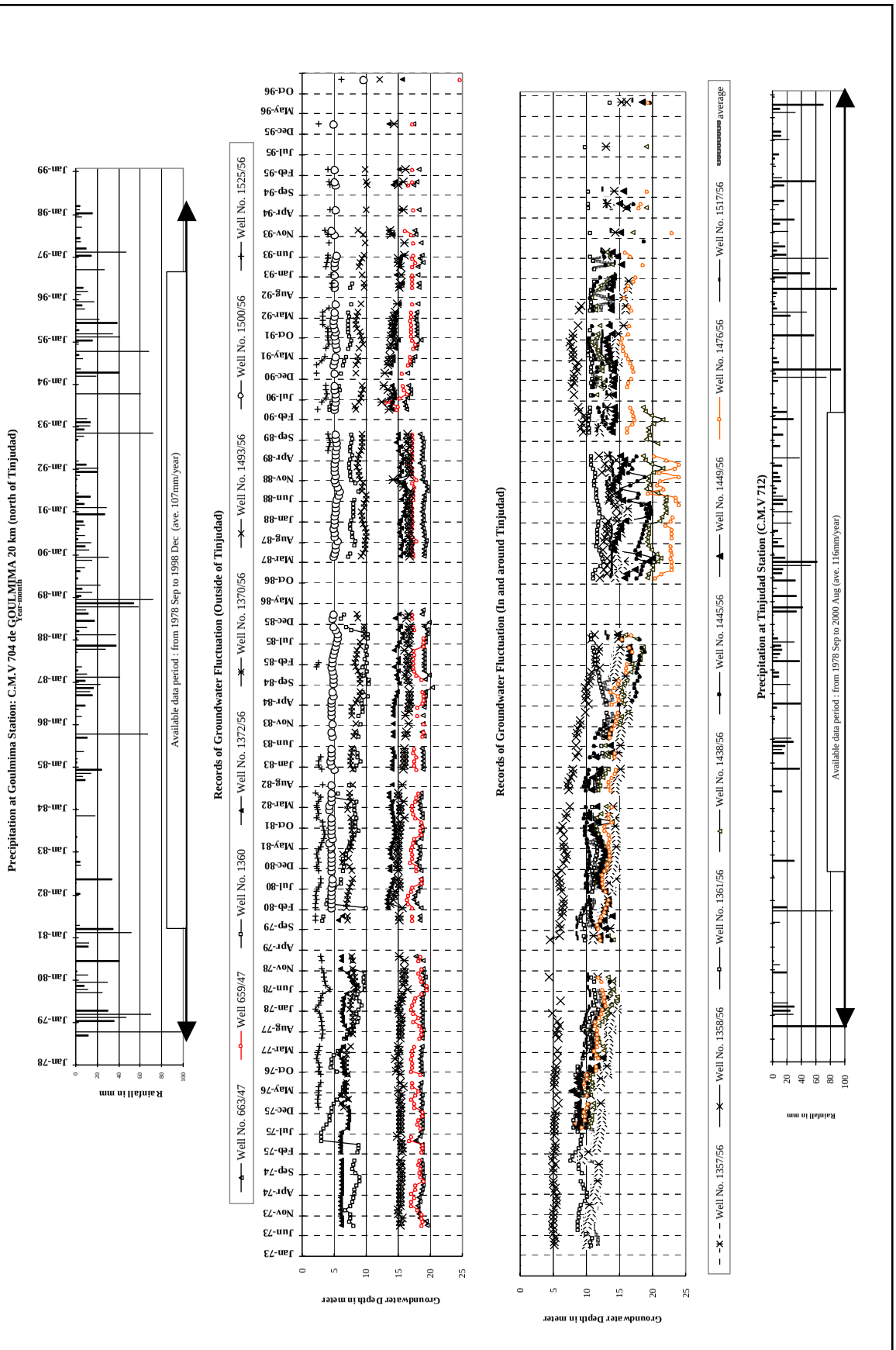
FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.7.2** **Contour of pH of Groundwater**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Legend

- Monitoring Well by DRH
- Observed Well in this study
- Observed at nearby the Well
- Oued Course
- Barrage Site

FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.7.3** **Electrical Conductivity of Groundwater (mS/m)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



