2.2 Water Sources

2.2.1 Mountain Area

(Wadi Al-Ma'awill Basin)

1) Al-Ajal

The irrigation and domestic water requirements are met by four hot springs located at the foot of the mountain.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C. (μs/cm)
1. Al-shubaikhah	(1983)	Hot Spring	0.011	50.8	2,000
	(1984)	"	0.009	50.7	1,950
	(1985)	"	0.012	50.5	2,000
2. Mahyul	(1983)	Hot Spring	0.003	38.6	1,656
	(1984)	"	0.002	38.6	1,560
	(1985)	"	0.005	37.4	1,378
3. Muhadith	(1983)	Hot Spring	0.001	43.7	1,803
	(1984)	"	0.001	42.7	1,700
	(1985)	"	0.002	44.0	1,788
4. Slil	(1983)	Hot Spring	0.008	43.6	1,684
	(1984)	"	0.001	44.8	1,640
	(1985)	"	0.006	43.0	1,504
Total	(1983)		0.023		
	(1984)		0.013		
	(1985)		0.025		

Note; Surveyed on June 12 1983, July 29 1984 and August 15 1985.

2) Al-Hibrah

The groundwater in the Wadi Al-Ma'awil are diverted by the Falaj for the irrigation and domestic water requirements. In the area outside of the falaj system, the irrigation water is supplied by pumping the groundwater.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C. (μs/cm)
Hibra	(1983)	Falaj	0.280	33.6	1,184
	(1984)	"	0.058	33.6	1,280
	(1985)	"	0.043	33.4	1,279
Wells	(1983 - 84)	Pumping	0.017	(5 lit/sec x 20 x 4hr / 24hr)	

Note; Surveyed on June 29 1983, July 29 1984 and August 19 1985.

3) Afi

The irrigation and domestic water requirements are met by the three falaj that collect the groundwater in the Wadi Al-Ma'awil Basin.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C. (μs/cm)
1. Al-Malaqi	(1983)	Falaj	0.036	32.4	611
	(1984)	"	0.013	33.1	540
	(1985)	"	0.010	33.3	511
2. Washah	(1983)	Falaj	0.139	33.6	592
	(1984)	"	0.091	33.2	550
	(1985)	"	0.074	33.7	572
3. Sheli	(1983)	Falaj	0.059	28.3	1,314
	(1984)	"	0.012	28.5	1,120
	(1985)	"	0	-	-
Total			0.234		
			0.116		
			0.084		
Wells		Pumping	0.025		

Note; Surveyed on June 16 1983, and July 21 1984 and August 18 1985.

In addition to these water sources, Afi village makes use of the groundwater through wells and pumping stations.

No. of Pumping Stations : About 30

Diameter x Pump Head (Standard Type) : ϕ2"- 3" x 6 m

Operation of pump : 4 hrs/day

Discharge amount : 5 lit/s x 30 x 4/24
= 0.025 $m^3/s/day$

4) Muslimat

Falaj in the village utilizes the underflow water at Wadi Mistal.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
1. Muslimat	(1983)	Falaj	0.171	34.0	688
	(1984)	"	0.045	33.5	730
	(1985)	"	0.019	32.0	741
2. Al-Awainah	(1983)	Falaj	0.015	30.2	1,609
	(1984)	"	0	-	-
	(1985)	"	0	-	-
Total	(1983)		0.186		
	(1984)		0.045		
	(1985)		0.019		
Wells		Pumping	0.017 (5 lit/s x 20 x 4hr/24hr)		

Note; Surveyed on June 29 1983, July 29 1984 and August 19 1985.

The following are details of the irrigation wells and pumping stations in the village.

No. of Wells and Pumping Station : About 20

Diameter, Pump Head (Standard Type) : ϕ2" to 3"x 4 m

Operation of pumps : 4 hrs/day

Discharge amount : 5 lit/s x 20 x 4/24 = 0.017 $m^3/s/day$

5) Nakhal

Nakhal village, being the largest village in the Wadi Al-Ma'awill basin, consumes a large quantity of water and has various water sources such as faraj, spring, surface water, and groundwater. Location of water sources are shown in Fig. E-2-3.

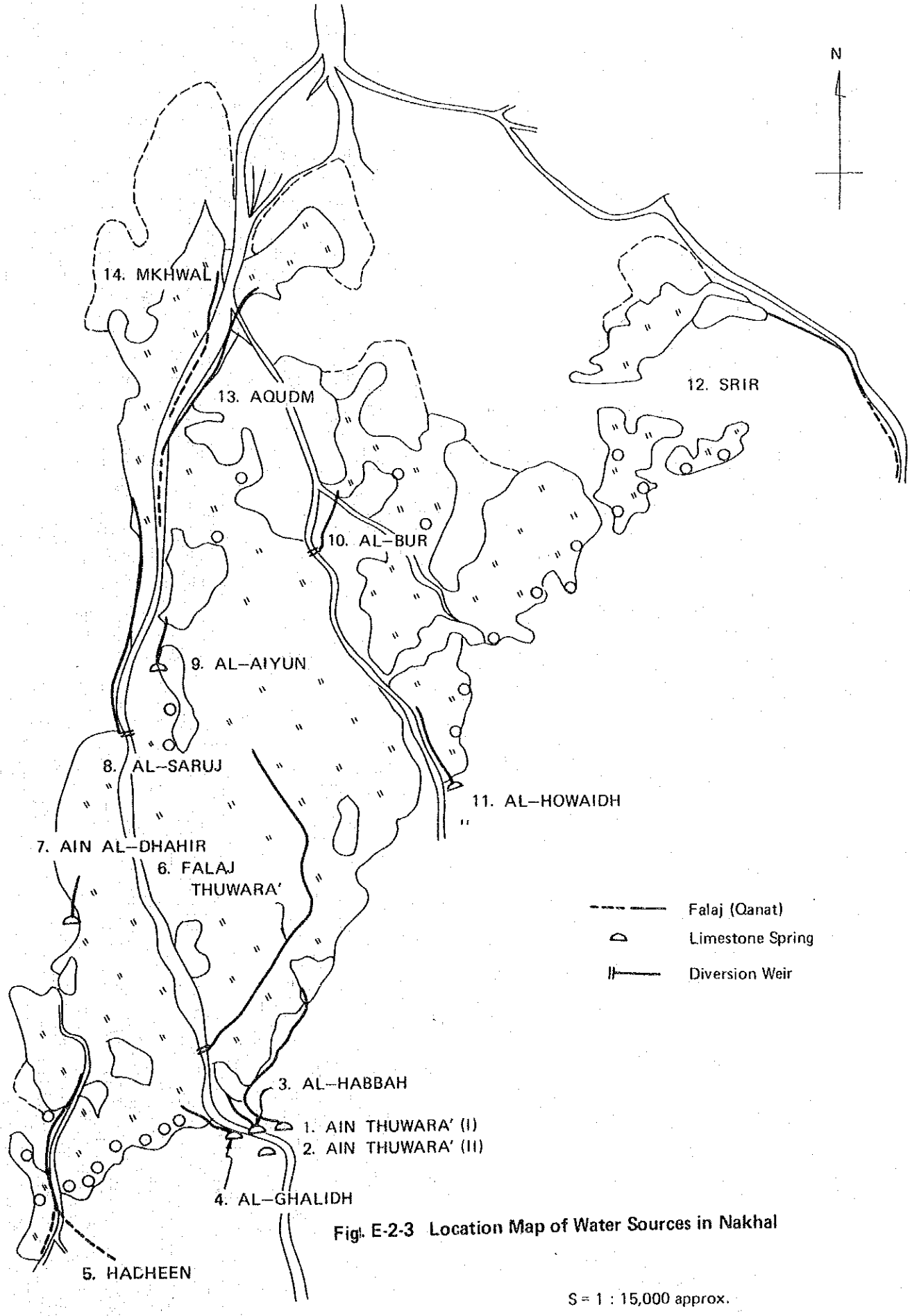


Fig. E-2-3 Location Map of Water Sources in Nakhal

S = 1 : 15,000 approx.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
1. Ain-Thuwara (I)	(1983)	Spring	0.018	35.9	737
	(1984)	"	0.013	36.4	780
	(1985)	"	0.012	36.5	785
2. Ain-Thuwara (II)*	(1983)	"	-	-	-
	(1984)	"	0.027	38.3	880
	(1985)	"	0.024	38.3	936
3. Al-Habba	(1983)	"	0.003	35.9	732
	(1984)	"	0.003	36.5	780
	(1985)	"	0.001	36.3	823
4. Al-Ghalidh	(1983)	"	0.020	36.9	851
(Al-Karid)	(1984)	"	0.014	37.0	870
	(1985)	"	0.014	36.9	911
5. Hadheen	(1983)	Falaj	0.020	36.4	851
	(1984)	"	0.007	36.3	860
	(1985)	"	0.002	36.7	834
6. Falaj Thuwara	(1983)	Diversion	0.079	35.8	747
	(1984)	"	0.051	37.1	810
	(1985)	"	0.036	37.1	851
7. Ain Al Dhahir	(1983)	Spring	0.005	-	-
	(1984)	"	-	-	-
	(1985)	"	-	-	-
8. Saruj	(1983)	Falaj	0.033	30.4	1,283
	(1984)	"	0.006	31.9	1,120
	(1985)	"	0.007	32.6	1,108
9. Al-Aiyum	(1983)	Spring	0.002	-	-
	(1984)	"	0.002	29.0	1,070
	(1985)	"	0.001	30.1	1,093
10. Al-Bur	(1983)	Diversion	0.005	33.7	1,457
	(1984)	"	0.005	32.9	1,320
	(1985)	"	0.003	29.3	1,278
11. Al-Howaidh	(1983)	Spring	0.005	-	-
	(1984)	"	0.003	35.4	780
	(1985)	"	0.014	34.3	761
12. Srir	(1983)	Falaj	0.048	35.3	614
	(1984)	"	0.006	36.8	660
	(1985)	"	0.005	35.3	652
13. Aqdum	(1983)	"	0.005	32.0	1,427
	(1984)	"	0.002	33.8	1,300
	(1985)	"	0.002	28.4	1,190
14. Mkhwal	(1983)	"	0.010	29.7	1,510
	(1984)	"	0.001	30.7	1,350
	(1985)	"	0	-	-
Total	(1983)		0.253		
	(1984)		0.118		
	(1985)		0.102		
Wells		Pumping	0.025		

Note; Surveyed on June 28 1983, July 29 1984 and August 18 1985.

* This is the Water Source for 6. Falaj-Thuwara.

Nakhl village abounds in water springs at the foot of the mountain as wells for the irrigation water supply as follows;

No. of Springs and Wells	:	About 30
Discharge of Spring or Pumped Water	:	- 1 lit/s to 8 lit/s per spring or well - Average Rate of Use (Estimate) 5 lit/s x 30 x 4/24 = 0.025 m^3/s/day
Water Temperature and E.C.	:	T = 29.8°C to 34.4°C
	:	E.C.= 853 to 1,574 µs/cm

Note; Surveyed on July 20, 1983

(Water Sources in the Wadi Bani Kharus Basin)

6) Al-Abiyad

This village is located in the mountain area and makes use of the under flow water which is dammed up by the shallow rock layers in the Wadi.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (µs/cm)
Al-Abiyad	(1983)	Falaj	0.168	34.6	535
	(1984)	"	0.036	33.7	760
	(1985)	"	0.022	35.5	918

Note; Surveyed on June 12 1983, July 21 1984 and August 28 1985.

7) Layjah

The irrigation system in this village makes concurrent use of water resources at Falaj Awabi and branches off (Branch - No.2) at the uppermost stream of the main channel. (See Falaj Awabi)

8) Istal

This village is located in the mountain area along the upper stream of the Wadi-Bani Kharus and utilizes the underflow water of the Wadi.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Istal	(1983)	Falaj	0.104	30.1	1,628
	(1984)	"	0.019	30.3	743
	(1985)	"	0.017	30.3	753

Note; Surveyed on June 13 1983, August 2 1984 and August 20 1985.

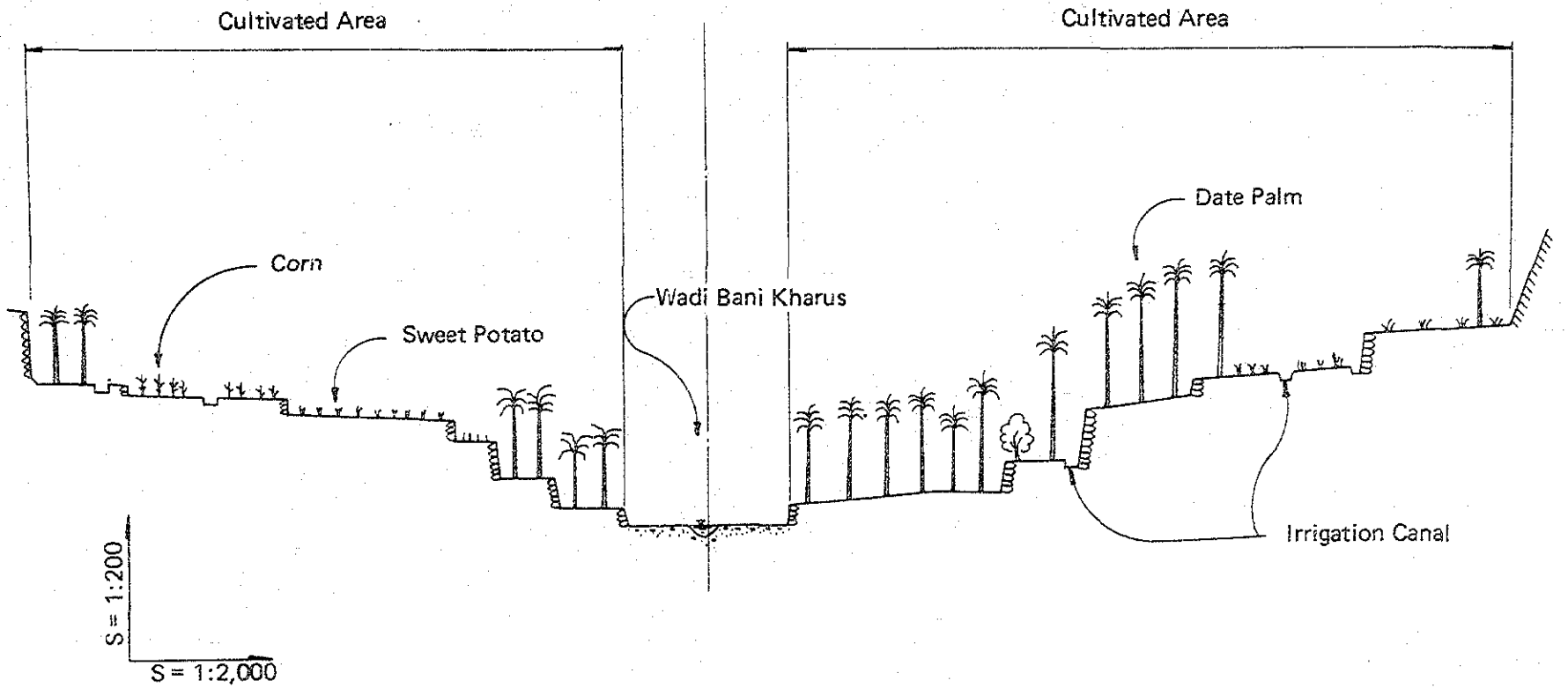
9) Al-Muhassanah

This village, being a major village in the Area, is located in the uppermost stream of the Wadi-Bani Kharus. Its residential and cultivable areas are developed in a narrow strip on both sides of the Wadi, showing the land use pattern to the mountain area.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Al-Muhassanah	(1983)	Falaj	0.012	26.1	768
	(1984)	"	0.030	27.4	787
	(1985)	"	0.015	27.0	910

Note; Surveyed on June 13 1983, August 2 1984 and August 20 1985.

Fig. E-2-4 Profile of Water and Land Use in the Village (Istal)



(Water Sources in the Wadi Al-Fara' Basin)

10) Jamma

This village is located in the Gravel plains and utilizes falaj systems.

Name of Water Sources		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
1. Jamma	(1983)	Falaj	0.360	34.2	942
	(1984)	"	0.131	33.9	1,008
	(1985)	"	0.021	33.6	1,022
2. Boyal	(1983)	"	0.110	33.7	911
	(1984)	"	0.027	33.8	981
	(1985)	"	0.006	33.8	988
Total	(1983)		0.470		
	(1984)		0.158		
	(1985)		0.027		

Note; Surveyed on June 13 1983, August 6 1984 and August 22 1985.

11) Al-Hazam

This village makes use of Falaj Hazam that provides abundant supply of water. Subsurface collecting qanat channels for this falaj are laid as far as 7 km upstream.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Al-Hazam	(1983)	Falaj	0.571	30.5	1,020
	(1984)	"	0.189	30.9	983
	(1985)	"	0.014	31.3	875

Note; Surveyed on June 21 1983, and July 11 1984 and August 22 1985.

Discharge at the Falaj reached the peak in March to May 1983, then gradually diminished down to about 30% of the peak discharge in July 1984 and less than 10% of the peak discharge in August 1985.

12) Al-Shubaikhah

This village neighbouring al-Hazam has its own falaj system.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Al-Shubaikhah	(1983)	Falaj	0.054	33.0	1,307
	(1984)	"	0.035	32.9	1,263
	(1985)	"	0.017	32.8	1,140

Note; Surveyed on June 15 1983, August 6 1984 and August 22 1985.

13) Wishal

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Falaj Wishal	(1983)	Falaj	0.248	33.0	757
	(1984)	"	0.090	33.3	770
	(1985)	"	0.002	30.7	717

Note; Surveyed on June 29 1983, August 6 1984 and August 17 1985.

14) Wabal

This village is located downstream of Al Rustaq and the falaj is from the mainstream of the Wadi Fara.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Wabal	(1983)	Falaj	0.128	27.6	1,065
	(1984)	"	0.012	28.3	1,047
	(1985)	"	0 (Aug.'85)	-	-

Note; Surveyed on June 28 1983, August 1984 and August 17 1985.

15) Al-Rustaq

Al-Rustaq is the largest city in the mountain area of the Batinah Coast and its economic activities are dependent on stable supply of water. The irrigation water requirement is met by the falaj systems, springs and by pumping the groundwater (see Fig. E-2-5).

Pumping Station

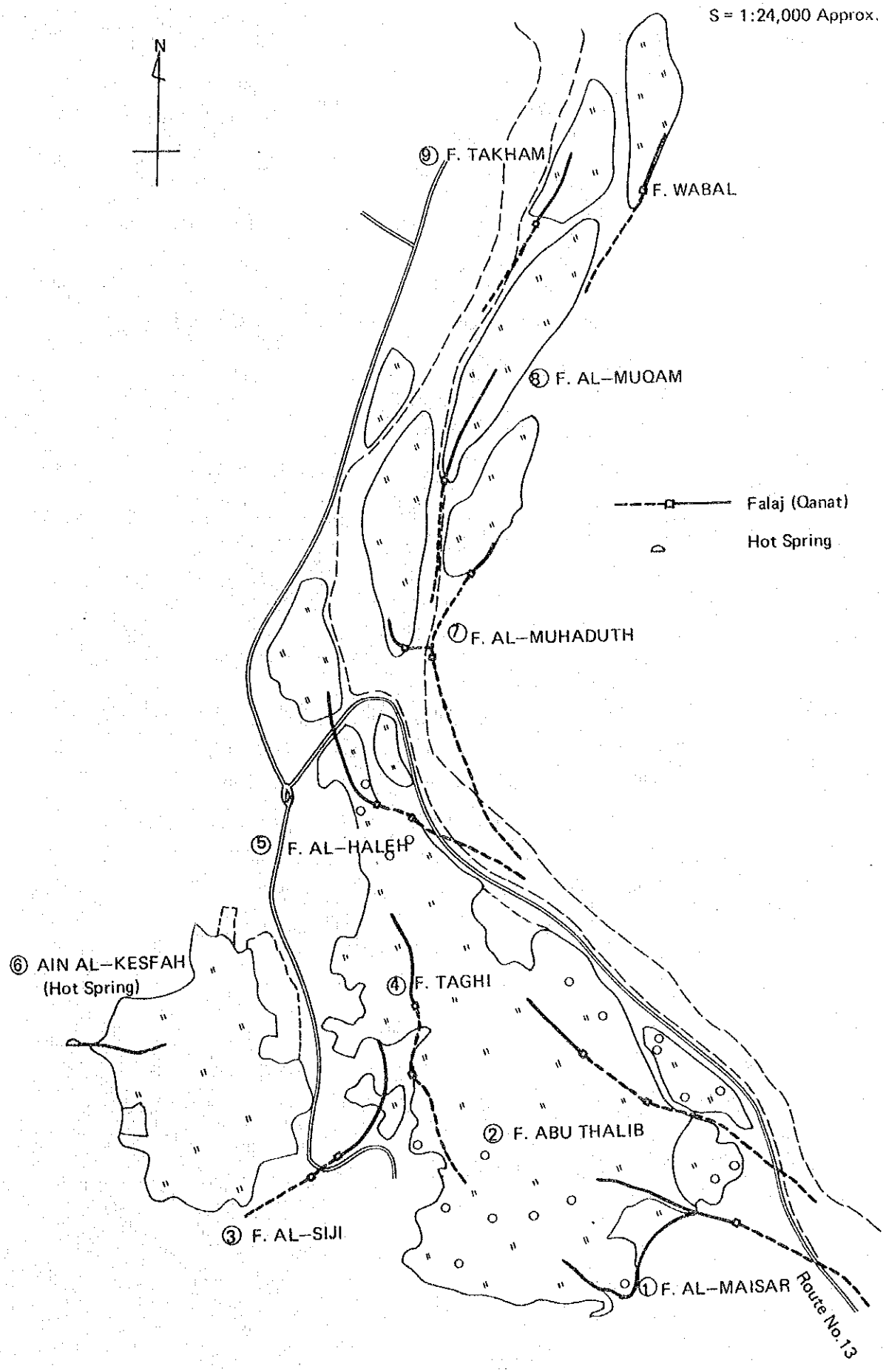
Diameter x Pump Head	:	ϕ2" to 3" x 4 m
No. of Stations	:	About 20

15) Al-Rustaq

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
1. Al-Maisre	(1983)	Falaj	0.319	31.9	606
	(1984)	"	0.138	31.7	670
	(1985)	"	0.052	31.6	683
2. Abu-Thalib	(1983)	Falaj	0.122	32.3	500
	(1984)	"	0.027	32.4	497
	(1985)	"	0.018	32.5	477
3. Al-Siji	(1983)	Falaj	0.058	39.3	964
	(1984)	"	0.024	39.4	1,046
	(1985)	"	0.015	39.3	1,120
4. Taghi	(1983)	Falaj	0.094	27.8	788
	(1984)	"	0.020	28.5	818
	(1985)	"	0 (Jan.'85)	-	-
5. Al-Haleh	(1983)	Falaj	0.051	28.5	676
	(1984)	"	0.007	30.0	503
	(1985)	"	0 (Oct.'84)	-	-
6. Ain-Al-Kesfah	(1983)	Hot Spring	0.077	45.0	1,300
	(1984)	"	0.054	44.9	1,285
	(1985)	"	0.056	44.9	1,292
7. Al-Muhaduth	(1983)	Falaj	0.112	28.7	1,112
	(1984)	"	0.003	29.9	1,125
	(1985)	"	0 (Oct.'84)	-	-
8. Al-Muqam	(1983)	Falaj	0.178	28.2	791
	(1984)	"	0.046	28.6	809
	(1985)	"	0.008	29.1	886
9. Takham	(1983)	Falaj	0.110	28.6	1,002
	(1984)	"	0.017	29.1	976
	(1985)	"	0 (Mar.'85)	-	-
Total	(1983)		1.121		
	(1984)		0.336		
	(1985)		0.149		
Wells		Pumping	0.017	(5 lit/s x 20 units x 4/24 hr)	

Note; Surveyed on June 21-30 1983, August 4 1984 and August 17 1985.

Fig. E-2-5 Location Map of Water Sources in Al-Rustaq



Operation of Pumps	:	4 hrs/day (average)
Discharge Amount	:	5 lit/s x 20 x 4/24
		= 0.017 m^3/s/day

16) Al Awabi

Falaj Awabi utilizes the underflow water from the upper stream of the Wadi Bani Auf and the Wadi Bani Kharus.

The Water resource from this Falaj is concurrently used by Layjah Village.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Al-Awabi	(1983)	Falaj	0.294	31.0	638
	(1984)	"	0.094	30.9	637
	(1985)	"	0.030	30.9	620

Note; Surveyed on February 21 1983, July 24 1984 and August 14 1985.

17) Fas'hah

Falaj Fas'hah makes use of the underflow water of the Wadi Sahtan.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Fas'hah	(1983)	Falaj	0.056	28.7	1,050
	(1984)	"	0.018	29.4	1,087
	(1985)	"	0.005	29.7	1,030

Note; Surveyed on June 15 1983, August 1 1984 and August 21 1985.

18) Amq

This village is located in the upper stream of Fas'hah and has Falaj Al-Qadim and Zagt.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
1. Al-qadim	(1983)	Falaj	0.037	29.1	906
	(1984)	"	0.003	30.1	915
	(1985)	"	0.001	30.4	806
2. Zagt	(1983)	Falaj	0.004	30.6	786
	(1984)	"	0.006	31.5	783
	(1985)	"	0.005	30.2	752
Total	(1983)		0.041		
	(1984)		0.009		
	(1985)		0.006		

Note; Surveyed on June 15 1983, August 1 1984 and August 21 1985.

Since the discharge at Falaj Zagt is limited, the irrigation requirement is met by the water stored in the farm pond.

(Water Sources in the Wadi-Bani-Ghafir)

19) Daris

This villages appears, from the topographic viewpoint, to utilize the underflow water of Wadi Fara.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Daris	(1983)	Falaj	0.031	32.7	1,119
	(1984)	"	0.006	32.5	974
	(1985)	"	0.003	32.2	940

Note; Surveyed on June 14 1983, August 6 1984 and August 22 1985.

20) Wustah

This village is located in the upper stream of Daris and belongs to the same Falaj system as that of Jalaj Daris.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Wustah	(1983)	Falaj	0.039	33.0	913
	(1984)	"	0.011	32.5	982
	(1985)	"	0.005	32.9	1,004

Note; Surveyed on June 14 1983, August 6 1984 and August 22 1985.

A pumping station is for the irrigation purpose installed in the north of the village.

21) Ali

Falaj Ali is situated in the further upstream Falaj Wustah.

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Ali	(1983)	Falaj	0.040	32.6	1,060
	(1984)	"	0.010	31.8	983
	(1985)	"	0.004	31.0	928

Note; Surveyed on June 14 1983, August 6 1984 and August 22 1985.

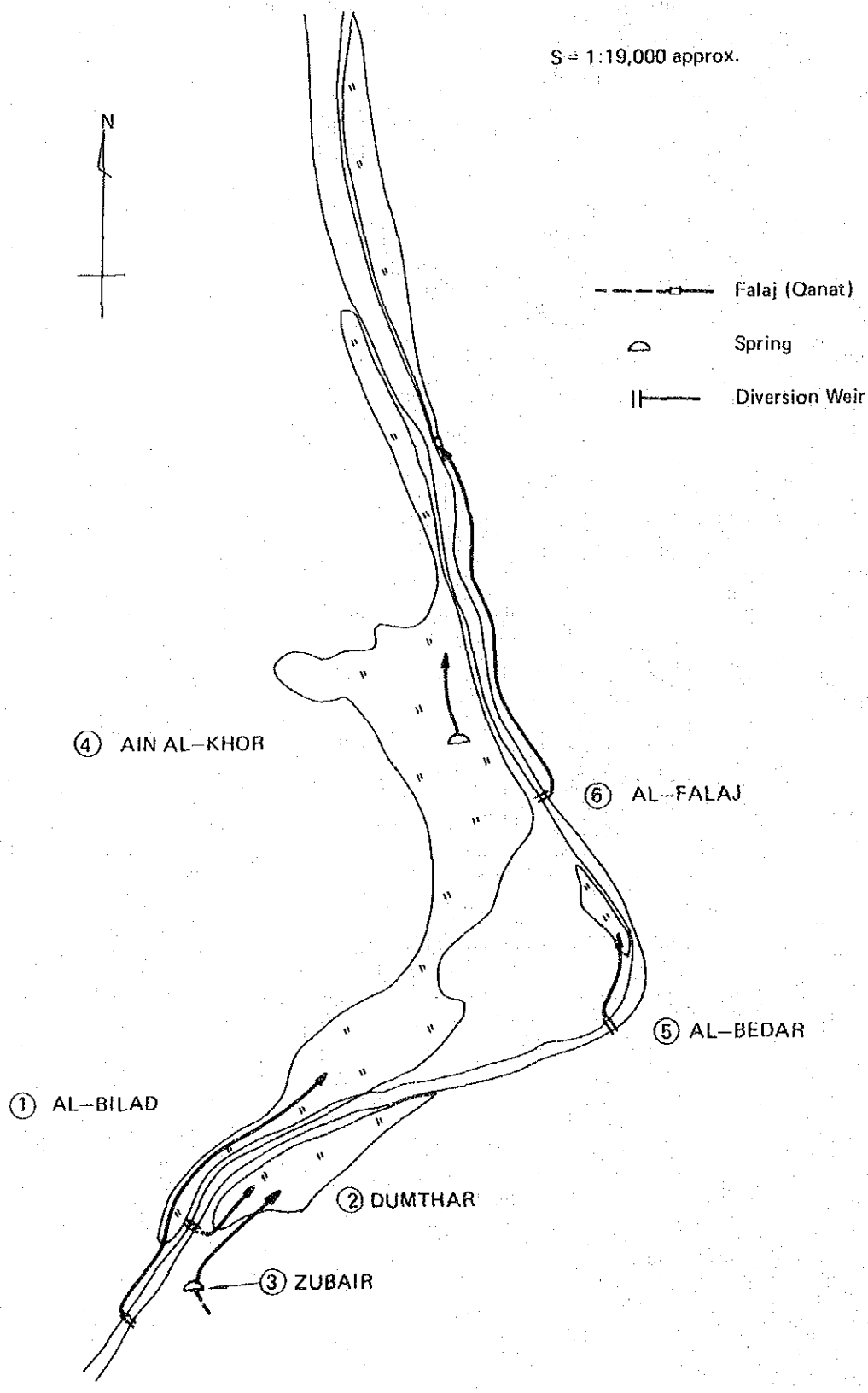
22) Al-Houqain

This village is dependent, for its water use, on six falaj systems listed below. The continuous observation on the discharge has been made at Falaj Al-Bilad, the largest system among the six Falaj systems (see Fig. E-2-6).

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (µs/cm)
1. Al-Bilad	(1983)	Falaj	0.143	32.3	607
	(1984)	"	0.021	31.6	643
	(1985)	"	0.039	34.8	676
2. Dumthar	(1983)	D.W	0.034	32.6	691
	(1984)	"	0.006	32.9	755
	(1985)	"	0.005	35.4	777
3. Zubair	(1983)	Spring	0.019	31.6	708
	(1984)	"	0.002	31.8	640
	(1985)	"	0.001	35.3	829
4. Ain-Al-Khor	(1983)	Spring	0.024	27.7	847
	(1984)	"	0.004	27.8	830
	(1985)	"	0.004	27.8	945
5. Al-Bedar	(1983)	Diversion Works	0.007	34.8	802
	(1984)	"	0.005	32.8	914
	(1985)	"	0.002	32.2	935
6. Al-Falaj	(1983)	Falaj	0.076	34.3	843
	(1984)	"	0.013	34.0	1,175
	(1985)	"	0.007	33.5	1,284
Total	(1983)		0.303		
	(1984)		0.051		
	(1985)		0.058		
Wells		Pumping	0.025	(5lit/s x 30units x 4hr/24hr)	

Note; Surveyed on June 13 1983, August 5 1984 and August 21 1985.

Fig. E-2-6 Location Map of Water Sources in Al-Houqain



(Water Source in the Wadi Ahin)

23) Al-Hayl

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
Nayl	(1983)	Diversion Works	0.031	32.9	858
	(1984)	"	0.012	33.7	880
	(1985)	"	0.004	32.5	1,014

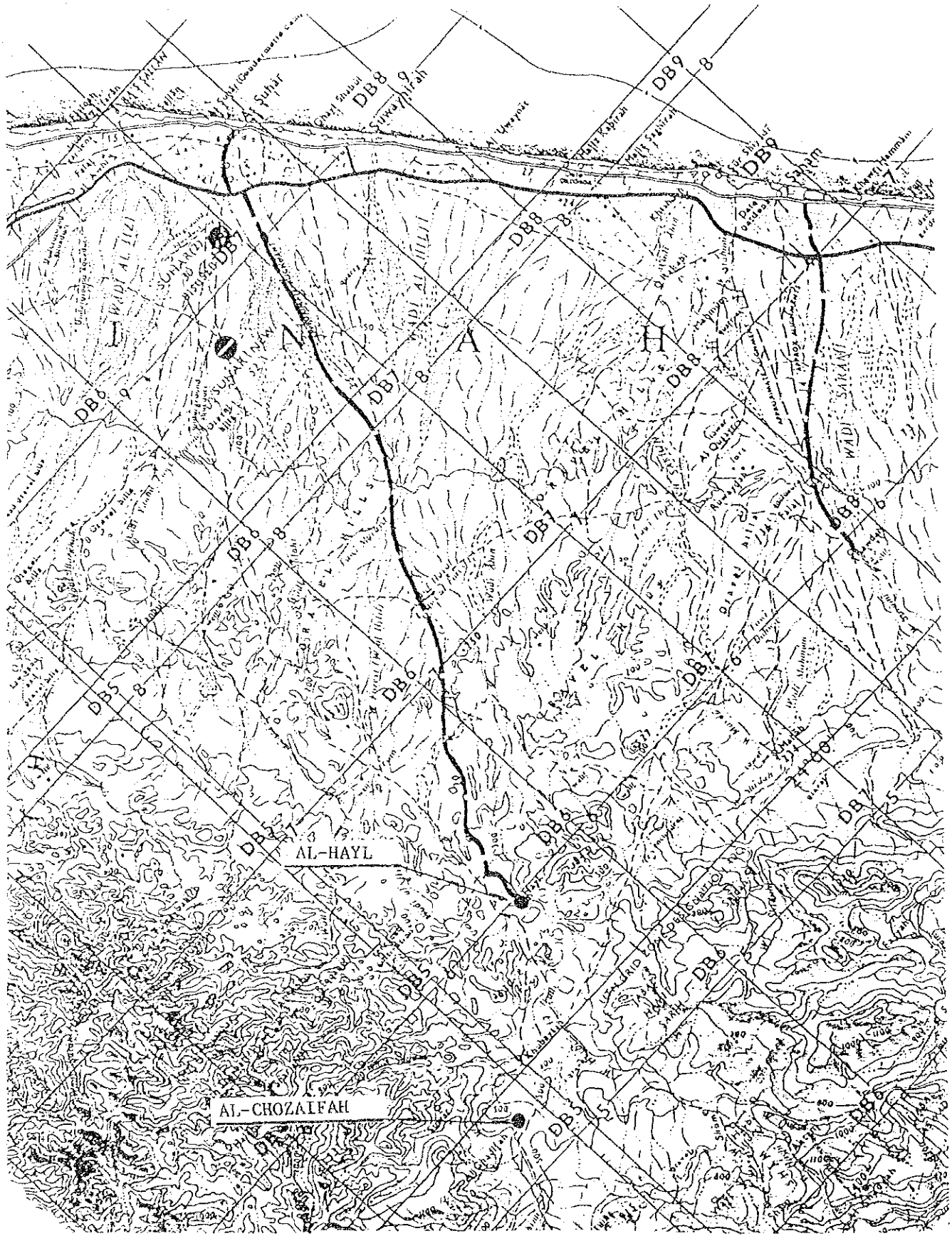
Note; Surveyed on June 27 1983, August 13 1984 and August 26 1985.