FEASIBILITY STUDY ON
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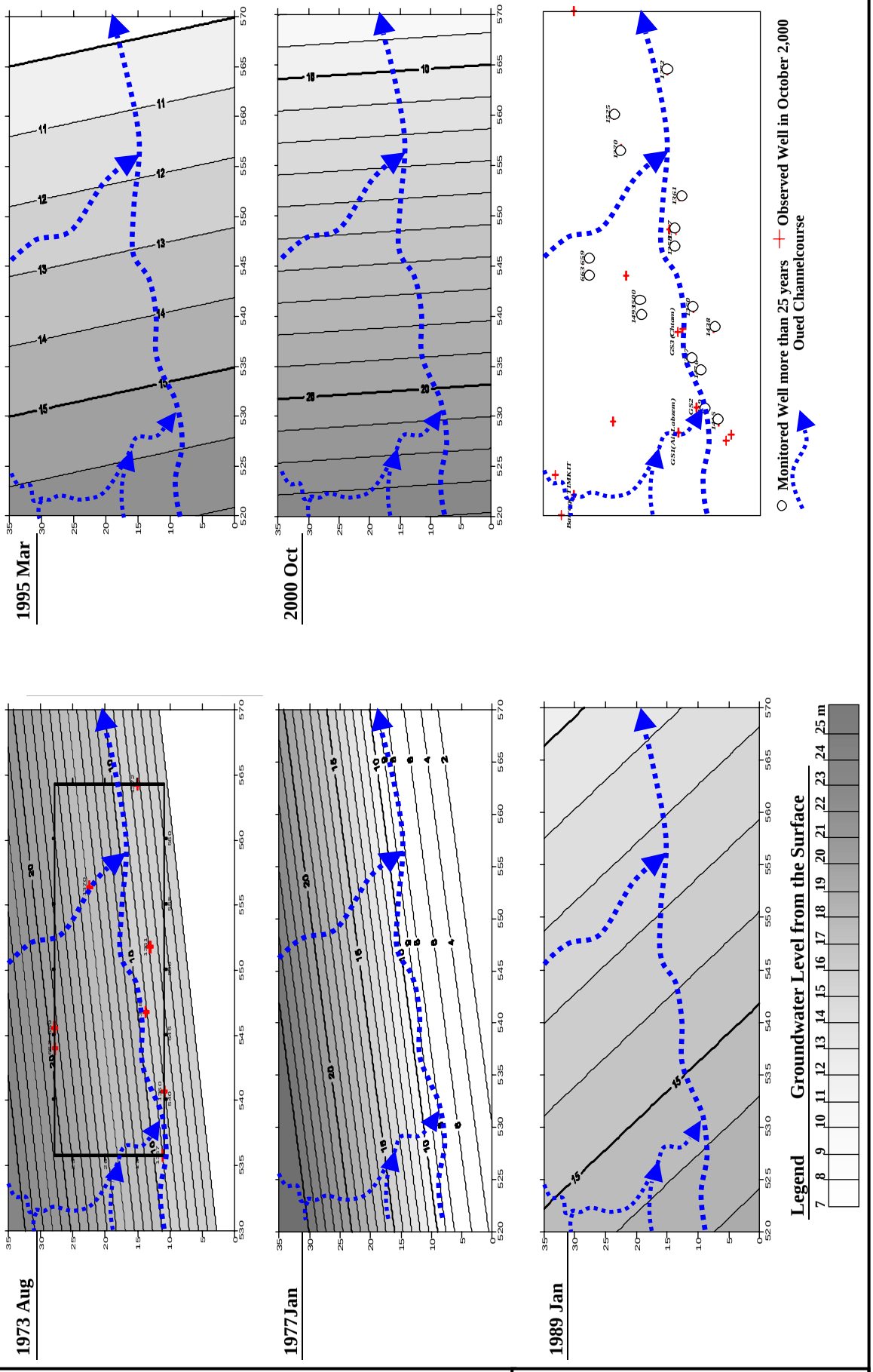
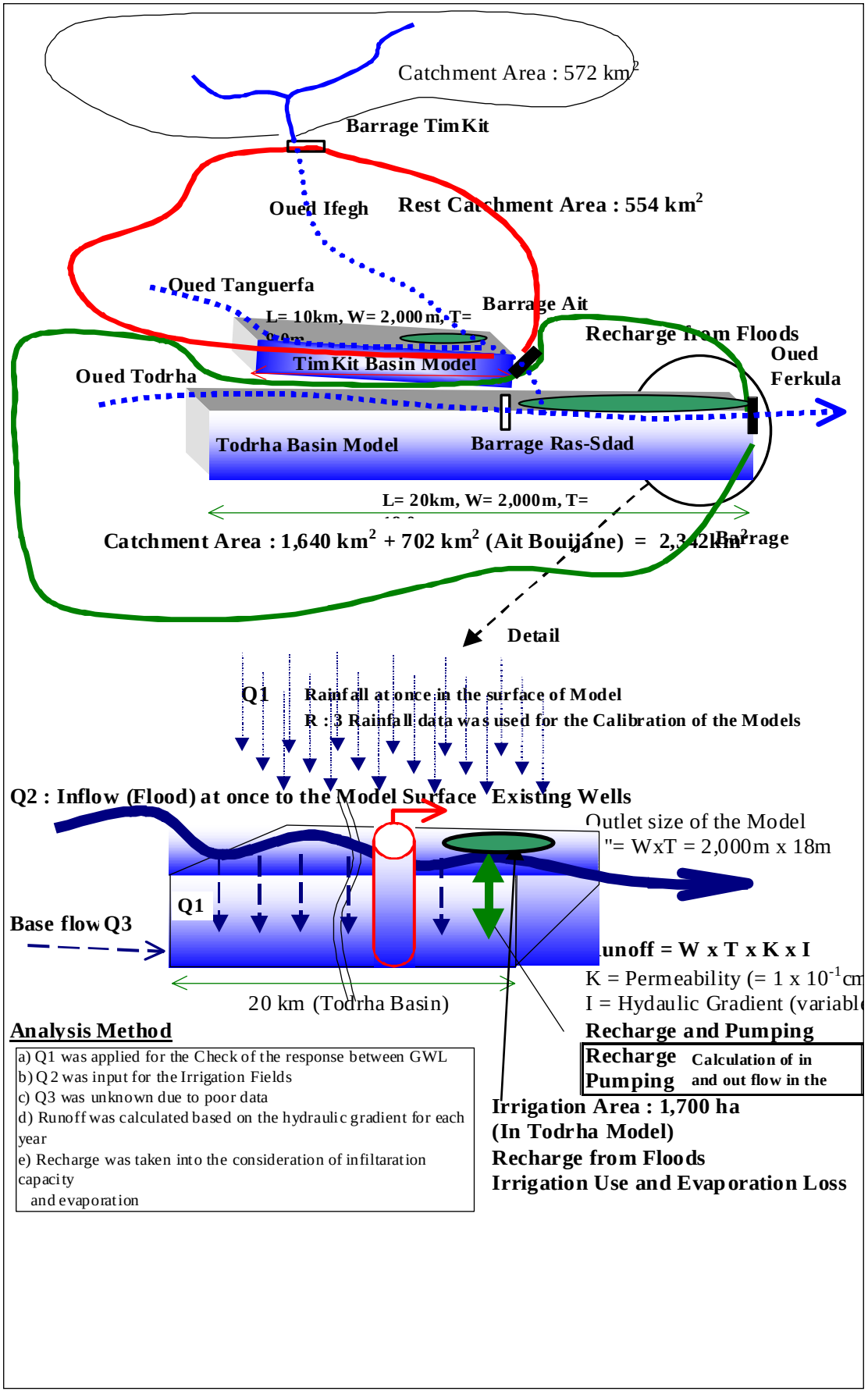
Figure XI4.7.4
Relation between Precipitation data and Groundwater Level Fluctuation since 1973



FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.7.5** **Groundwater Contour Map since 1973**
JAPAN INTERNATIONAL COOPERATION AGENCY	



FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.7.6** **Concept of Groundwater Analysis**
JAPAN INTERNATIONAL COOPERATION AGENCY	