24) Al-Ghozaifah

Name of Water Source		Type	Discharge (m^3/s)	W.T (°C)	E.C (μs/cm)
1. Habat	(1983)	Diversion Works	0.091	28.6	687
	(1984)	"	0.024	33.4	863
	(1985)	"	0.012	31.7	865
2. Ghozaifah	(1983)	Diversion Works	0.028	29.1	728
	(1984)	"	0.029	33.4	971
	(1985)	"	0.019	32.0	1,126
3. Khubaitah	(1983)	Diversion Works	0.070	31.3	825
	(1984)	"	0.020	35.5	1,233
	(1985)	"	0.003	36.7	1,553
Total	(1983)		0.189		
	(1984)		0.073		
	(1985)		0.034		

Note; Surveyed on June 27 1983, August 13 1984 and August 26 1985.

Fig. E-2-7 Location Map of Aflaj in the Project Area



2.2.2 Coastal Area

The water sources identified in the coastal area are wells and pumping stations.

The field survey was conducted in the Sample Area of Barka, Al-Musanâah, Swaiq, and Saham areas, covering 100 to 300 ha, with respect to the number and depth of wells, depth from the ground surface to groundwater surface, number of pumping stations, diameter, water temperature and E.C. value.

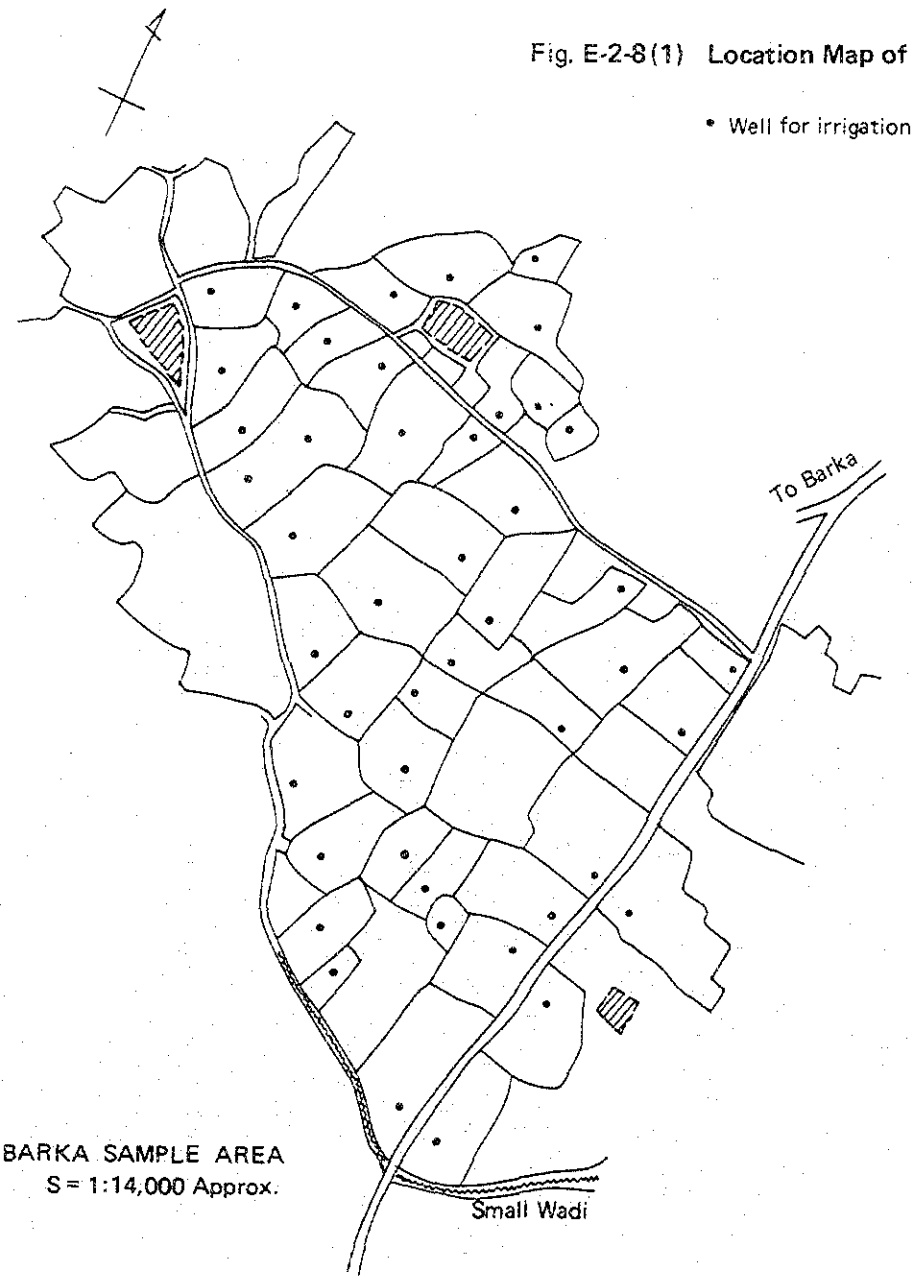
The shape of farms and the location of wells are presented in Fig. E-2-8(1)/(2), and a summary of survey is shown in Table E-2-2.

Table E-2-2 Water Sources in the Sample Area

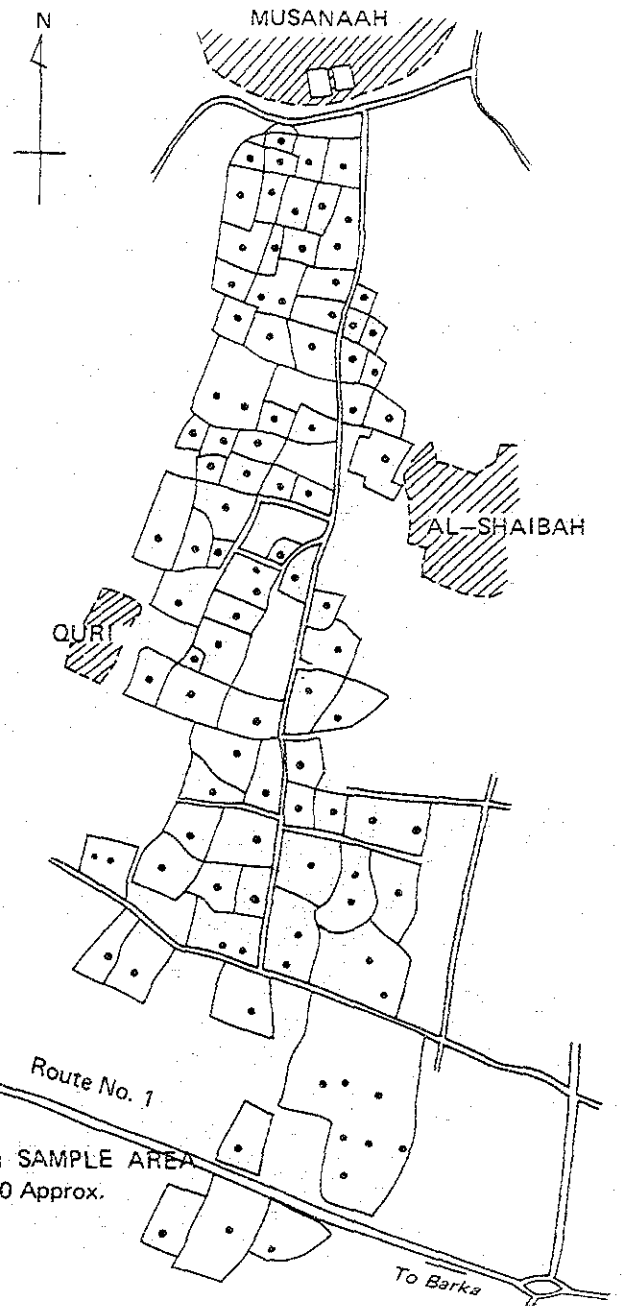
Item	Sample Area			
	Barka	Al-Musanaah	Al-Suwaiq	Saham
Cultivated Area (ha)	85.3	264.2	81.5	88.1
No. of Wells	44	99	36	60
Depth from Ground Surface to Groundwater Surface (m)	6.2-12.9 Hand dug	3.4-15.8 Hand dug	5.7-13.9 Hand dug	1.0-5.9 Hand dug
Well Depth (m)	8.5-15.0	6.2-18.5	7.5-14.7	2.7-9.8
No. of Pumping Stations	54	114	40	66
Diameter	ϕ2"- 3"	ϕ2"- 3"	ϕ3"	ϕ2"- 3"
Average Irrigated Area per Pumping Station (ha)	1.58	2.32	2.04	1.33
Water Temperature (°C)	29.4-33.4	22.0-32.0	23.9-32.6	28.2-37.3
E.C. (μs/cm)	1,748- 7,770	1,330- 12,200	835- 6,260	870- 5,420
Period of Observation	23 July '83	13 - 26 Mar'83	15 Mar '83	25 June '83

Fig. E-2-8(1) Location Map of Sample Area (1)

• Well for irrigation

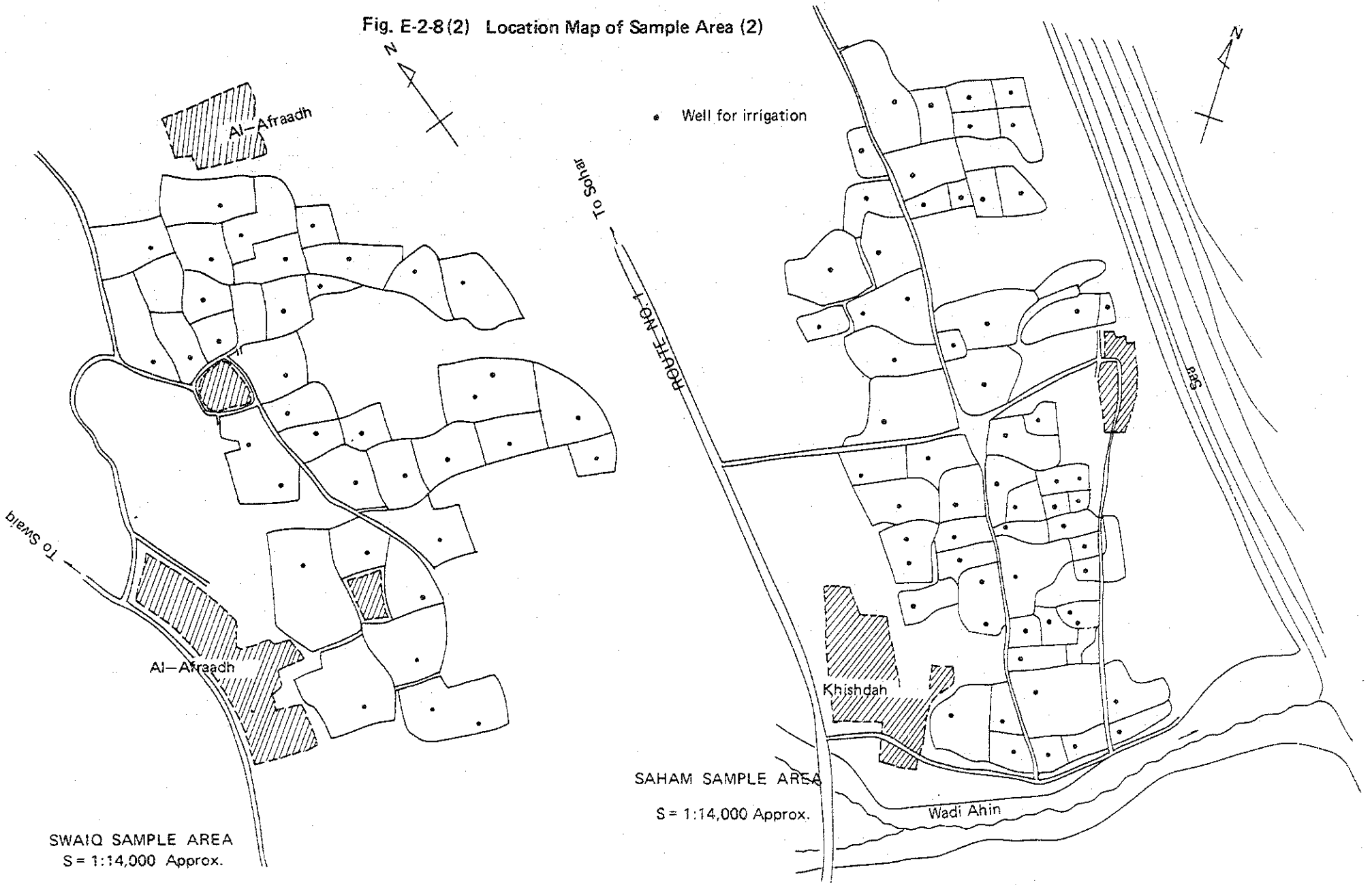


BARKA SAMPLE AREA
S = 1:14,000 Approx.



Al-MUSANÁAH SAMPLE AREA
S = 18,000 Approx.

Fig. E-2-8(2) Location Map of Sample Area (2)



2.3 Present Irrigation System

2.3.1 Mountain Area

The scale of the village in the mountain region, particularly the size of arable land, is largely determined by the amount of discharge at the water sources because the crop production in the arid zone is crucially dependent on the availability of irrigation water.

Thus, in order to assess the present status of irrigation in the region, six sample falaj have been selected to continously observe the discharge.

Falaj under Observation

Name	Wadi	Type
Al-Bilad	Bani Ghafir	Diversion Works
Al-Hazam	Al-Fara'	Falaj (Qanat)
Al-Maisre (Rustaq)	- do -	- do -
Abu-Thalib (Rustaq)	- do -	- do -
Al-Awabi	Bani Kharus	- do -
Al-Karid	Al-Ma'awill	Hot Spring

Hydrographs from each falaj by month are presented in Figure E-2-12. Hydrographs at each falaj appear to reach the peak in March to April 1983 and then diminish gradually until August 1985 when the discharge is reduced by about 10 percent of the peak discharge.

As is the case with the coastal area, the irrigation method employed is basin irrigation in a small unit of the circumscribed area. The major difference from the coastal area is in the distribution method and the water sources.

In the mountain area where the limited water sources are shared among the inhabitants, the rational distribution of irrigation water is important, whereas it is not in the coastal area where each farm has its own water source (pumping station). Therefore, water distribution in the mountain region is obliged to follow prescribed rules in terms of use time and quantity.

The field survey in Awabi village revealed that the water distribution is carried out in a unit called "Athar".

The water released from falaj is distributed through the main canal (Q) and then diverted to the secondary canals (Q/2) that eventually branch off into two lateral canals (Q/4). Thus, the water being equally distributed at each canal, the discharge capacity (q) of the lateral canal is one fourth of that of the main canal, and all the lateral canals in the area have an identical discharge capacity.

Athar is a time share unit used on a falaj management corresponding to the amount that the lateral canal is capable of discharging in just half an hour.

Thus, 1 Athar = q x 0.5 hr = Q x 1/4 x 0.5 hr
where q = discharge capacity of the lateral canal
Q = discharge capacity of the main canal

This unit also represents the right to the water use and each farm household owns the right in certain units of Athar as determined by its farming scale. In order to obtain new rights to water use, the farm household is obliged to pay for the right in cash, the amount of payment varying depending on the contract period. In Awabi village, one unit of Athar is estimated to cost 70 to 140 R.O. per year.

The actual discharge that Athar represents in Awabi village is estimated as follows:

1 Athar = q x 0.5 hr
= q x 1/2 x 3,600 sec
= 27 90 m^3

q, however, denotes the discharge capacity of the lateral canal and varies depending on the capacity of the water source.

2.3.2 Coastal Area

The crop production in the coastal area is largely dependent on the groundwater pumped up from the hand-dug wells. The unit of irrigation system, as noted elsewhere, is the farm with the exclusive well and pumping station whose operational hours and discharge vary depending upon the type of crops planted and other farm management conditions such as the state of operation and maintenance of the facilities as well as the labor input affordable for the irrigation.

The irrigation method practiced is basin irrigation whereby an area of 20 to 40 square metres is circumscribed with levees.

The current irrigation supply was estimated by the actual measurement of the water use with a cumulative flow metre installed at 20 pumping stations (16 sample farms with 18 wells).

The monthly water use per unit area during the peak irrigation period of March to September ranges from 50 mm to 700 mm per month, with an average of 150 to 240 mm, as mentioned in Table E-2-7.

Among three types of farms (i.e., date palm mono-cropping farm, mixed farm of date palm, mango, and alfalfa, and newly developed farm of vegetables and alfalfa), the mixed farm requires the largest amount of irrigation water, then comes the newly developed farm while the intake at the date palm farm is rather low.

Table E-2-3 Land Use of Sample Farms in the Coastal Area

(Unit: ha)

No.	Meter No.	Items						Type of Farming
		Alfalfa	Vegetable	Date, Mango Lime	Pasture	Fallow	Total Area	
1	2541	-	3.70	-	-	4.70	8.40	New (vegetable) farm
2	2511	0.60	-	1.65	-	-	2.25	Mixed farm
3	2540							
4	2532	-	-	1.20	-	0.50	1.70	Date palm farm
5	1075	2.18	1.64	-	0.53	0.96	5.31	New farm with pasture
6	2551							
7	2549	0.80	0.90	1.10	-	-	2.83	New farm
8	2544							
9	2550	-	-	0.88	-	-	0.88	Date palm farm
10	2545	2.50	1.51	(2.50)	-	2.78	6.79	Mixed farm
11	2539	0.40	1.29	-	-	1.06	2.75	New farm
12	2519	0.95	0.46	1.55	-	-	2.96	Mixed farm
13	2538	-	-	0.46	-	-	0.46	Date palm farm
14	2534	0.29	-	1.32	-	-	1.61	Mixed farm
15	2546	0.94	-	1.00	-	-	1.94	Mixed farm
16	2537	1.20	1.71	1.20	-	0.32	4.43	Mixed farm
17	2548	-	-	3.44	-	0.39	3.83	Date palm farm
18	2535							
19	2547	-	-	0.33	-	-	0.33	Mixed farm
20	2543	0.46	-	2.80	-	0.25	3.51	Mixed farm

2.4 Domestic Water Use

Domestic water use has been surveyed at Barka and Al-Musanâah of the coastal area. In general, each household has its own hand-dug well to be used for miscellaneous purposes such as for livestock and laundry. This water is not potable since it has a high salinity content (E.C. value being 7,700 to 17,500 u/cm) as shown in Table E-2-4.