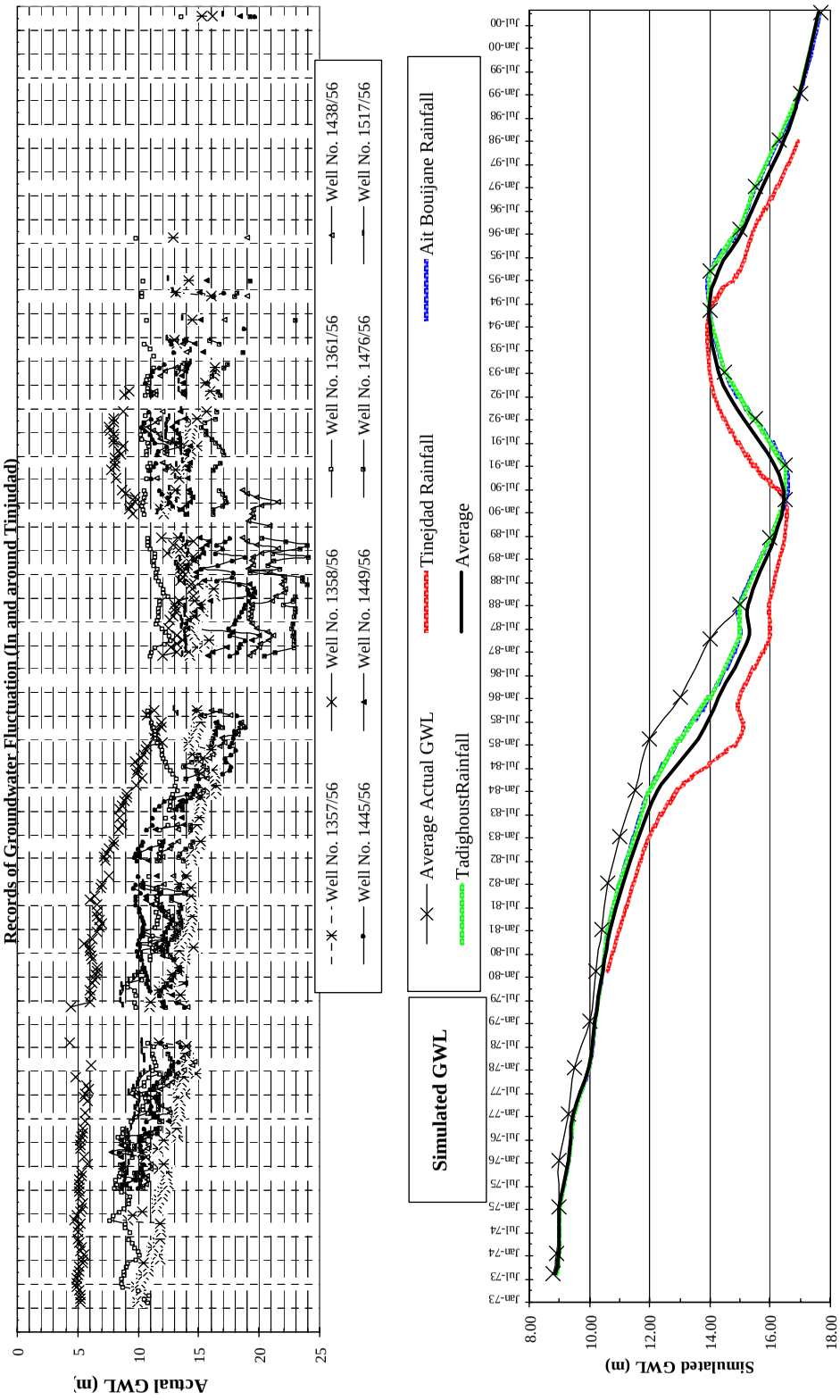


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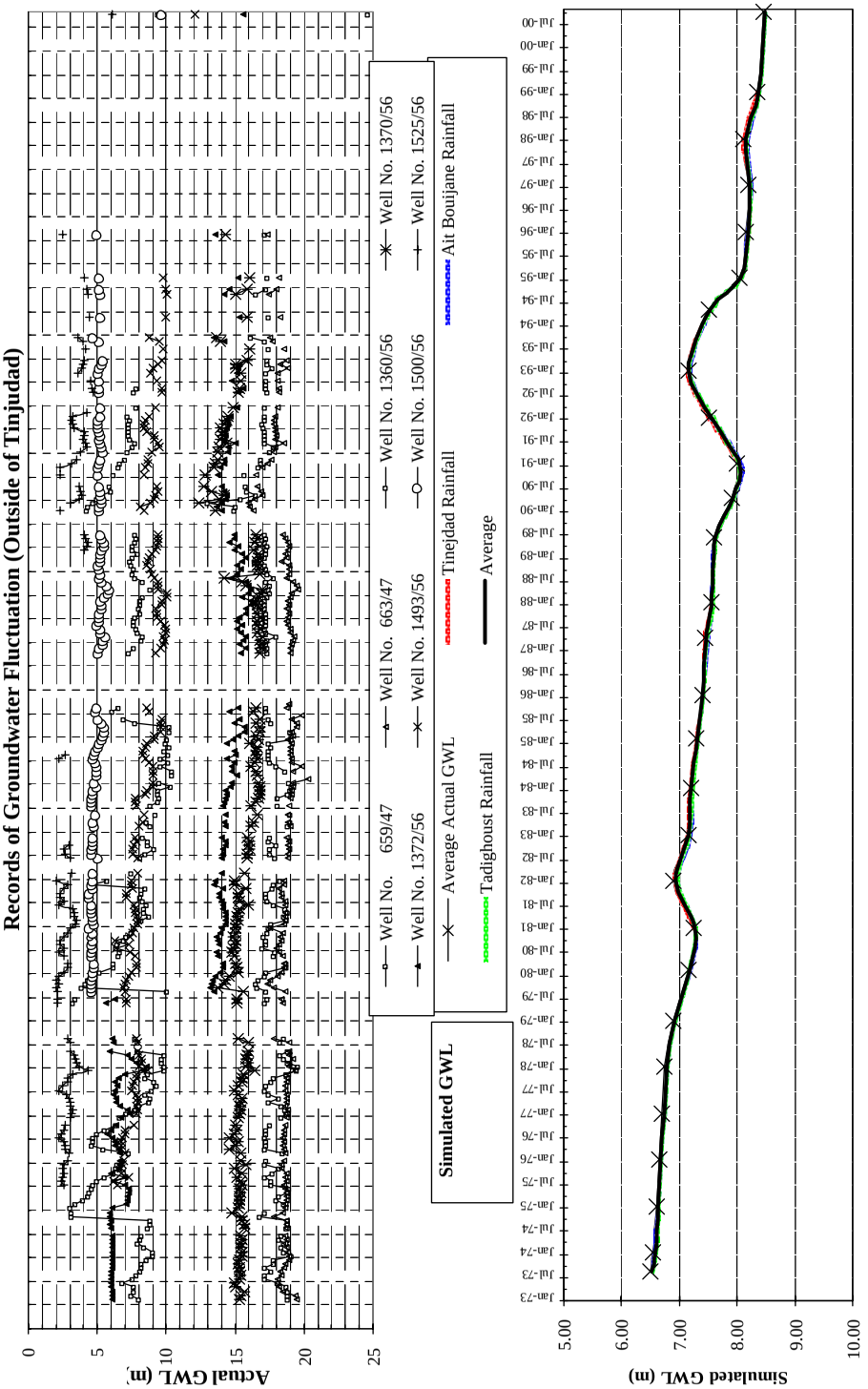
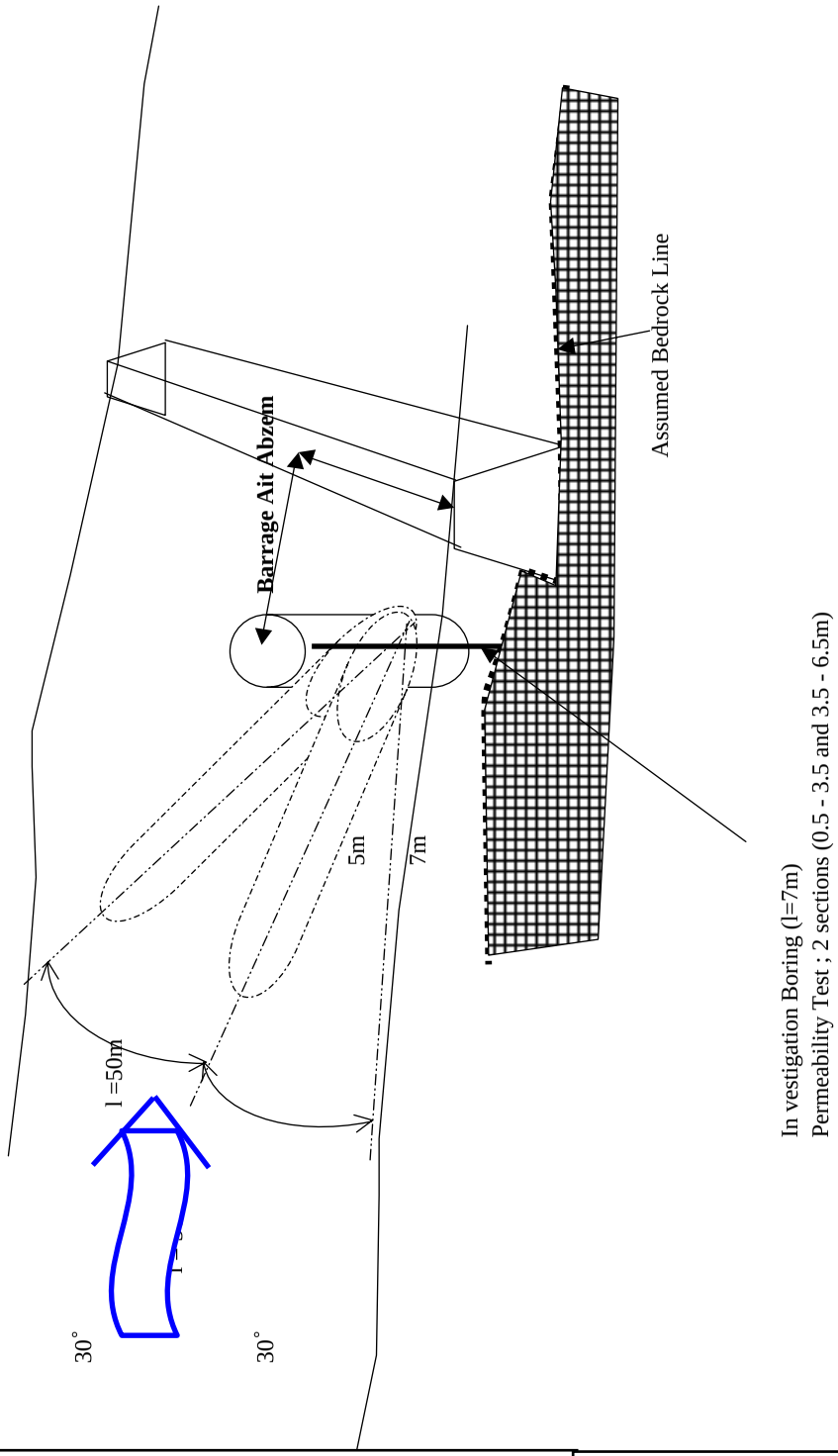
Figure XI4.7.7
Calibration Result for
Groundwater Simulation (Todrha)



FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.7.8** **Calibration Result for** **Groundwater Simulation (Timkit)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