Domestic water is supplied by a water-wagon. There are several wells in the coastal area that supply high quality water exclusively for domestic use and these are located along Wadi Al-Eis in case of Al-Musanâah and in Al Naman in the case of Barka.

The E.C. value and water temperature for this domestic water are 1,070 us/cm and 33.1°C, respectively.

Domestic water is stored in a family water tank with a capacity of 0.5 to 1.5 m^3 and is used whenever necessary. Domestic water is delivered once every three to five days and it costs about 1 Rial-Omani per cubic metre.

Daily water consumption per capita is 22 liters of domestic potable water or about 100 liters inclusive of water for livestock and other miscellaneous uses.

Table E-2-4 Water Quality of Family Wells

Family	Well	Well Depth (m)	Water Temperature (°C)	E.C (μs/cm)	Remarks
A.	Hand dug	5.8	30.9	10,620	Al-Musana'ah
B.	"	6.5	31.4	7,720	"
C.	"	4.7	30.0	9,400	"
D.	"	2.5	30.0	17,530	Barka
E.	"	6.4	32.0	11,210	"
F.	"	4.5	30.8	7,770	"

Note; Surveyed on June to July 1983.

Table E-2-5 Domestic Water Consumption

Family	Items: Drinking Use: No. of Family	Drinking Use: Tank C. (m^3)	Drinking Use: Time	Drinking Use: (1) Volume Per day (m^3)	Drinking Use: Per Capita (m^3/man)	Other Use[1/]: Tank C. (m^3)	Other Use[1/]: Time	Other Use[1/]: (2) Volume Per day (m^3)	(1) + (2) (m^3)
(Musanåah)									
A.	38	1.47	1/3 day	0.490	0.013	1.06	2/day	2.12	2.61
B.	20	1.47	1/5 day	0.294	0.015	1.00	3/day	3.00	3.29
C.	9	1.00	1/4 day	0.250	0.028	0.50	1/day	0.50	0.75
(Barka)									
D.	11	0.73	1/4 day	0.183	0.017	0.73	1/2 day	0.37	0.55
E.	10	1.00	1/2 day	0.500	0.050	0.75	2/day	1.50	2.00
F.	10	0.43	1/5 day	0.086	0.009	0.43	2/day	0.86	0.95
Average	16			0.300	0.022			1.39	1.69

Note: 1/ Inclusive of water for livestock and laundry
° Date of Survey: Al-Musanåah June 22, 1983, Barka July 7, 1983
° Tank C; Tank Capacity

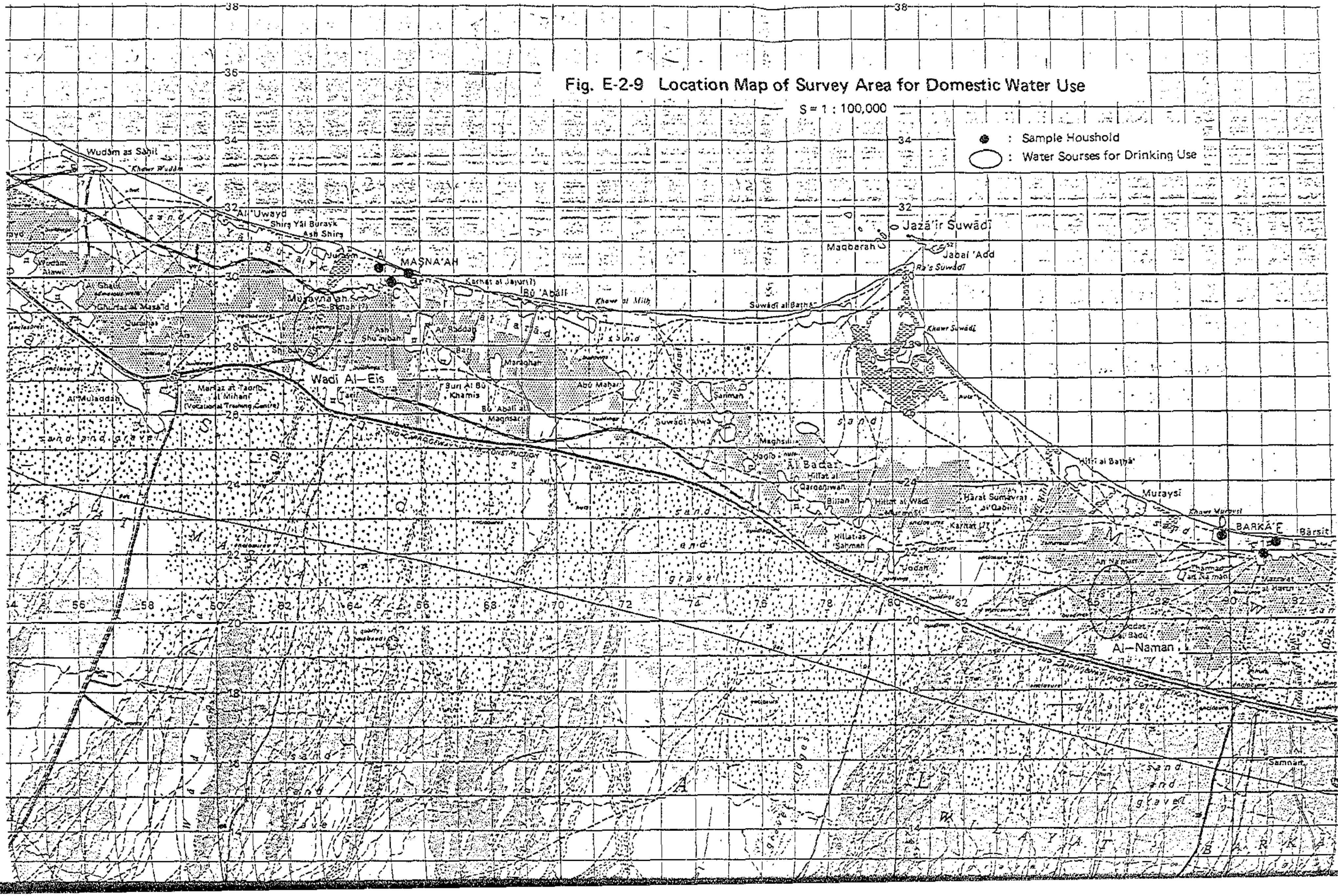


Fig. E-2-9 Location Map of Survey Area for Domestic Water Use

2.5 Water Consumption

2.5.1 Present Water Consumption

(1) Introduction

It is said that salt accumulation in the farm land of the Batinah Coast has become so critical as to reduce the local agricultural production. Many people explain this in relation with excessive consumption of the groundwater for irrigation in the coastal areas in particular.

For confirmation of this matter, the water consumption survey was conducted in the Wadi Al-Ma'awil basin and other four Wadi basins and direct observation of the actual water consumption was made to estimate the basin-wise water consumption based on the kinds of water consumption at present in the area.

The water consumption observation in the coastal area was made in 16 selected sample farm with cumulative flow meters installed at pumps for checking amount of discharges once or twice a month.

The water sources for the villages in the mountainous area depend on limestone springs, aflaj (qanat) and wadi flows, among which six aflaj have been selected as samples and staff gauges installed to regularly observe the water level together with the speed of current and water quality by EC meter.

The time series change in water used were studied for the period from March, 1983 to August, 1985. The observation records show clearly the specific features of the water use in the Area. Summary of the observations are as follows:

a) The annual average amount of water used for two years from 1983 to 1984 was approximately 233 MCM for irrigation and other miscellaneous purposes.

This value is equivalent to 2,333 mm/year for the whole Study Area.

Table E-2-6 Annual Water Consumption

Year	Mountain ('000m^3)	Coastal ('000m^3)	Total ('000m^3)
1983/84	169,455	108,196	277,651
1984/85	73,909	115,184	189,093
Mean	121,682	111,690	233,372
Water use per units (mm/year)	5,018	1,473	2,333
Area (ha)	(2,425)	(7,580)	(10,005)

In terms of the areas for water use, the mountainous areas consume much more water than the coastal areas, although consumption fluctuates heavily.

b) There is an extreme difference in water use between the coastal areas and gravel plains or mountain oasis. The former depends on groundwater as the water source and the water intake is made by pumping up of the water, which enables to control the water amount to respond to differences in individual consumption amounts, while the latter depends upon the natural runoff water sources such as falaj, limestone spring and wadi flow and the intake amount is uncontrollable and varies with yields of aflaj. In the latter case, therefore, the amount of intake does not always correspond to the effective consumption amount of water or the minimum consumption.

c) In the coastal areas, the monthly average amount of water use per unit acreage is about 180 mm, where as in the mountainous areas and gravel plains, about 400 mm.

d) In the coastal areas, inefficient irrigation practices have caused overdrafting at about half (50%) of the farms. There are some months when the water amount drafted has been almost more than double the actual irrigation water required. The farms which have used much more water than the average are those which are newly developed mixed farms with larger capacity pumps installed than the irrigation service acreages require.

Ordinarily, the amount of irrigation water for date mono-cropping farms is 45 mm to 150 mm/month on an average, which is smaller than that for mixed farms with alfalfa and tree crops.

e) The water amount of aflaj water sources in the mountainous areas ranges from 200 to 800 mm on average, except for such aflaj as Al-Bilad (Houqain) which is directly affected rain water runoff and particularly Al-Hazam which yielded much water in April, 1983. There is not much difference, however, in the decreasing trend of discharge among these aflaj.

f) In July, 1984 the falaj keepers issued reports about water shortage in every falaj. The amount of the falaj discharge was considered to be equal to the current minimum falaj requirement, just before the above-mentioned phenomenon took place. This amount is about 250 mm per month.

g) The survey which was conducted during a long spell of drought from August, 1983 to August, 1985, revealed that 24 aflaj (40%) out of surveyed 60 aflaj could not intake water at all, and if such drought should continue further, damages would increase considerably.

In summary, the survey has resulted in drawing attention to some important problems to solve regarding water use as follows:

i) Some farms have overdrafted the wells due to inefficient irrigation practices, which should be improved.

ii) The water quality of the wells in the sample farms was surveyed for EC values which ranged from 800 to 13,000 s/cm. The water with higher EC values is not suitable to irrigation. Even from a conservative standpoint, the water with EC values more than 3,000 s/cm should not be used for irrigation and some countermeasures should be taken for improving the quality of water sources.

iii) The wells provided in the farms in the coastal areas are operated and maintained by individual persons. An appropriate operation and maintenance standard should be drafted to define reasonable O&M services.

iv) The amount of water taken from the aflaj in the mountainous areas and gravel plains has a heavy seasonal fluctuation. It is necessary to establish some countermeasures for efficient water use to meet minimum requirements even when the yield is abundant, and also to look for ways to strengthen the water sources to secure the necessary water amount during the drought season.

(2) Water Use in the Coastal Areas

1) Water Sources Facilities

In the coastal area, the crops are grown by irrigation with pumped up groundwater. Consequently, the farms in this area are concentrated in places with silty soils which allow easy access to the groundwater to farming. As a result, densely planted land has been newly developed in a strip 3.0 to 5.0 km wide along the coast. Many wells for groundwater are hand dug wells about 10.0 m deep. Recently, however, farms increasingly provide about 100 ft. deep tube wells dug by new techniques, and in particular, almost of all farms in the newly reclaimed land along the highway have installed this type of tube well. The type of the pump unit employed at the hand dug well is a volute pump while a borehole pump is used for the deep wells.

The survey in the sample areas of Barka, Al-Musanâah, Al-Suwaiq, and Saham summarized the facilities of the water sources as mentioned before in Table E-2-2.

In detail, there have been about 4,100 wells in the whole survey Area of 7,580 ha, for which the farm owners have provided pumping units on an individual basis and operated them without any inter-relationship among the pumps.

2) Characteristics of Water Use in the Coastal Area

Table E-2-7 shows the amount of water used in the selected sample farms in the period between April, 1983 and March, 1985. Figure E-2-10 has been developed from the aforesaid table.

The monthly water use of all farms was about 165 mm on average in 1983/84 and 178 mm in 1984/85. There are large differences in annual water use per unit area by farm. According to the observation records for 1983/84 and 1984/85, the annual water use ranges from 630 mm to 5,330 mm per year (Table E-2-7(1) and (2)).

The characteristics of water use in the coastal plain can be summarized as follows:

i) In general, the peak of water use took place in the period from April to July.

ii) The amount of water used is different by crop. The mixed farms with tree crops of dates, mango, lime, etc. with alfalfa or other vegetable use 1.6 to 1.8 times (about 181 mm to 195 mm on a monthly basis) more water than that of the mono-cropping farm of dates (about 110 mm on a monthly basis).

iii) For farms with crops using more than about 2,000 mm of annual irrigation water (see Table E-2-12), the following characteristics were observed at more than two locations.

1. The area commanded by pump unit is small. (The capacity of pump per unit acreage is large.)
2. The newly reclaimed mixed farms used much more water for irrigation.
3. The borehole pumps are installed enabling drafting of much more water.
4. The farming lands have sandy soils.
5. The farmers concerned are very enthusiastic about farming works.

In other words, the following two kinds of farms are comparatively large water users.

I. The farmers concerned are very eager to irrigate the crops grown on the farms in spite of unfavourable soil conditions with sandy soils. Hence, they apply an inappropriate irrigation methods.)

II. The farms with larger capacity pumping facilities have a tendency to draft excessively. This is due to unreasonable application of irrigation technique.

The Lashio Farm represents the former case, while the Saham (II) Farm the latter.

The above two representatives farms are the largest water consumers of all.

On the other hand, many farms using little irrigation water have the following conditions.

1. The wells provided are hand-dug wells and water is poor in quality.
2. The yields of the wells are small.
3. Maintenance services are poorly provided for well facilities and pumps.
4. The farms carry out date mono-cropping where the planted trees are very old.
5. Labour is in sort supply.

All of these farms will become large consumers of water if the above troubles can be solved.

The reasons why a large amount of water is used on some farms are the ineffective water distribution system and the inefficient irrigation method. The former due to the fact that the irrigation and water distribution are performed at the same time, and the latter is due to the fact that a large amount of water is conveyed to the terminal fields through leaky farm ditches for flood irrigation which incur large conveyance losses and are deemed unsuitable to water-saving in agriculture. The data and information of the current water conveyance losses and irrigation efficiency should be examined in a further detailed survey.

The observation data of the water use in the selected sample farms is tabulated in Appendix E-2.

Table E-2-7 Monthly Average Water Use of Sample Farms

(Unit: mm)

Name of Sample Farm	1983 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	1984 Jan.	Feb.	Mar.	Total (mean)	Remarks
1. LASHICO	240	280	320	280	340	260	280	160	200	200	220	260	3,040 (253)	New Mixed Farm
2. BARKA(I)	140	180	200	150	80	140	200	180	200	200	180	180	2,030 (169)	"
3. BILLAH	160	180	200	240	140	140	160	120	120	100	120	160	1,840 (153)	"
4. MUSANAAH(III)	80	0	120	140	140	140	140	140	160	120	140	120	1,440 (120)	"
Average	155	160	210	203	175	170	195	150	170	155	165	180	(174)	
5. SAHAM(II)	400	400	470	470	440	390	200	170	210	150	80	150	3,530 (294)	Mixed Farm
6. BARKA(II)	280	150	150	300	300	300	300	180	240	230	200	190	2,820 (235)	"
7. MULADDAH	190	290	290	260	260	260	230	230	90	200	200	260	2,760 (230)	"
8. SWAIQ(I)	170	180	180	180	160	155	155	155	155	155	155	155	1,955 (163)	"
9. ABU-ABALI(I)	130	190	130	150	150	150	150	110	120	110	110	160	1,660 (138)	"
10. MUSANAAH(II)	110	190	160	160	120	50	70	120	120	110	110	110	1,430 (119)	"
11. MUNFASH	110	220	250	330	320	-	-	-	-	-	-	-	1,230 (246)	"
12. SAHAM(I)	90	90	110	110	110	70	25	-	-	-	-	-	605 (86)	"
Average	185	214	218	245	233	196	161	161	156	159	143	171	(187)	
13. UQDAH	130	130	170	270	180	220	160	160	160	200	250	280	2,310 (193)	Date Farm
14. MUSANAAH(I)	85	85	170	140	160	100	100	10	10	20	50	55	985 (82)	"
15. SWAIQ(II)	65	90	80	70	60	70	70	70	60	50	50	50	785 (65)	"
16. ABU-ABALI(II)	55	280	45	60	100	50	-	-	-	-	-	-	-	
Average	84	146	116	135	125	110	110	80	77	90	117	128	1,318 (110)	
Total and Average	2,435	2,935	3,045	3,310	3,060	2,495	2,240	1,805	1,845	1,845	1,865	2,130	29,010	
	152	183	190	207	191	166	160	139	142	142	143	164	(165)	
Average Mixed Farm	170	187	214	224	204	183	178	156	163	157	154	176	2,166 (181)	

Table E-2-7 Monthly Average Water Use in the Sample Farm (2)

(Unit: mm)