FEASIBILITY STUDY ON
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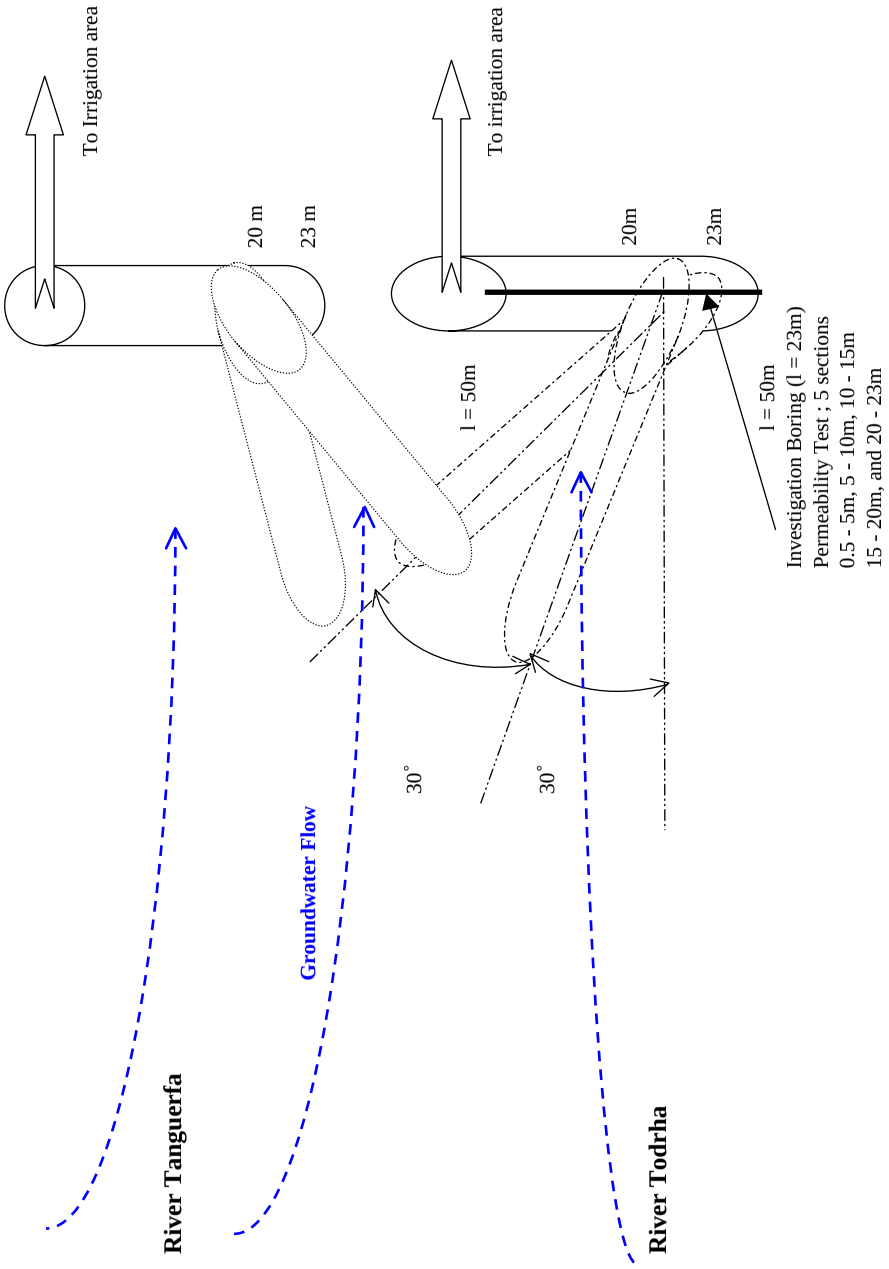
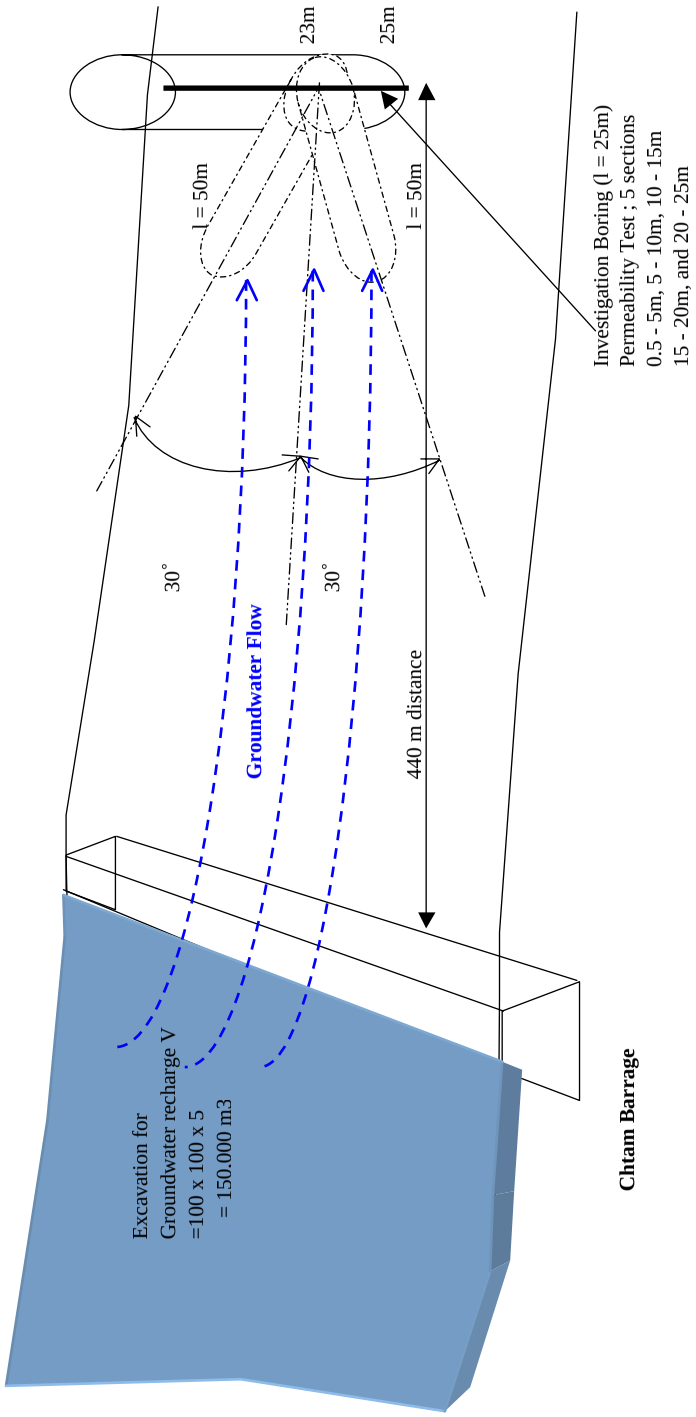
Figure XI4.7.9
Well Design (Barrage Ait Labzem Site)



FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.7.10** **Well Design (Confluence of Oued Tanguerfa and Tinjdad)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



FEASIBILITY STUDY ON
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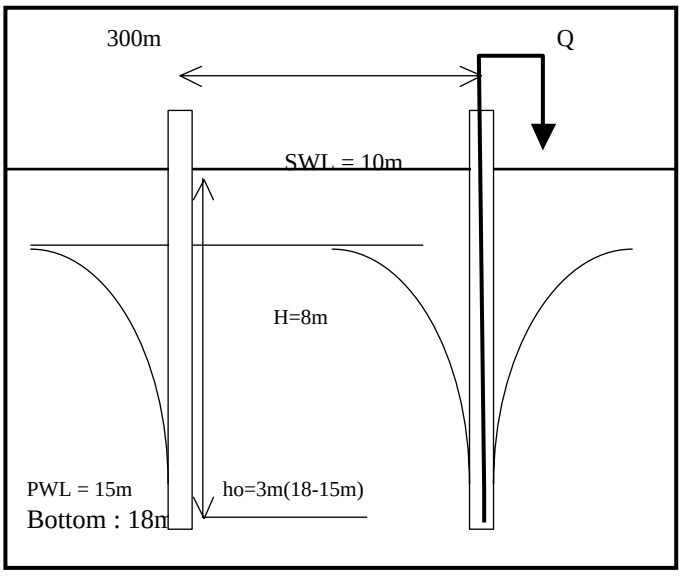
Figure XI4.7.11
Well Design (Cbarrage Chitam Site)



$Q = \pi K(H2-ho2)/Loge(R/ro)=33$ l/sec

Q : discharge

K: Permeability (=1 x 10-1 cm/sec)

H and ho : Thickness of aquifer

ro : Radius of well (=0.75m)

S : drawdown (=5m)

FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI4.7.12** **Influence of the Well Interval**
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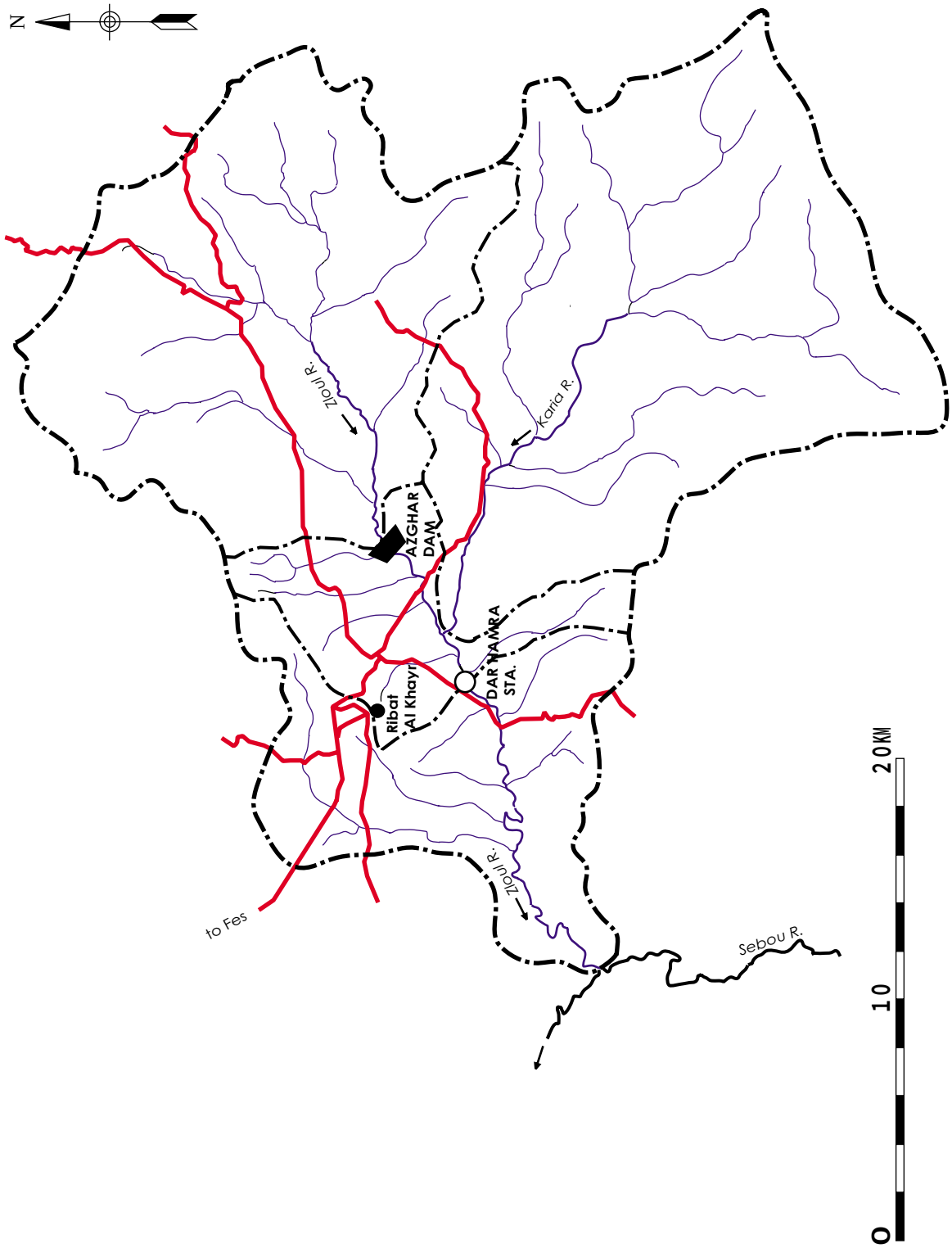
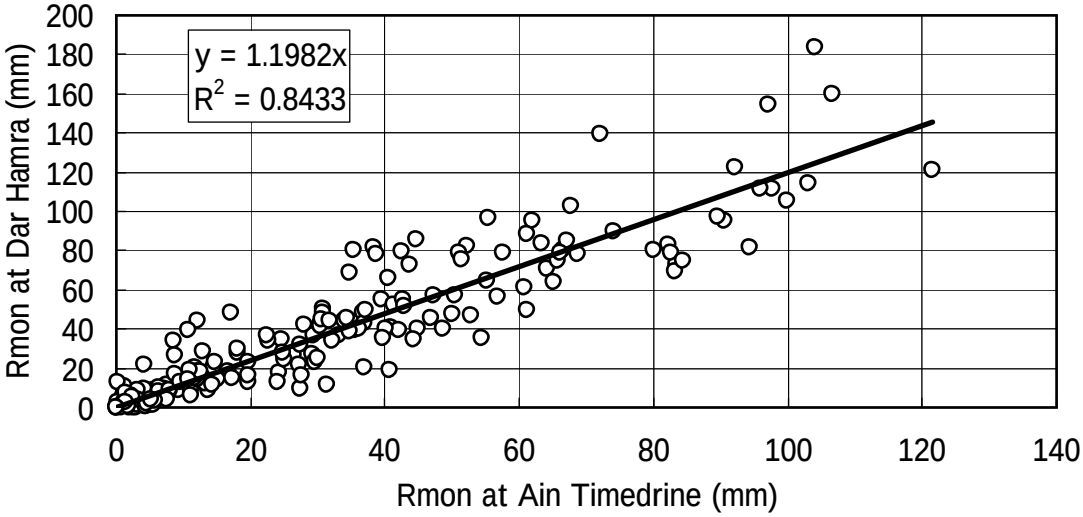
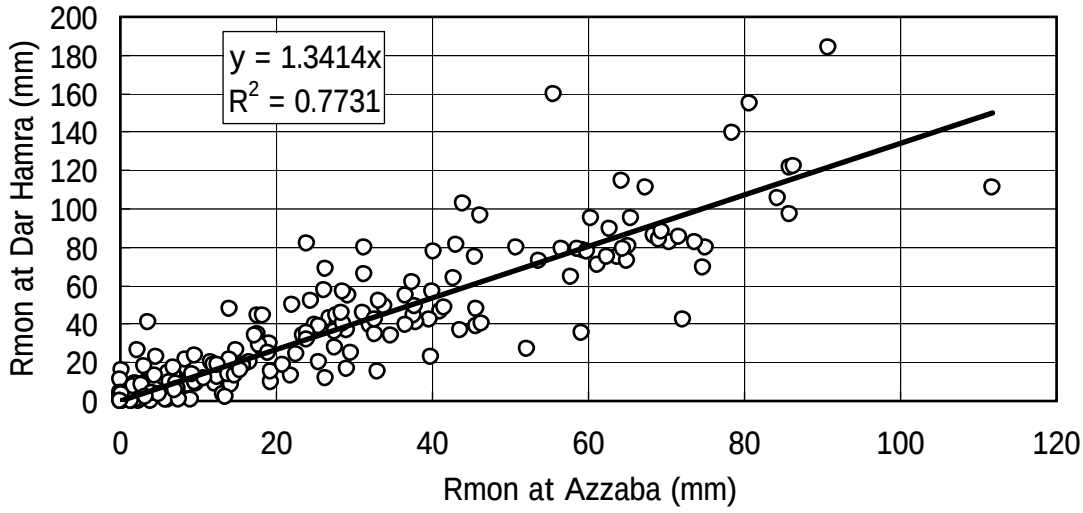
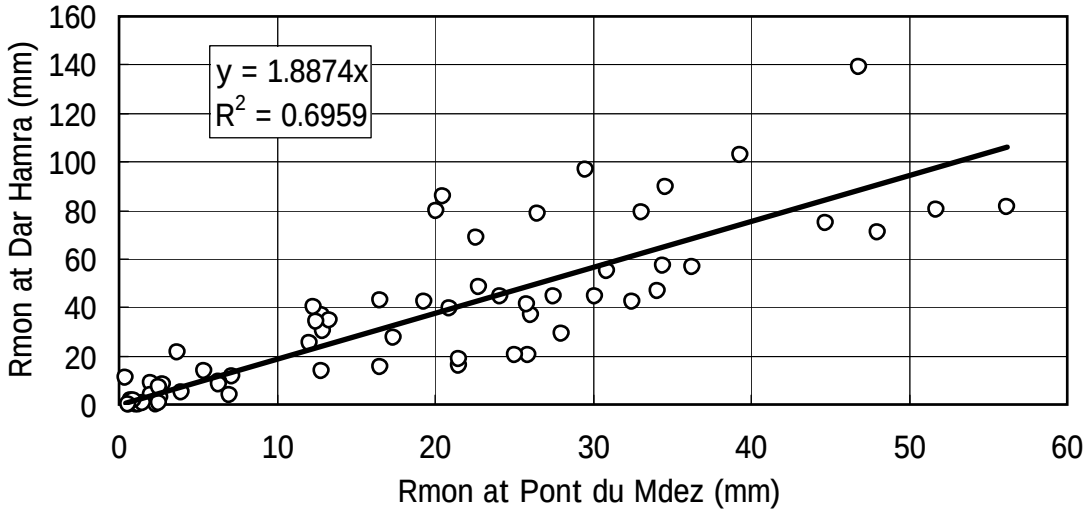