Name of Sample Farm	1984 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	1985 Jan.	Feb.	Mar.	Total (mean)	Remarks
1. LASHICO	280	300	360	280	300	330	390	340	240	140	230	120	3,210 (268)	New Mixed Farm
2. BARKA(I)	220	200	180	140	180	200	200	150	140	150	160	180	2,100 (175)	"
3. BILLAH	200	180	160	140	160	170	140	140	120	120	140	150	1,820 (152)	"
4. MUSANAAH(III)	200	240	200	100	180	200	130	200	140	100	150	180	2,020 (168)	"
Average	225	230	200	165	205	225	215	208	160	128	170	158	(191)	
5. SAHAM(II)	210	440	550	630	700	570	450	360	640	150	280	350	5,330 (444)	Mixed Farm
6. BARKA(II)	210*	220*	210*	-	-	-	-	-	-	-	-	-	-	
7. MULADDAH	260	260	260	260	260	270	180	330	230	40	120	200	2,670 (223)	"
8. SWAIQ(I)	180	180	180	110	110	120	150	130	140	60	150	120	1,630 (136)	"
9. ABU-ABALI(I)	160	180	170	170	100	40	40	140	150	150	-	-	1,300 (130)	"
10. MUSANAAH(II)	120	190	160	150	120	110	100	100	80	100	90	90	1,410 (118)	"
11. MUNFASH	-	-	-	-	-	-	-	-	-	-	-	-	-	"
12. SAHAM(I)	-	-	-	-	100	90	80	120	80	80	60	110	720 (90)	"
Average	186	250	264	264	232	200	167	197	220	97	140	174	(199)	
13. UQDAH	280	280	330	190	120	280	140	240	160	90	50	100	2,260 (188)	Date Farm
14. MUSANAAH(I)	55	50	210	160	80	20	-	-	-	-	-	-	575 (96)	
15. SWAIQ(II)	80	80	70	50	50	80	50	40	30	20	40	40	630 (53)	
16. ABU-ABALI(II)	-	-	-	-	-	-	-	-	-	-	-	-	-	
Average	138	137	203	133	83	127	95	140	95	55	45	70	(110)	
Total and Average	2,245 (187)	2,580 (215)	2,730 (228)	2,380 (198)	2,460 (189)	2,480 (191)	2,050 (171)	2,290 (191)	2,150 (179)	1,200 (100)	1,470 (134)	1,640 (149)	25,675 (178)	
Average Mixed Farm	206	240	232	215	219	213	191	203	190	113	155	166	2,343 (195)	

* Total and average water use is calculated except the data of Barka(II) farm

Table E-2-7 Monthly Average Water Use in the Sample Farm (3)

(Unit: mm)

Name of Sample Farm	1985 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	1986 Jan.	Feb.	Mar.	Total (mean)	Remarks
1. LASHICO	10	180	270	320										New Mixed Farm
2. BARKA(I)	190	210	190	190										"
3. BILLAH	130	160	130	120										"
4. MUSANAAH(III)	210	250	250	240										"
Average	135	200	210	218										
5. SAHAM(II)	400	530	340	220										Mixed Farm
6. BARKA(II)	-	-	-	-										"
7. MULADDAH	120	190	190	180										"
8. SWAIQ(I)	130	170	170	170										"
9. ABU-ABALI(I)	-	-	-	-										"
10. MUSANAAH(II)	130	160	180	150										"
11. MUNFASH	-	-	-	-										"
12. SAHAM(I)	80	30	50	90										"
Average	172	216	186	162										
13. UQDAH	50	20	90	90										Date Farm
14. MUSANAAH(I)	-	-	-	-										"
15. SWAIQ(II)	60	80	80	40										"
16. ABU-ABALI(II)	-	-	-	-										
Average	55	50	85	65										
Total and Average	1,510	1,980	1,940	1,810										
	(137)	(180)	(176)	(165)										
Average Mixed Farm	154	208	198	190										

Figure E-2-10 (1) Monthly Average Water Use (1)

Figure E-2-10(2) Monthly Average Water Use (2)

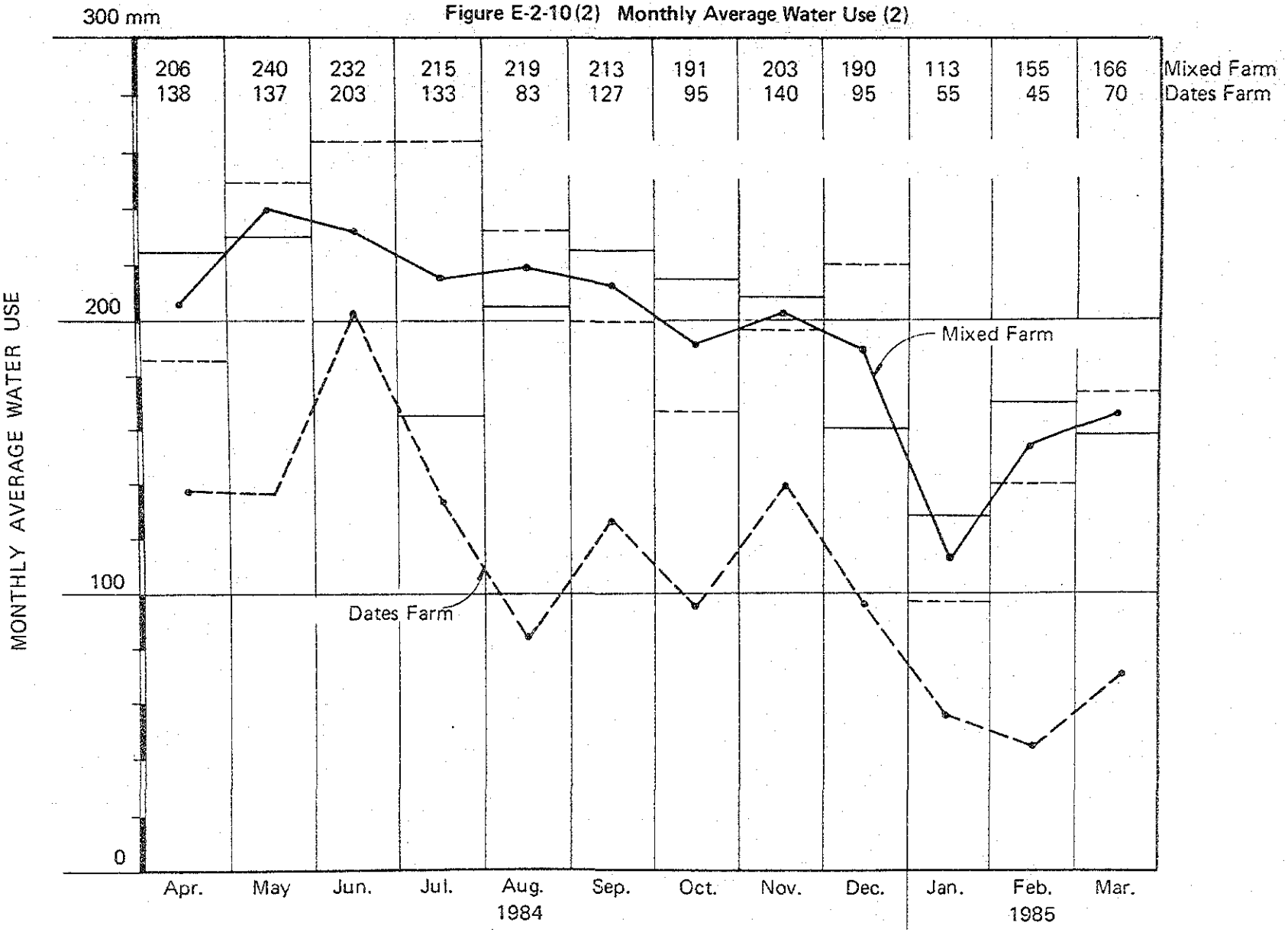


Table E-2-8 List of Sample Farms in the Coastal Area

Name of Production Farm	No. of Wells	No. of Pumps	Type of Farming	Land use (in ha)					
				Total	Alf.	Veg.	Dates, Lime	Pasture	Fallow
1. Barka (I)	1	2	New Veg. Farm	8.40	0.70	3.00	-	-	4.70
2. Barka (II)	1	2	Mixed Farm	2.25	0.30	-	1.65	-	0.30
3. Uqdah	1	1	Dates palm Farm	1.70	-	0.15	1.20	-	0.35
4. Lasico	2	2	New Mixed Farm	5.31	2.18	1.64	-	0.53	0.96
5. Billah	1	2	New Mixed Farm	2.80	0.80	0.90	1.10	-	-
6. Abu-Abali (I)	1	1	Mixed Farm	6.79	(2.50)	1.51	2.50	-	2.78
7. Abu-Abali (II)	1	1	Dates palm Farm	0.88	-	-	0.88	-	-
8. Musanaah (I)	1	1	"	0.46	-	-	0.46	-	-
9. Musanaah (II)	1	2	Mixed Farm	2.96	0.95	0.46	1.55	-	-
10. Musanaah (III)	1	1	New Mixed Farm	2.75	0.40	-	0.90	-	1.45
11. Muladdah	1	1	Mixed Farm	1.61	0.29	-	1.32	-	-
12. Munfash	1	2	"	2.90	0.90	-	1.00	-	1.00
13. Swaiq (I)	1	1	"	4.43	1.20	1.71	1.20	-	0.32
14. Swaiq (II)	2	2	Dates palm Farm	3.00	0.10	-	2.80	-	0.10
15. Saham (I)	1	1	Mixed Farm	3.51	0.30	-	2.16	-	1.05
16. Saham (II)	1	1	Mixed Farm	0.33	(0.05)	(0.05)	0.33	-	-
Total	18			50.08	8.12	9.37	19.05	0.53	13.01

Notes : 1) The above land use table is prepared based on the records available as of spring cropping, 1984.

2) Acreages in parenthesis are the lands cropped with those crops of alfalfa, dates, lime, Mango, etc. and some of the area are estimated in duplicate.

(3) Water Use in the Mountainous Area and Gravel Plain

1) Water Sources Facilities

As a result of surveying 24 major villages in the Project Area, the facilities of water sources in the mountainous area and gravel plain can be specified as follows.

a) Aflaj (Qanat) ..... 59% (35 Aflaj)
Limestone Spring ..... 23/% (14 springs)
Wadi flow intake by diversion weir ..... 18% (11 weirs)

b) Ordinarily in the Area, there are one or two water sources for one village, which have served for irrigation as well as domestic use.

c) The large villages like Nakhal, Al-Rustaq, and Hauqain, having a large-scale irrigation areas, are making the better use of aflaj, springs and wadi flows in combination.

d) The yield of the limestone springs has had little fluctuation for these two years. On the other hand, the amount of water intake from aflaj where wadi flow is easily affected by rainfall in the upstream basins, there has been much difference observed in the discharge between the wet season and the dry season. Therefore, the water intake from these sources are deemed to be unstable in general.

(2) Specific Features of Water Use

The intake amount from those sources in the mountain area and the gravel plain is affected by water collecting capacity of aflaj, yield of spring and the goundwater discharge of Wadi. There seems to be certain relationship existing between the water supply capacity of these sources and the related village size. The following show the actual water use and the characteristics of the water use for six selected aflaj as the results of 30 months continuous observation from March, 1983 to August 1985.

a) Comparison of the amount of water intake at six aflaj is shown in Figure E-2-11, which indicates that all six aflaj have a similar trend with regard to the water amount which had decreased since August, 1983. After such drastic decrease continued up to July, 1984[1/], such decreasing trend was mitigated, although recovery was not to a surplus amount.

Note; 1/ In the mountain area like Al-Rustaq, there was a rainfall of about 60 mm observed but there has been no significant rainfall observed since then.

b) The Falaj Hazam is more abundant in water than the other aflaj in the wet season. The said abundant water amount ranges from 2,000 mm to 5,000 mm for the monthly intake amount per unit acreage. Such amount reaches almost seven times as much as that of 300 to 800 mm/month at other aflaj.

c) The Falaj Al'bilad, where the wadi surface flow is used, showed a different tendency in its water use in the former aflaj of the observation period. This is because the direct diverted water intake is carried out at this falaj by diversion weir across the wadi and the water intake is directly affected by the rainfall in the upstream basin. It is shown that the wadi flow peaks fall on the water intake peak.

Since they are dependable water sources, the wadi and falaj that are easily affected by rainfall should be able to supply water stably even during a very long drought spell in the related basins.

The amount of water intake from the Falaj Al-Bilad shown in Figure E-2-11 has an extremely high peak corresponding to heavy rainfall in August, 1983. After that rainfall, the intake amount has decreased gradually. The maximum intake amount is about 1,300 mm/month, while the minimum is about 120 mm/month.

d) The intake amount from the Nakhal limestone spring (Al-Karid) has been decreasing since the observation started, but its yield is stable in a range from 250 mm to 350 mm on a monthly average basis.

e) The aflaj of Al-Maisre, Abu-Thalab (Al-Rustaq), and Al-Awabi show a similar tendency to each other in decrease in amount of water intake. In other words, the monthly water used of 400 mm has decreased to 200 mm in a year.

f) For other aflaj, observations were made in June, 1983, August of 1984 and 1985 to estimate the discharges available. As a result, it was found that these aflaj have the similar tendency in decrease in water intake amount to that of the aforesaid three aflaj.

For one drough year between August, 1983 and August, 1984, the water intake from the aflaj.(excepting for Falaj.Hazam) was in a range from 120 mm to 410 mm per month and about 230 mm/month on an average. In this period at August, 1984, the users of Aflaj. Al-Bilad and Abu-Thelab made complaints about water shortage.
Furthermore, for one year from August, 1984 to 1985, severe drought attacked the area and the water intake became more critical.
About 24 aflaj. of all in the Area (about 40 percent) suffered from severe drought when discharge was less than 10 percent of the discharge in June, 1983 when the discharge was comparatively abundant.

Based on the above, the minimum water requirement or the critical water requirement in the farm land in the mountain area is estimated as follows.

- A long spell of drought since August, 1983, had caused a gradual decrease in aflaj. discharge, and in this process, the discharge of the aflaj. just before the users of aflaj. water made complaints for water shortage can be considered as the minimum water necessary for the village.

- The time when such critical discharge appeard in the Area was around May and June, 1984, for the current survey. The discharge estimated for this two month period was about 250 mm to 300 mm per month per unit acreage.

- Based on 250 mm/month as the minimum water amount necessary, the relationship between capacity of falaj. "Q" and irrigation service area (farm land acreage in village) "A" can be expressed by the following equation.

  Where: Q = A
  Q: Necessary falaj.discharge (m^3/s)
  A: Irrigation Service area (ha)
  : Minimum water requirement

Therefore, 1 l/s of discharge in drought times is considered as the fundamental unit to cultivate the one hectare of the farm land in the Area.

$$Q = 250 \text{ mm/month} \times 1.0 \text{ ha}$$
$$= 0.250 \text{ m} \times 1/30 \times 1/8.64 \times 1.0 \text{ ha} \times 1{,}000$$
$$= 0.96 \text{ l/s/ha} \fallingdotseq 1.0 \text{ l/s/ha}$$

- The water intake amounts from a falaj for the one year from April, 1984 to March, 1985 is deemed as the minimum water use per year based on the monthly average of water intake of about 250 mm/month.

(4) Annual Water Use in Northern Batinah Coast

In the Batinah Coast Area covering about 10,000 ha, about 233 MCM of water is used annually for irrigation and domestic consumption. As shown in Table E-2-11, the annual water use in the mountainous area varies considerably by year from 169 MCM for 1983/84 and 74 MCM for 1984/85, whereas the annual water use in the coastal area has little yearly fluctuation. The former case has resulted from the fact that the yields of such water sources as aflaj and limestone springs are directly affected by rainfall occurrance time and amount.

On the other hand, the amount of water taken by pumps in the coastal area is little affected by rainfall which is scarce, and therefore, the water used in the area is almost equivalent to irrigation water in its amount. There will be little fluctuation in the annual amount of water pumped up in the coastal area if the cropping acreage and growing crops do not change.

The total water use in 1983/84 and 1984/85 for the whole Area including both the mountainous area and coastal area is 278 MCM and 189 MCM, respectively. The amount in 1984/85 which occurred in a severe drought year can be considered as an approximation of the present minimum water use necessary for villagers.

Under the circumstances, it can be understood that the approx. 89 MCM of water which is the difference between the used water in 1983/84 and 1984/85 would include the recharging water of the groundwater around aflaj in the mountainous area and gravel plain and the evapotranspiration.

The facts suggest that the water intake from water source to canal of aflaj in the wet season should be controlled for groundwater recharging.