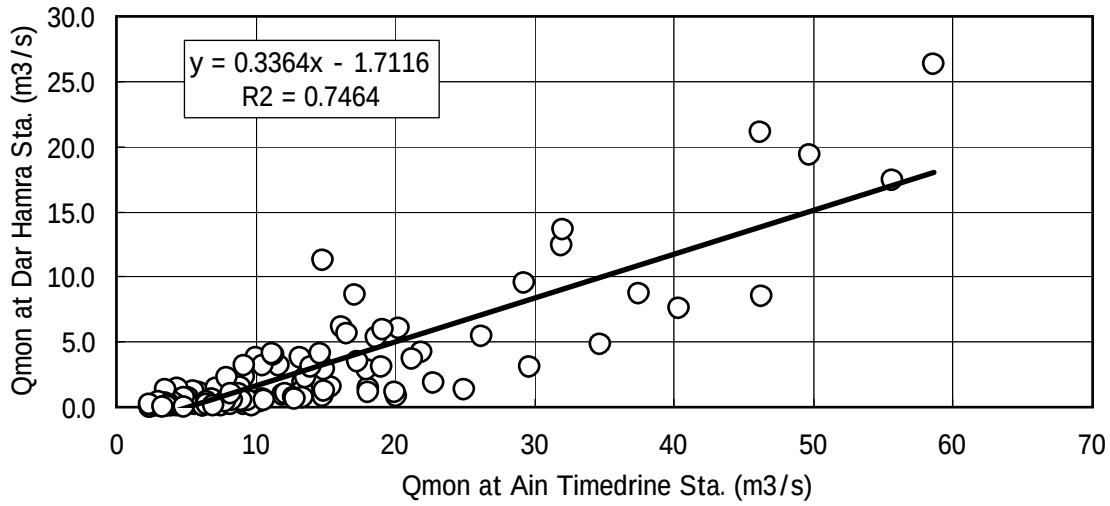
FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI5.1.1** **General Location Map:** **Zloul River Basin**
JAPAN INTERNATIONAL COOPERATION AGENCY	