Table E-2-9 Water Recources in the Mountain Area

Village	Area (A)	Water Source				Discharge (Aug.'84) (Q)		Q/A
		Total No.	Spring	Falaj	Wadi Flow			
	(ha)					(m^3/s)		(mm/m)
1. Al-Ajal	43.7	4	4	-	-	0.025		148
2. Hibra	116.4	1	-	1	-	0.058		129
3. Afi	137.6	3	-	3	-	0.116		219
4. Muslimat	111.7	2	-	2	-	0.045		104
5. Nakhal	236.5	14	7	5	2	0.118		130
6. Al-Abiyad	53.5	1	-	-	1	0.036		174
7. Layjah	-	1	-	1	-	-		-
8. Istal	41.6	1	-	1	-	0.019		118
9. Al-Musaynaah	58.0	1	-	1	-	0.030		134
10. Daris	12.9	1	-	1	-	0.006		121
11. Wustah	19.6	1	-	1	-	0.011		145
12. Ali	34.2	1	-	1	-	0.010		78
13. Hawqain	83.7	6	2	-	4	0.051		158
14. Jammah	71.4	2	-	2	-	0.158		574
15. Hazam	43.4	1	-	1	-	0.189		1,129
16. Subaykah	22.7	1	-	1	-	0.035		400
17. Wishal		1	-	1	-	0.090		
18. Wabal	675.8	1	-	1	-	0.012	0.438	168
19. Rustaq		9	1	8	-	0.336		
20. Awabi	76.6	1	-	1	-	0.094		318
	(112.7)							(216)
21. Fashah	28.8	1	-	1	-	0.018		162
22. Amq	18.9	2	-	2	-	0.009		123
23. Al-Hail	8.4	1	-	-	1	0.012		370
24. Al-Gbozaifah	23.5	3	-	-	3	0.073		805
Total	1,955.0	60	14	35	11	1.551		5,707
Total (%)			(23)	(59)	(18)			(272)

Table E-2-10 Monthly Water Use of Falaj

(Unit: mm/ha)

Month	Name of Falaj						Average 1/
	Al-bilad	Ab-Thalab	Maisre	Awabi	Al-Karid	Hazam	
Mar. '83	-	-	-	-	-	-	-
Apr.	-	790	610	560	340	3,800	575 (1,220)
May	-	930	740	640	630	5,210	735 (1,630)
Jun.	710	800	620	550	560	4,480	648 (1,287)
Jul.	570	800	690	520	470	4,200	610 (1,208)
Aug.	1,100	840	630	490	500	3,700	712 (1,210)
Sep.	1,270	700	580	560	540	3,500	730 (1,192)
Oct.	1,150	700	580	570	560	3,800	712 (1,227)
Nov.	750	860	490	520	460	3,600	616 (1,113)
Dec.	670	610	390	510	440	3,100	524 (953)
Jan. '84	540	570	320	520	440	3,250	478 (940)
Feb.	430	440	370	420	380	2,850	408 (815)
Mar.	490	300	330	470	300	2,720	378 (768)
Apr.	400	300	340	320	380	2,730	348 (745)
May	330	240	320	290	360	3,050	308 (765)
Jun.	250	200	320	310	400	2,500	296 (663)
Jul.	210	160	310	330	340	1,300	270 (442)
Aug.	160	160	220	410	350	1,400	260 (450)

Table E-2-10 Monthly Water Use of Falaj (Cont'd)

(Unit: mm/ha)

Month	Name of Falaj						Average 1/
	Al-bilad	Ab-Thalab	Maisre	Awabi	Al-Karid	Hazam	
Sep. '84	160	250	230	310	370	960	264 (380)
Oct.	120	210	250	270	350	840	240 (340)
Nov.	140	210	210	240	280	560	216 (273)
Dec.	250	210	210	210	240	540	224 (277)
Jan. '85	250	210	210	210	310	530	238 (287)
Feb.	240	200	190	200	330	490	232 (275)
Mar	200	170	180	200	310	360	212 (237)
Apr.	220	170	150	190	260	200	198 (198)
May	260	200	140	180	320	180	200 (213)
Jun.	280	150	150	-	260	180	210 (204)
Jul.	250	130	120	-	270	120	193 (178)
Total Average	438	411	354	385	384	2,148	395
Apr.'83 to Mar. '84 Average	701	695	529	528	468	3,684	584 (1,101)
Apr.'84 to Mar. '85 Average	226	210	249	275	335	1,270	259 (428)

Note: 1/ Average of "Water use" is estimated with Five Aflaj except Falaj Hazam.

Fig. E-2-11 Monthly Water Use (Discharge) of Sample Falaj

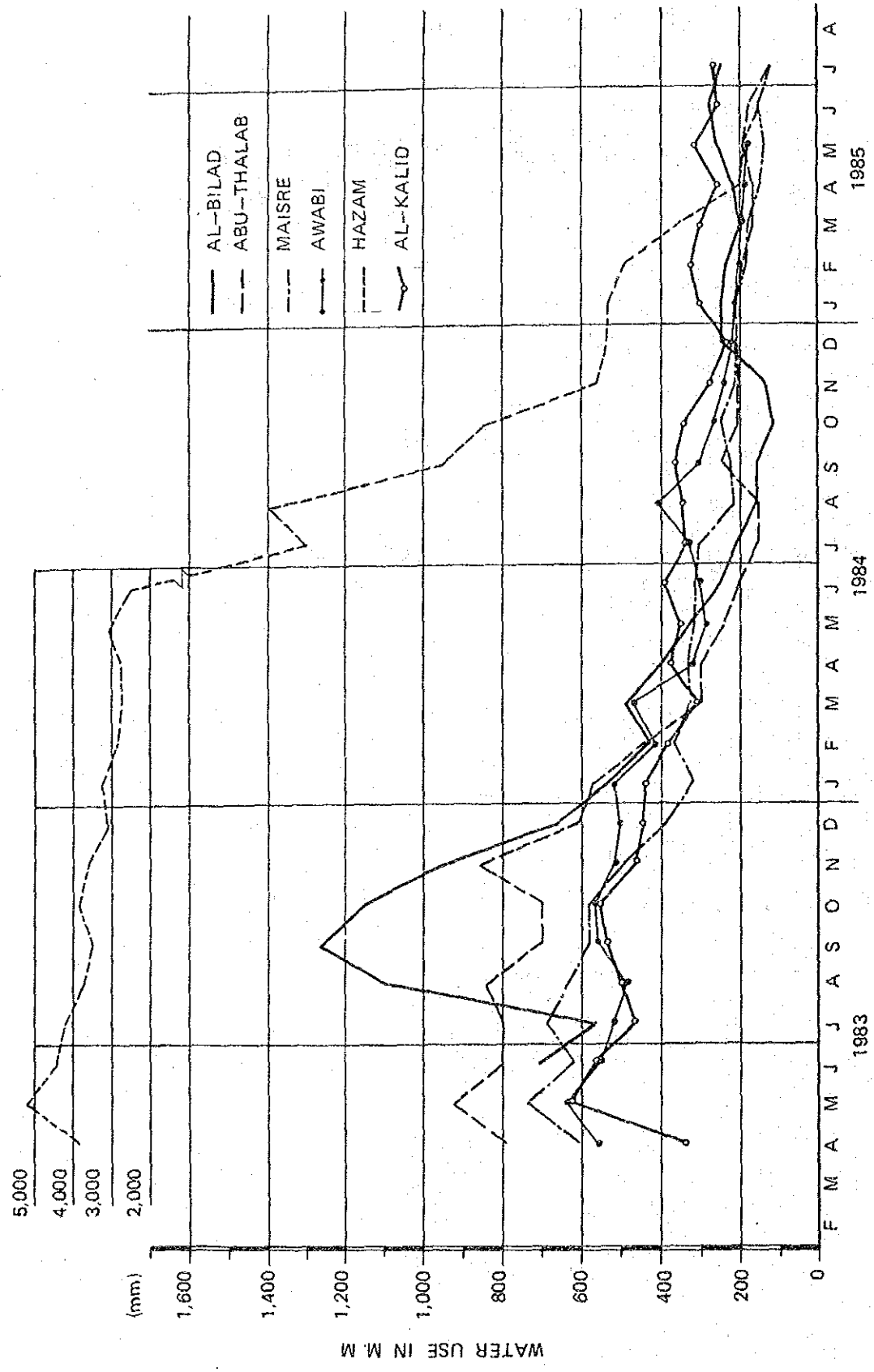


Fig. E-2-12 Hydrograph of Aflaj

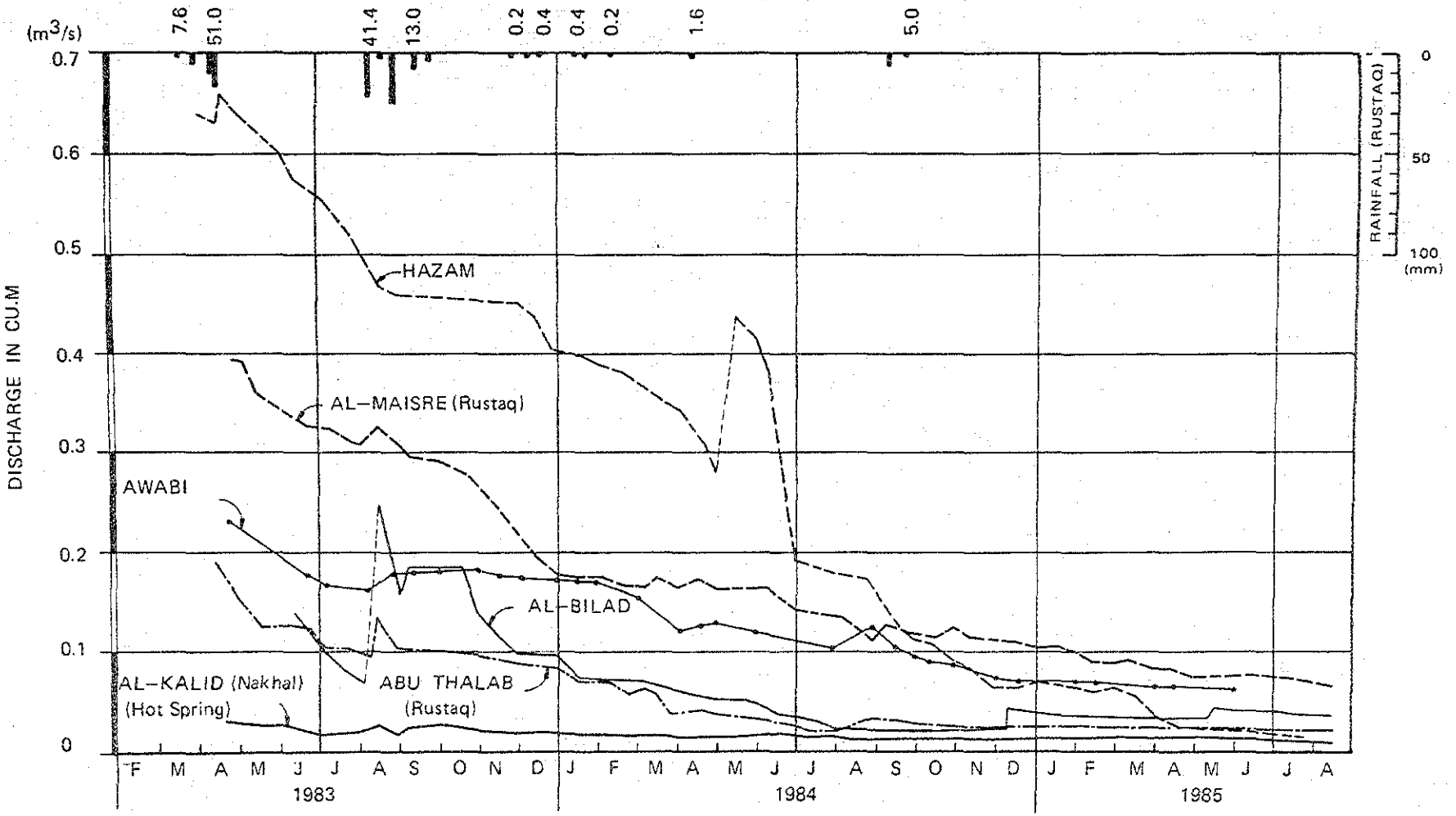


Fig. E-2-13 Monthly Average Water Use of Aflaj

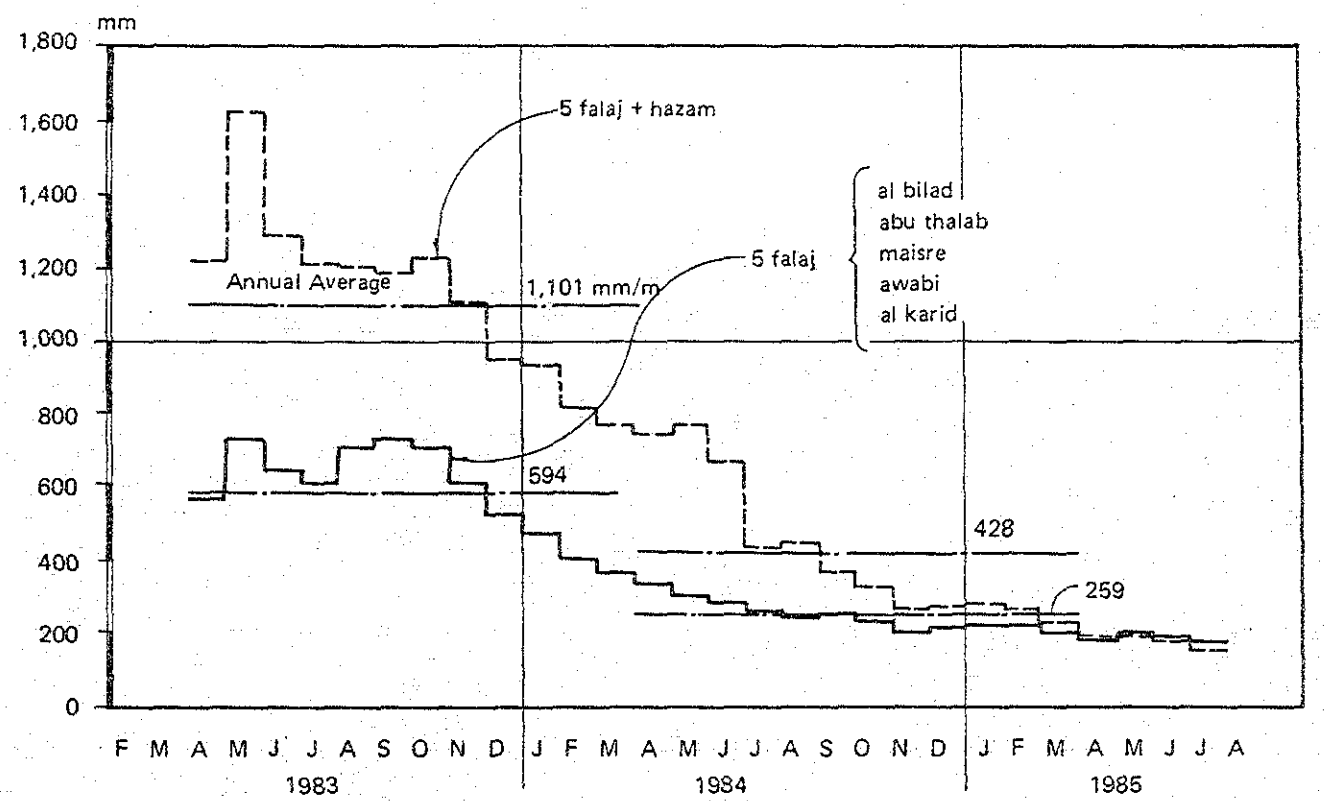


Table E-2-11 Annual Water Consumption by Wadi

Item		Irrigation Area			Used Water		
		Coastal	Mountain	Total	Coastal	Mountain	Total
Ahin	83/84	540	73	613	7,708	4,901	12,609
	84/85	"	"	"	8,205	2,140	10,345
	mean	"	"	"	7,956	3,521	11,477
Bani-Ghafir	83/84	1,830	298	2,128	26,121	20,212	46,333
	84/85	"	"	"	27,808	8,814	36,622
	mean	"	"	"	26,965	14,513	41,478
Fara	83/84	1,680	1,084	2,764	23,980	76,175	100,155
	84/85	"	"	"	25,529	33,224	58,753
	mean	"	"	"	24,754	54,700	79,454
Bani-Kharus	83/84	1,440	269	1,709	20,556	18,614	39,170
	84/85	"	"	"	21,882	8,118	30,000
	mean	"	"	"	21,219	13,366	34,585
Ma'awill	83/84	2,090	701	2,791	29,831	49,554	79,385
	84/85	"	"	"	31,760	21,613	53,373
	mean	"	"	"	30,796	35,584	66,379
Total	83/84	7,580	2,425	10,005	108,196	169,455	277,651
	84/85	"	"	"	115,184	73,909	189,093
	mean	"	"	"	111,690	121,682	233,372

For information, the monthly water use by wadi and by districts are shown in Appendix E-1.

In addition, the water use is computed by the following procedures.

i) The unit water use for the coastal area was determined by dividing it into the following two parts, taking into consideration the present status of cropping in the area.

a. Mixed Farms; Those farms which are grown with tree crops like dates, lime mango, etc. and alfalfa, vegetables, etc. in combination

b. Date Farms; Those farms which carry out date palm mono-culture.

The unit water requirement is taken as the average value of the monthly measured amount of water used according to the records taken at selected 16 sample farms of each group.

ii) The unit water use for the villages in the mountainous area and the gravel plain was determined based on the measured values of the amount of water used in the selected six sample aflaj after taking into account the type of water sources as aflaj, limestone springs and wadi flow. The selected aflaj are the Al-Bilad (Houqain), Al-Maisre, Abu-Thalab (Al-Rustaq), Al-Hazam, Awabi and Al-Karid (Nakhal). The unit water requirement, however, was computed by using all records excepting those of Hazam which is the largest water user of all six aflaj.

iii) The irrigation service acreage was determined based on the aerial photos of the Area and the acreage obtained was applied without any changes from 1983 to 1985.

2.5.2 Water Use and Water Management

(1) Study on Water Use

It is realized that salinity concentration has been making considerable intrusion into the soils and groundwater in the coastal area. It it said that overdrafting of the groundwater is one of the reasons for such salinity concentraiton.

The current survey was made to measure the actual water use (pumping up of the groundwater) in the coastal area continuously for two years. The study was made on the amount of actual water use by comparing the above measured data with the calculated crop water requirements based on meteorolgical data and measurement values of evaporation from water surface.

The measurement records show that the annual water use per unit acreage (ha) varied widely from 630 mm to 5,300 mm, differing by water management method at each farm and capacity of the respective water sources. The measurement records for 16 farms for two years (1983/84 to 1984/85) revealed that the actual water amount used ranges from 2,045 mm to 2,163 mm on the annual average.

In general, mixed farms are found to be larger water users than the mono-croppng farms of date palms.

The aforesaid 16 farms were divided into the following three types by their crops grown, and comparison was made on water amount used between measurement values and calculated values at the selected farm which used the largest amount of water in the farming group specified. The results of comparison are shown in Figure E-2-14.

(I) New Mixed Farm: (Lashico)

The New Mixed Farms are reclaimed recently with tree crops, alfalfa and vegetables grown in combination, and the trees dotted in the alfalfa fields are mostly young. Borehole type pumps are commonly used in the field. These New Mixed Farms are found mainly along the highway or in the southern part therefrom.

(II) Mixed Farms: (Saham II)

The mixed Farms are those which grow tree crops of dates, mango and lime, and alfalfa and vegetables in mixture. Most of the crop trees are 15 to 20 years old. Most of these farms are found in the area extending between the highway and the seashore, although a little apart from the seashore.

(III) Date Palm Farms: (Uqdah)

These farms are found along the coastal area and carry out date mono-cropping. Some of them however, grow alfalfa in parts of the farms.

The comparison made for the above three types of farms can be summarized as follows:

i) Both measurement values and calculated values show peak water use in the months of June and July, the bottom in the months from December through February, although there is a slight variation found among farms. In August, the mixed farms were much larger users than other farms.

ii) The cropping patterns of the farms are almost the same in the years 1983/84 and 1984/85, but there is a large difference in amount of water used annually.

In the case of Saham II, a considerable difference was observed between the monthly water requirement of 200 mm and the amount of water actually used of 400 mm (1983) and 600 mm (1984). In short, it can be said that no regulation has been established yet in the use of water.

iii) There was significant annual overdraft at the farms of Lashico, Saham (II) and Uqdah: 81 percent (1,401 mm), 92 percent (2,120 mm) and 33 percent (562 mm) respectively, against their disigned water requirements. (See Table E-2-12)

iv) On the assumption that the calculated water requirements per unit acreage are almost the same for the farms with similar cropping pattern, about 50 percent of all the farms would overdraft, whereas the remaining 50 percent would be irrigated with less water than the requirement, as shown in Table E-2-12. In 1983/84, seven out of 13 farms overdrafted. The amount overdrafted was about 21 percent of the whole on average.

In other words, there are some farms over irrigating mainly because of unsuitable irrigation methods applied at present, lack of knowledge of irrigation, and ineffective and inefficient management/maintenance of many wells and pumps on an individual basis services.

(2) Present Water Management and Its Problems

It can be said that for minimum subsistence village life in arid zones it is necessary to perform successful water management. In other words, it is necessary to secure stable water supply for irrigation of the farms belonging to the villages in the arid zones and to make stringently fair distribution of the water available according the individual rights to use it.

The relationship between villages and their water sources has been changing historically and socially. However, all villages essentially require to have a water supply corresponding to their own scale, and villages have been making a great effort to practice successful operation and maintenance of their water sources. Water source facilities have different size and structure by their local conditions, particularly natural conditions. Operation and maintenance services are rendered to meet various types and conditions of the facilities.

Fig. E-2-14 Monthly Water Use in Sample Farm

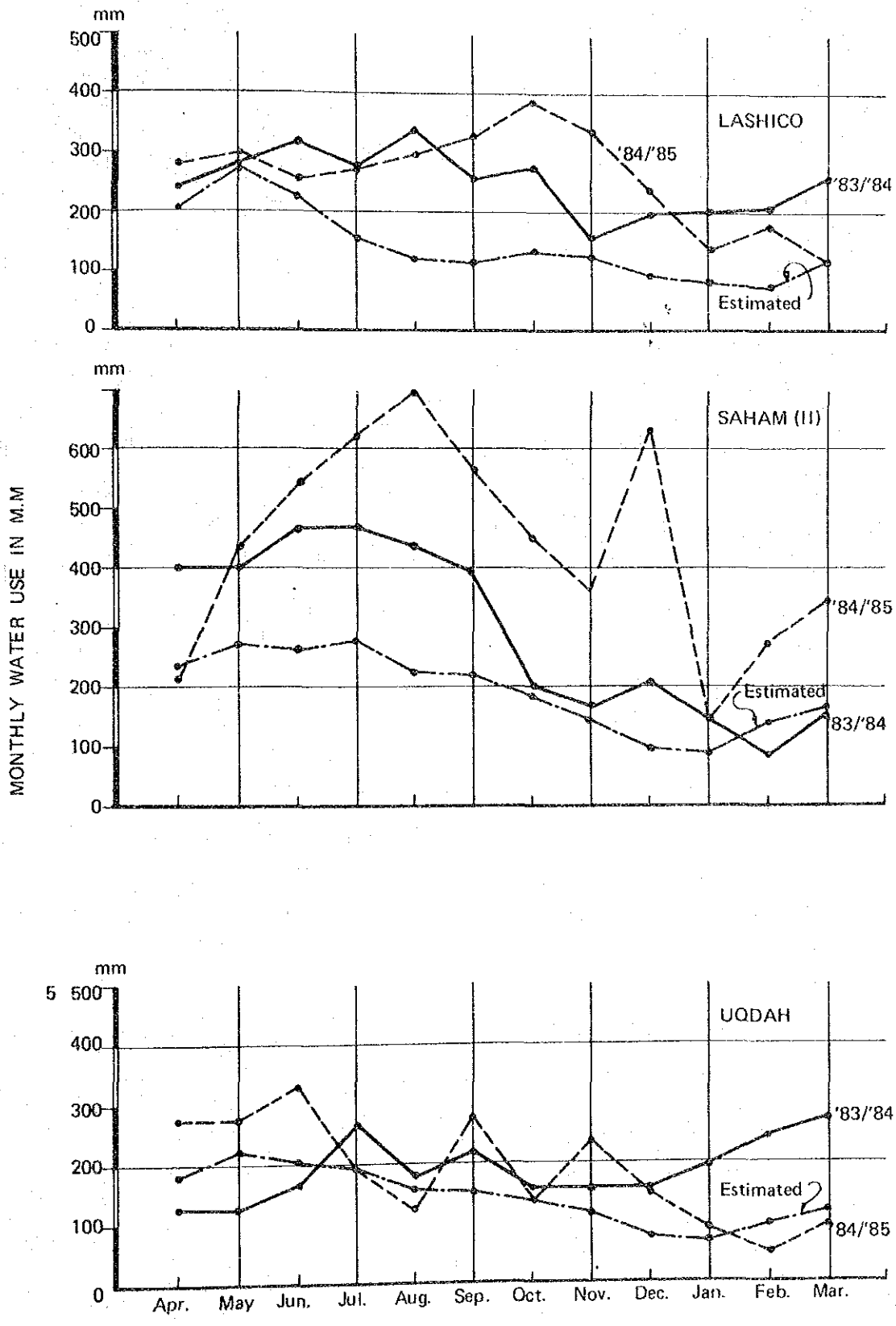


Table E-2-12 Water Use of Sample Farms

(Units; mm)

Sample Farm	Annual Water Use '83/'84 Estimated	'83/'84 Observed	'83/'84 Diff.	'84/'85 Observed	'84/'85 Diff.	Mean (Overdraft)	
(New Mixed Farm)	(1)	(2)	(3)=(2)-(1)	(4)	(5)=(4)-(1)	((3)+(5))/2	x100/(1)
1. Lashico	1,724	3,040	1,316	3,210	1,486	1,401	(81)
2. Barka (I)	"	2,030	306	2,100	376	341	(20)
3. Billah	"	1,840	116	1,820	96	106	(6)
4. Musanaah (III)	"	1,440	(-284)	2,020	296	-6	(0)
(Mixed Farm)							
5. Saham (II)	2,310	3,530	1,220	5,330	3,020	2,120	(92)
6. Barka (II)	"	2,820	510	-	-	510	(22)
7. Muladdah	"	2,760	450	2,670	360	405	(18)
8. Swaiq (I)	"	1,955	(-355)	1,630	(-680)	-518	(0)
9. Abu-Abali (I)	"	1,660	(-650)	1,300	(-1,010)	-830	(0)
10. Musanaah (II)	"	1,430	(-880)	1,410	(-900)	-890	
11. Munfash	-	-	-	-	-	-	(-)
12. Saham (I)	-	-	-	-	-	-	(-)
(Dates palm Farm)							
13. Uqdah	1,723	2,310	587	2,260	537	562	(33)
14. Musanaah (I)	"	985	(-738)	-	-	-738	(0)
15. Swaiq (II)	"	785	(-938)	630	(-1,093)	-1,016	(0)
16. Abu-Abali (II)	-	-	-	-	-	-	(-)
Total/Mean	25,925		4,505		6,171	5,445	(21)
° Number of Farm (Overdraft)	13	13	7	11	7		
° Mean (mm)	1,994		644		882		

Table E-2-13 Estimated Crop Water Requirement at Sample Farms

Items		Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1) Reference crop[1/] Evapotranspiration Eto; (mm)		211	246	231	242	200	192	162	130	84	79	127	148	2,052
2) ETcrop (mm)														
° Aflalfa	Kc	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	
	ETcrop	179	209	196	206	170	163	138	111	71	67	108	126	
° Dates (dense)	Kc	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	for saham
	ETcrop	190	221	208	218	180	173	146	117	76	71	114	133	
° Dates (sparse)	Kc	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	for uqdah
	ETcrop	148	172	162	164	140	134	113	91	59	55	89	104	
° Summer and Winter Crop	Kc	0.7	0.95	0.65	-	-	-	0.4	0.7	1.0	0.8	-	0.4	
	ETcrop	148	234	150	-	-	-	65	91	84	63	-	59	
3) Water Requirement (Qn = ETcrop x 1/Ep x LR x An/Ac)														mm/ha
° Lasico Farm		207	275	220	147	121	116	133	128	96	82	77	122	1,724 (New Mixed)
° Saham (II) Farm		238	276	260	273	225	216	183	146	95	89	143	166	2,310 (Mixed)
° Uqdah Farm		185	224	201	188	156	149	136	114	77	70	99	124	1,723 (Dates)

where: An; Cropped acreage of each crop in ha
Ac; Cultivated area through the year in ha
Ep; Irrigation Efficiency (0.8)
LR; Leaching requirement (0%=1.00)

1/; ETo is calculated by Pan Evaporation Method

Table E-2-14 Cropping Pattern and Crop Coefficient (Kc Value)

Sample Farm		1983 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	1984 Jan.	Feb.	Mar.	Cult. Area (ha)
	Kc	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	
Lasico		Alfalfa A = 2.18 ha (Lime Young Tree)												3.82
	Kc	0.7	0.95	0.65				0.4	0.7	1.0	0.8		0.4	
		Summer Crops A = 1.64 ha						Winter Crops A = 1.64 ha						
		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
Saham (II)		Dates A = 0.33 ha (Double cropping with alfalfa and veg.)												0.33
	Kc	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	
Uqdah		Dates A = 1.20 ha												1.35
	Kc	0.7	0.95	0.65				0.4	0.7	1.0	0.8		0.4	
		Summer Crops A = 0.15 ha						Winter Crops A = 0.15 ha						

1/ Kc Value: Sourced by F.A.O. Irrigation and Drainage Paper 24. However, Kc Values for Date Palm trees are avaraghd and take into account field condition.

In the Study Area, the water sources can be typically classified into two types: aflaj in the mountainous and gravel plains areas and wells/pump-up facilities in the coastal area.

In this classification, the former is a natural intake from aflaj, limestone springs and wadi flow, while the latter is an artificial intake by pumping up from wells and tubewell.

The operation and maintenance of the water source facilities of the former case has been made collectively on a group basis, while of the latter case it is made quite individually.

The villagers in the mountain area have to make a reasonable and fair distribution of the communal and limited water sources based limitation of time share and quantity according to a rule. In the village of Awabi, irrigation has been practised communally based on the unit of water distribution named "Athar". All the distribution canals in the village provide the capacity of a quarter of the main canal based on the water amount at water source.

The unit of Athar is equivalent to an amount of water that can flow through the village irrigation canals for 30 minutes. (Water Use Right)

The farmers in the area have practiced irrigation of their own farm land in fixed order and with allocated numbers of Athar of water corresponding to the scale of their own land. The supervisors or executors of such irrigation practices according to the said rule are the chief of each village and Wakir, the person in charge of the water management of the falaj.

One Athar of water in the village of Awabi was found to be about 50 m^3 (30 s/s x 0.5 hours).

On the other hand, the operation and maintenance of the wells and pumping facilities in the coastal area have been carried out complete on a individual basis. The pumping units are commonly operated in the following manner.

- Operation days ..... 200-300 day/year
- Operation hours (peak time) ..... 9 hrs.
  (6:00-12:00AM 3:00-6:00PM)
- Pumping capacity ..... 3 - 7 liter/sec.

The amount of groundwater drafted varies by kind of well and operation hours, and there is no inter-relationship among wells in any respect.

In conclusion, the following matters can be mentioned for the current water management for the water use in the Study Area.

i) Water distribution from the aflaj in the mountainous area has been carried out communally according to the rule of the water management, and it is recommended to continue this method in the future as well.

ii) There has been no rule on the water management for the wells and pumps installed in the coastal area. This fact has allowed overdrafting in the area, but the situation should be re-examined for the better use of the precious water.

iii) Operation and maintenance of the water sources in the coastal area should be studied carefully for restriction of drafting hours, improvement of the irrigation methods, and rationalization and arrangement of water sources.

2.5.3 Some Problems on Future Water Use

It is essentially required to tackle and solve the following problems for appropriate future water use due to the limited water resources in the Study Area in order to secure stable crop production in the Area.

For the Coastal Area

1) A status survey should be conducted on the existing facilities of wells, pumps, etc. for water use to clarify their function and the quality of water concerned. It is also necessary to solve various problems such as improvement of well facilities, repair and improvement of pumping facilities, and rearrangement of well location for effective water use, etc.

2) In the Study Area, the increase in water use has been seen as a serious problem, and it is deemed, in many cases, that such problems take place primarily on the newly reclaimed farms.

Approval for reclamation of farms should be given based on the promise that the new farm have an appropriate size with proper capacity of the pumps and wells which are to be reasonably laid out and that operation and maintenance of these facilities will be practiced in an appropriate and effective manner. Under such circumstances the procedure for approval of new farms should be carefully restudied. Powerful administrative guidance should be given to farm owners so that they will execute effective and proper water intake with discharge meters on the like installed on the pumping facilities. In addition, research and study should be made to introduce sprinkler irrigation and/or drip irrigation as a kind of water-saving pressure on the farms.

3) The total resolution of these problems can be realized only by re-deployment of water source facilities including unification and abolishment for both existing farms and newly reclaimed farms, modernization of irrigation system by providing distribution pipelines, and so on. It is essential that the effective and efficient management should be performed for both the water sources and irrigation.

Appendix E-1

Calculation of Monthly Water Use by District.

MONTHLY WATER USE BY DISTRICT (VILLAGE)

(WADI: Ahin) (Units: '000m^3)

Items	Farm Area (ha)	Irrigation Area (ha) 1/	Year 1983 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year 1984 Jan.	Feb.	Mar.	Total Water Use ('000m^3)	Remarks
Unites water use in Coastal Area																
for Mixed Farm (mm/ha/month)			170	187	214	224	204	183	178	156	163	157	154	176		
for Dates palm Farm (mm/ha/month)			84	146	116	135	125	110	110	80	77	90	117	128		
(1) Coastal Area																
Mixed Farm 2/ (69%)	372.6	279.5	475	523	598	626	570	511	498	436	456	439	430	492	6,054	
Dates Farm 2/ (31%)	167.4	125.5	105	183	146	169	157	138	138	100	97	113	147	161	1,654	
Sub-Total	540.0	405.0	580	706	744	795	727	649	636	536	553	552	577	653	7,708	
Unites Water Use in the Gravel plain and Mountain Area (mm/ha/month)			575	735	648	610	712	730	712	616	524	478	408	378		
(2) Gravel plain & Mountain Area																
village Al-Hail	8.4	8.4	49	62	55	51	60	61	60	52	44	40	34	32	600	
Al-Ghozaifah	23.5	23.5	135	173	152	144	167	172	167	145	123	112	96	89	1,675	
Other	41.0	36.9	212	271	239	225	263	269	263	227	194	173	151	139	2,626	
Sub-Total	72.9	68.8	396	506	446	420	490	502	490	424	361	325	281	260	4,901	
Total	612.9	473.8	976	1,212	1,190	1,215	1,217	1,151	1,126	960	914	877	858	913	12,609	

Note: 1/ The existing irrigation areas are estimated as follows according to the present land use.
Coastal Area ; Farm Area x 75%
Gravel Plain & Mountain Area; Village ... Aerial Photograph
Others .... Farm Area x 90%

2/ In the coastal areas, land use allocation is made for mixed farm by 69% and dates farm by 31% based on the results of Sample Survey for Musanaah and Saham.

MONTHLY WATER USE BY DISTRICT (VILLAGE)

(WADI: Ahin) (Units: '000m^3)

Items	Farm Area (ha)	Irrigation Area (ha) 1/	Year 1984 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year 1985 Jan.	Feb.	Mar.	Total Water Use ('000m^3)	Remarks
Unites water use in Coastal Area																
for Mixed Farm (mm/ha/month)			206	240	232	215	219	213	191	203	190	113	155	166		
for Dates palm Farm (mm/ha/month)			138	137	203	133	83	127	95	140	95	55	45	70		
(1) Coastal Area																
Mixed Farm 2/ (69%)	372.6	279.5	576	671	648	601	612	595	534	567	531	316	433	464	6,548	
Dates Farm 2/ (31%)	167.4	125.5	173	172	255	167	104	159	119	176	119	69	56	88	1,657	
Sub-Total	540.0	405.0	749	843	903	768	716	754	653	743	650	385	489	552	8,205	
Unites Water Use in the Gravel plain and Mountain Area (mm/ha/month)			348	308	296	270	260	264	240	216	224	238	232	212		
(2) Gravel plain & Mountain Area																
village Al-Hail	8.4	8.4														
Al-Ghozaifah	23.5	23.5														
Other	41.0	36.9														
Sub-Total	72.9	68.8	239	212	204	186	179	182	165	149	154	164	160	146	2,140	
Total	612.9	473.8	988	1,055	1,107	954	895	936	818	892	804	549	649	698	10,345	

Note: 1/ The existing irrigation areas are estimated as follows according to the present land use.
Coastal Area ; Farm Area x 75%
Gravel Plain & Mountain Area; Village ... Aerial Photograph
Others .... Farm Area x 90%

2/ In the coastal areas, land use allocation is made for mixed farm by 69% and dates farm by 31% based on the results of Sample Survey for Musanaah and Saham.