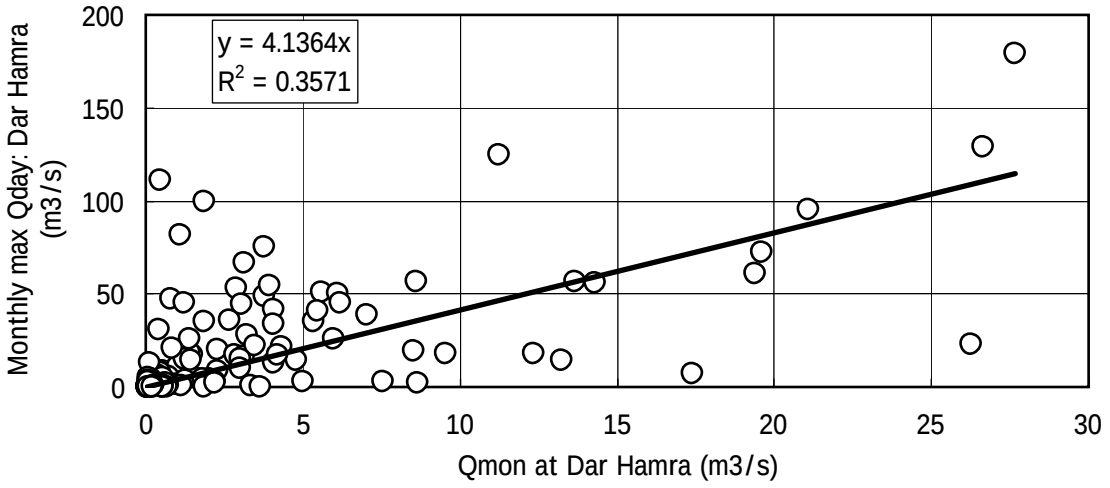


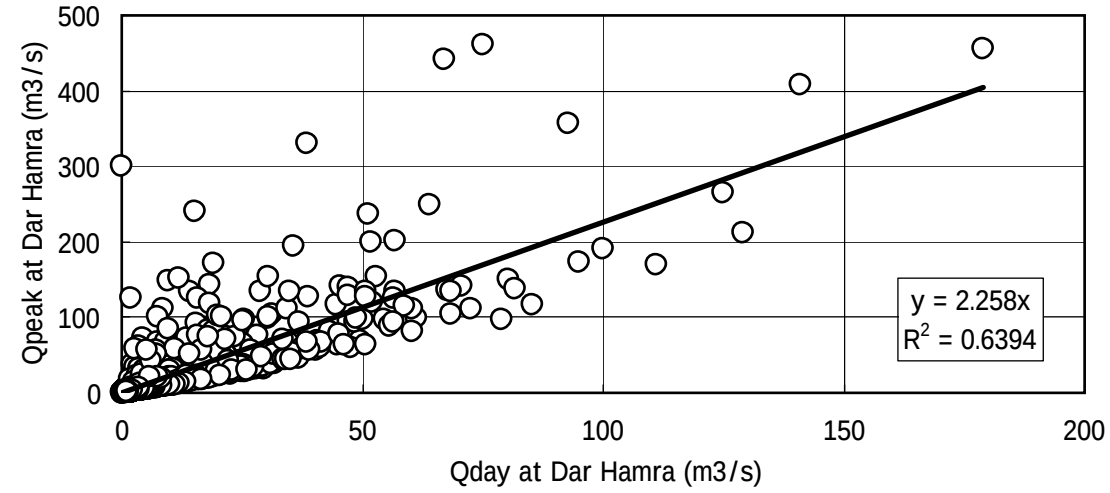




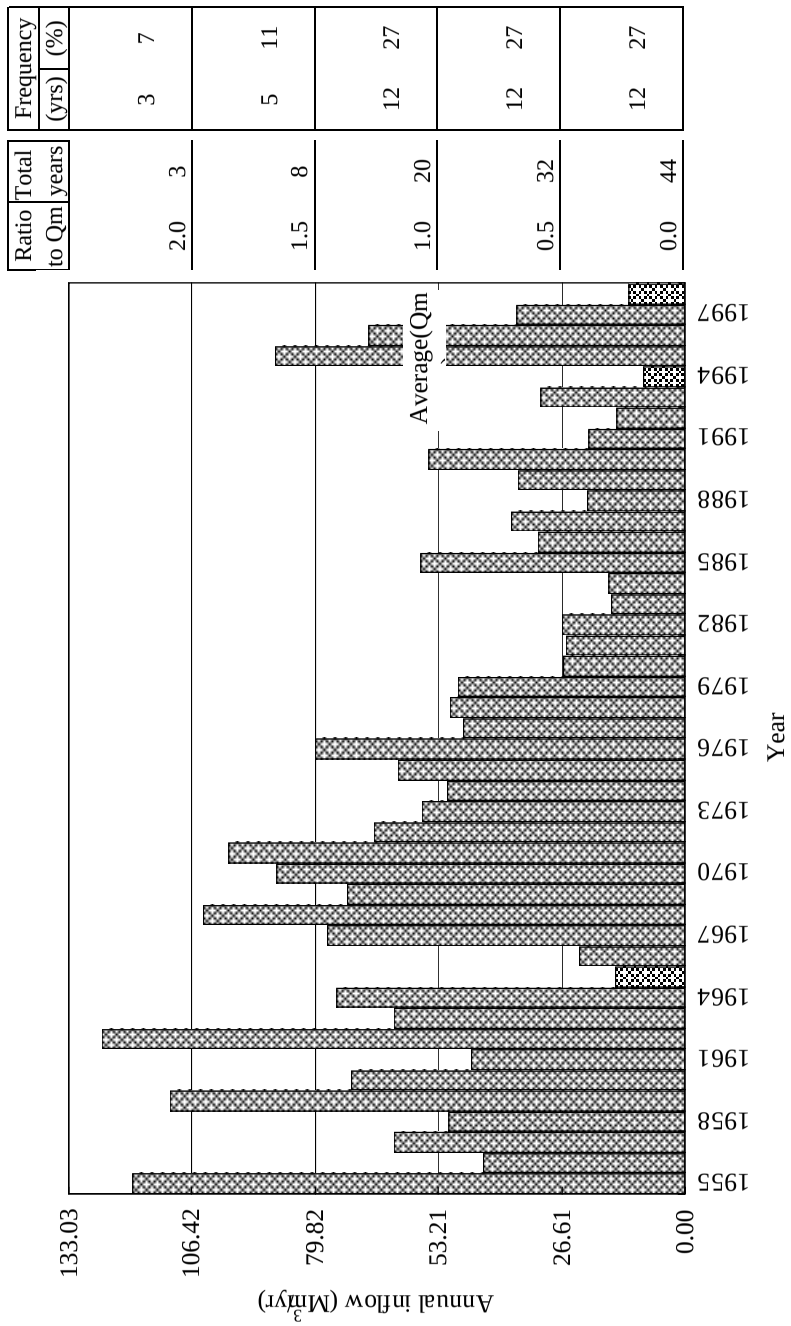
FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI5.3.1** **Correlation of Monthly Rainfall**
JAPAN INTERNATIONAL COOPERATION AGENCY	







FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI5.4.1** **Discharge Correlation: Qmon, Qday, Qpeak**
JAPAN INTERNATIONAL COOPERATION AGENCY	XII-33



FEASIBILITY STUDY ON WATER RESOURCES DEVELOPMENT IN RURAL AREA	**Figure XI5.4.2** **Annual Inflow: Azghar Dam**
JAPAN INTERNATIONAL COOPERATION AGENCY	

FEASIBILITY STUDY ON
WATER RESOURCES DEVELOPMENT
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Figure XI5.4.3
Probability Analysis by Gumbel Method

Mean = 225.58 mm

Observed data arranged in the order of magnitude		
Year	DAR HAMRA (m^3/s)	Return period (year)
1987/88	461.0	11.60
1995/96	456.0	11.16
1985/86	331.0	4.41
1989/90	265.0	2.82
1994/95	241.0	2.42
1993/94	237.0	2.37
1996/97	212.0	2.04
1986/87	173.0	1.66
1990/91	170.0	1.64
1991/92	154.0	1.52
1992/93	83.4	1.18
1988/89	81.2	1.17
1984/85	68.0	1.13

Calculation results	
Return period (year)	DAR HAMRA (m^3/s)
1000	1019.0
500	933.0
250	846.9
200	819.2
100	733.0
50	646.4
30	582.3
25	559.2
20	530.9
15	494.2
10	441.7
5	348.7
4	317.2
3	274.6
2	208.2
1.500	151.1
1.333	122.2
1.250	103.8
1.111	59.3
1.071	39.0
1.053	27.0
1.042	18.1
1.034	10.5
1.020	-7.0
1.010	-26.8
1.005	-44.1
1.004	-49.1
1.002	-63.8
1.001	-76.8