MONTHLY WATER USE BY DISTRICT (VILLAGE)

(WADI: Bani Ghafir)

(Units: '000m^3)

Items	Farm Area (ha)	Irrigation Area (ha) 1/	Year 1983 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year 1984 Jan.	Feb.	Mar.	Total Water Use ('000m^3)	Remaeks
Unites water use in Coastal Area																
for Mixed Farm (mm/ha/month)			170	187	214	224	204	185	178	156	163	157	154	176		
for Dates palm Farm (mm/ha/month)			84	146	116	135	125	110	110	80	77	90	117	128		
(1) Coastal Area (Swaiq)																
Mixed Farm 2/ (69%)	1,262.7	947.0	1,610	1,771	2,027	2,121	1,932	1,733	1,686	1,477	1,544	1,487	1,458	1,667	20,513	
Dates Farm 2/ (31%)	567.3	425.5	357	621	494	574	532	468	468	340	328	383	498	545	5,608	
Sub-Total	1,830.0	1,372.5	1,967	2,392	2,521	2,695	2,464	2,201	2,154	1,817	1,872	1,870	1,956	2,212	26,121	
Unites Water Use in the Gravel plain and Mountain Area (mm/ha/month)			575	735	648	610	712	730	712	616	524	478	408	378		
(2) Gravel plain & Mountain Area																
village Daris	12.9	12.9	74	95	84	79	92	94	92	79	68	62	53	49	921	
Wustah	19.6	19.6	113	144	127	120	140	143	140	120	103	94	80	74	1,398	
Ali	34.2	34.2	197	251	222	209	244	250	244	211	179	163	140	129	2,439	
Hawqain	83.7	83.7	481	616	542	510	596	611	596	515	439	400	341	316	5,963	
Others	148.0	133.2	766	979	863	813	948	972	948	820	698	637	543	504	9,491	
Sub-Total	298.4	283.6	1,631	2,085	1,838	1,731	2,020	2,070	2,020	1,745	1,487	1,356	1,157	1,072	20,212	
Total	2,128.4	1,656.1	3,598	4,477	4,359	4,426	4,484	4,271	4,174	3,562	3,359	3,226	3,113	3,284	46,333	

Note: 1/ The existing irrigation areas are estimated as follows according to the present land use.
Coastal Area ; Farm Area x 75%
Gravel Plain & Mountain Area; Village ... Aerial Photograph
Others .... Farm Area x 90%

2/ In the coastal areas, land use allocation is made for mixed farm by 69% and dates farm by 31% based on the results of Sample Survey for Musanaah and Saham.

MONTHLY WATER USE BY DISTRICT (VILLAGE)

(WADI: Bani Ghafir) (Units: '000m^3)

Items	Farm Area (ha)	Irrigation Area (ha) 1/	Year 1984 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year 1985 Jan.	Feb.	Mar.	Total Water Use ('000m^3)	Remaeks
Unites water use in Coastal Area																
for Mixed Farm (mm/ha/month)			206	240	232	215	219	213	191	203	190	113	155	166		
for Dates palm Farm (mm/ha/month)			138	137	203	133	83	127	95	140	95	55	45	70		
(1) Coastal Area (Swaiq)																
Mixed Farm 2/ (69%)	1,262.7	947.0	1,951	2,273	2,197	2,036	2,074	2,017	1,809	1,922	1,799	1,070	1,468	1,572	22,188	
Dates Farm 2/ (31%)	567.3	425.5	587	583	864	566	353	540	404	596	404	234	191	298	5,620	
Sub-Total	1,830.0	1,372.5	2,538	2,856	3,061	2,602	2,427	2,557	2,213	2,518	2,203	1,304	1,659	1,870	27,808	
Unites Water Use in the Gravel plain and Mountain Area (mm/ha/month)			348	308	296	270	260	264	240	216	224	238	232	212		
(2) Gravel plain & Mountain Area																
village Daris	12.9	12.9														
Wustah	19.6	19.6														
Ali	34.2	34.2														
Hawqain	83.7	83.7														
Others	148.0	133.2														
Sub-Total	298.4	283.6	987	873	839	766	737	749	681	613	635	675	658	601	8,814	
Total	2,128.4	1,656.1	3,525	3,729	3,900	3,368	3,164	3,306	2,894	3,131	2,838	1,979	2,317	2,471	36,622	

Note: 1/ The existing irrigation areas are estimated as follows according to the present land use.
Coastal Area ; Farm Area x 75%
Gravel Plain & Mountain Area; Village ... Aerial Photograph
Others .... Farm Area x 90%

2/ In the coastal areas, land use allocation is made for mixed farm by 69% and dates farm by 31% based on the results of Sample Survey for Musanaah and Saham.

MONTHLY WATER USE BY DISTRICT (VILLAGE)

(WADI: Fara) (Units: '000m^3)

Items	Farm Area (ha)	Irrigation Area (ha) 1/	Year 1983 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year 1984 Jan.	Feb.	Mar.	Total Water Use ('000m^3)	Remaeks
Unites water use in Coastal Area																
for Mixed Farm (mm/ha/month)			170	187	214	224	204	183	178	156	163	157	154	176		
for Dates palm Farm (mm/ha/month)			84	146	116	135	125	110	110	80	77	90	117	128		
(1) Coastal Area (Musanaah)																
Mixed Farm 2/ (69%)	1,159.2	869.4	1,478	1,626	1,861	1,947	1,774	1,591	1,548	1,356	1,417	1,365	1,339	1,530	18,832	
Dates Farm 2/ (31%)	520.8	390.6	328	570	453	527	488	430	430	312	301	352	457	500	5,148	
Sub-Total	1,680.0	1,260.0	1,806	2,196	2,314	2,474	2,262	2,021	1,978	1,668	1,718	1,717	1,796	2,030	23,980	
Unites Water Use in the Gravel plain and Mountain Area (mm/ha/month)			575 (3,800)	735 (5,210)	648 (4,480)	610 (4,200)	712 (3,700)	730 (3,500)	712 (3,800)	616 (3,600)	524 (3,100)	478 (3,250)	408 (2,850)	378 (2,720)	( ); For Hazam 3/	
(2) Gravel plain & Mountain Area																
village Jammah	71.4	71.4	411	525	463	436	508	521	508	440	374	341	291	270	5,089	
Hazam	43.4	43.4	250	319	281	265	309	317	309	267	227	207	177	164	3,092	
Subaykan	22.7	22.7	131	167	147	138	162	166	162	140	119	109	93	86	1,620	
Wishal	151.4	151.4	871	1,113	981	924	1,078	1,105	1,078	933	793	724	618	572	10,790	
Wabal	197.4	197.4	1,135	1,451	1,279	1,204	1,405	1,441	1,405	1,216	1,034	944	805	746	14,065	
Rustaq	327.0	327.0	1,880	2,403	2,119	1,995	2,328	2,387	2,328	2,014	1,713	1,563	1,334	1,236	25,300	
Awabi	76.6	76.6	440	563	496	467	545	559	545	472	401	366	313	290	5,457	
Fashah	28.8	28.8	166	212	187	176	205	210	205	177	151	138	118	109	2,054	
Amp	18.9	18.9	109	139	122	115	135	138	135	116	99	90	77	71	1,346	
Others	146.0	131.4	756	966	852	801	935	958	935	809	689	628	536	497	9,362	
Sub-Total	1,083.6	1,069.0	6,149	7,858	6,927	6,521	7,610	7,802	7,610	6,584	5,600	5,110	4,362	4,041	76,175	
Total	2,763.6	2,329.0	7,955	10,054	9,241	8,995	9,872	9,823	9,588	8,252	7,318	6,827	6,158	6,071	100,155	

Note: 1/ The existing irrigation areas are estimated as follows according to the present land use.
Coastal Area ; Farm Area x 75%
Gravel Plain & Mountain Area; Village ... Aerial Photograph (1981)
Others .... Farm Area x 90%

2/ In the coastal areas, land use allocation is made for mixed farm by 69% and dates farm by 31% based on the results of Sample Survey for Musanaah and Saham.

3/ The intake amount of water from Hazam Falaj, which is shown in parentheses, is considerably large, and this value was estimated by considering the consumption at Hazam district as being equal to the average of other districta. The difference, therefore, between intake amount and consumption is assumed to be returned to the ground for recharging the groundwater.

MONTHLY WATER USE BY DISTRICT (VILLAGE)

(WADI: Fara)

(Units: '000m^3)

Items	Farm Area (ha)	Irrigation Area (ha) 1/	Year 1984 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year 1985 Jan.	Feb.	Mar.	Total Water Use ('000m^3)	Remaeks
Unites water use in Coastal Area																
for Mixed Farm (mm/ha/month)			206	240	232	215	219	213	191	203	190	113	155	166		
for Dates palm Farm (mm/ha/month)			138	137	203	133	83	127	95	140	95	55	45	70		
(1) Coastal Area (Musanaah)																
Mixed Farm 2/ (69%)	1,159.2	869.4	1,791	2,087	2,017	1,869	1,904	1,852	1,660	1,765	1,652	982	1,348	1,443	20,370	
Dates Farm 2/ (31%)	520.8	390.6	539	535	793	519	324	496	371	547	371	215	176	273	5,159	
Sub-Total	1,680.0	1,260.0	2,330	2,622	2,810	2,388	2,228	2,348	2,031	2,312	2,023	1,197	1,524	1,716	25,529	
Unites Water Use in the Gravel plain and Mountain Area (mm/ha/month)			348 (2,730)	308 (3,050)	296 (2,500)	270 (1,300)	260 (1,400)	264 (960)	240 (840)	216 (560)	224 (540)	238 (530)	232 (490)	212 (360)	( ); For Hazam 3/	
(2) Gravel plain & Mountain Area																
village Jammah	71.4	71.4														
Hazam	43.4	43.4														
Subaykah	22.7	22.7														
Wishal	151.4	151.4														
Wabal	197.4	197.4														
Rustaq	327.0	327.0														
Awabi	76.6	76.6														
Fashah	28.8	28.8														
Amq	18.9	18.9														
Others	146.0	131.4														
Sub-Total	1,083.6	1,069.0	3,720	3,293	3,164	2,886	2,779	2,822	2,566	2,309	2,395	2,544	2,480	2,266	33,224	
Total	2,763.6	2,329.0	6,050	5,915	5,974	5,274	5,007	5,170	4,597	4,621	4,418	3,741	4,004	3,982	58,753	

Note: 1/ The existing irrigation areas are estimated as follows according to the present land use.
Coastal Area: Farm Area x 75%
Gravel Plain & Mountain Area; Village ... Aerial Photograph (1981)
Others .... Farm Area x 90%

2/ In the coastal areas, land use allocation is made for mixed farm by 69% and dates farm by 31% based on the results of Sample Survey for Musanaah and Saham.

3/ The intake amount of water from Hazam Falaj, which is shown in parentheses, is considerably large, and this value was estimated by considering the consumption at Hazam district as being equal to the average of other districts. The difference, therefore, between intake amount and consumption is assumed to be returned to the ground for recharging the groundwater.

MONTHLY WATER USE BY DISTRICT (VILLAGE)

(WADI: Bani-Kharus) (Units: '000m^3)

Items	Farm Area (ha)	Irrigation Area (ha) 1/	Year 1983 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year 1984 Jan.	Feb.	Mar.	Total Water Use ('000m^3)	Remaeks
Unites water use in Coastal Area																
for Mixed Farm (mm/ha/month)			170	187	214	224	204	183	178	156	163	157	154	176		
for Dates palm Farm (mm/ha/month)			84	146	116	135	125	110	110	80	77	90	117	128		
(1) Coastal Area (Billah, Bu-Abali)																
Mixed Farm 2/ (69%)	993.6	745.2	1,267	1,394	1,595	1,669	1,520	1,364	1,326	1,163	1,215	1,170	1,148	1,312	16,143	
Dates Farm 2/ (31%)	446.4	334.8	281	489	388	452	419	368	368	268	258	301	392	429	4,413	
Sub-Total	1,440.0	1,080.0	1,548	1,883	1,983	2,121	1,939	1,732	1,694	1,431	1,473	1,471	1,540	1,741	20,556	
Unites Water Use in the Gravel plain and Mountain Area (mm/ha/month)			575	735	648	610	712	730	712	616	524	478	408	378		
(2) Gravel plain & Mountain Area																
village Al-Abiyad	53.5	53.5	308	393	347	326	381	391	381	330	280	256	218	202	3,813	
Layjah	36.1	36.1	208	265	234	220	257	264	257	222	189	173	147	136	2,572	
Istal	41.6	41.6	239	306	269	254	296	304	296	256	218	199	170	157	2,964	
Al-Musynaah	58.0	58.0	334	426	376	354	413	423	413	357	304	277	236	219	4,132	
Others	80.0	72.0	414	529	467	439	513	526	513	444	377	344	294	273	5,133	
Sub-Total	269.2	261.2	1,503	1,919	1,693	1,593	1,860	1,908	1,860	1,609	1,368	1,249	1,065	987	18,614	
Total	1,709.2	1,341.2	3,051	3,802	3,676	3,714	3,799	3,640	3,554	3,040	2,841	2,720	2,605	2,728	39,170	

Note: 1/ The existing irrigation areas are estimated as follows according to the present land use.
Coastal Area: Farm Area x 75%
Gravel Plain & Mountain Area; Village ... Aerial Photograph
Others .... Farm Area x 90%

2/ In the coastal areas, land use allocation is made for mixed farm by 69% and dates farm by 31% based on the results of Sample Survey for Musanaah and Saham.

MONTHLY WATER USE BY DISTRICT (VILLAGE)

(WADI: Bani-Kharus) (Units: '000m^3)

Items	Farm Area (ha)	Irrigation Area (ha) 1/	Year 1984 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year 1985 Jan.	Feb.	Mar.	Total Water Use ('000m^3)	Remaeks
Unites water use in Coastal Area																
for Mixed Farm (mm/ha/month)			206	240	232	215	219	213	191	203	190	113	155	166		
for Dates palm Farm (mm/ha/month)			138	137	203	133	83	127	95	140	95	55	45	70		
(1) Coastal Area (Billah, Bu-Abali)																
Mixed Farm 2/ (69%)	993.6	745.2	1,535	1,788	1,729	1,602	1,632	1,587	1,423	1,513	1,416	842	1,155	1,237	17,459	
Dates Farm 2/ (31%)	446.4	334.8	462	459	680	445	278	425	318	469	318	184	151	234	4,423	
Sub-Total	1,440.0	1,080.0	1,997	2,247	2,409	2,047	1,910	2,012	1,741	1,982	1,734	1,026	1,306	1,471	21,882	
Unites Water Use in the Gravel plain and Mountain Area (mm/ha/month)			348	308	296	270	260	264	240	216	224	238	232	212		
(2) Gravel plain & Mountain Area																
village Al-Abiyad	53.5	53.5														
Layjah	36.1	36.1														
Istal	41.6	41.6														
Al-Musaynaah	58.0	58.0														
Others	80.0	72.0														
Sub-Total	269.2	261.2	909	804	773	705	679	690	627	564	585	622	606	554	8,118	
Total	1,709.2	1,334.2	2,906	3,051	3,182	2,752	2,589	2,702	2,368	2,546	2,319	1,648	1,912	2,025	30,000	

Note: 1/ The existing irrigation areas are estimated as follows according to the present land use.
Coastal Area ; Farm Area x 75%
Gravel Plain & Mountain Area; Village ... Aerial Photograph
Others .... Farm Area x 90%

2/ In the coastal areas, land use allocation is made for mixed farm by 69% and dates farm by 31% based on the results of Sample Survey for Musanaah and Saham.

MONTHLY WATER USE BY DISTRICT (VILLAGE)

(WADI: Ma'awil1) (Units: '000m^3)

Items	Farm Area (ha)	Irriga-tion Area (ha) 1/	Year 1983 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year 1984 Jan.	Feb.	Mar.	Total Water Use ('000m^3)	Remaeks
Unites water use in Coastal Area																
for Mixed Farm (mm/ha/month)			170	187	214	224	204	183	178	156	163	157	154	176		
for Dates palm Farm (mm/ha/month)			84	146	116	135	125	110	110	80	77	90	117	128		
(1) Coastal Area (Barka)																
Mixed Farm 2/ (69%)	1,442.1	1,081.6	1,839	2,023	2,315	2,423	2,206	1,979	1,925	1,687	1,763	1,698	1,666	1,904	23,428	
Dates Farm 2/ (31%)	647.9	485.9	408	709	564	656	607	534	534	389	374	437	569	622	6,403	
Sub-Total	2,090.0	1,567.5	2,247	2,732	2,879	3,079	2,813	2,513	2,459	2,076	2,137	2,135	2,235	2,526	29,831	
Unites Water Use in the Gravel plain and Mountain Area (mm/ha/month)			575	735	648	610	712	730	712	616	524	478	408	378		
(2) Gravel plain & Mountain Area																
village Al-Ajal	43.7	43.7	251	321	283	267	311	319	311	269	229	209	178	165	3,113	
Hibra	116.4	116.4	669	855	754	710	829	850	829	717	610	556	475	440	8,294	
Afi	137.6	137.6	791	1,011	892	839	980	1,004	980	848	721	658	561	520	9,805	
Muslimat	111.7	111.7	642	821	724	681	795	815	795	688	585	534	456	422	7,958	
Nakhal	236.5	236.5	1,361	1,739	1,532	1,443	1,684	1,726	1,684	1,457	1,240	1,130	965	895	16,856	
Others	55.0	49.5	285	364	322	302	352	362	352	305	259	237	202	187	3,529	
Sub-Total	700.9	695.4	3,999	5,111	4,506	4,242	4,951	5,076	4,951	4,284	3,644	3,324	2,837	2,629	49,554	
Total	2,790.9	2,262.9	6,246	7,843	7,385	7,321	7,764	7,589	7,410	6,360	5,781	5,459	5,072	5,155	79,385	

Note: 1/ The existing irrigation areas are estimated as follows according to the present land use.
Coastal Area ; Farm Area x 75%
Gravel Plain & Mountain Area; Village ... Aerial Photograph
Others .... Farm Area x 90%

2/ In the coastal areas, land use allocation is made for mixed farm by 69% and dates farm by 31% based on the results of Sample Survey for Musanaah and Saham.

MONTHLY WATER USE BY DISTRICT (VILLAGE)

(WADI: Ma'awill) (Units: '000m^3)

Items	Farm Area (ha)	Irrigation Area (ha) 1/	Year 1984 Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year 1985 Jan.	Feb.	Mar.	Total Water Use ('000m^3)	Remaeks
Unites water use in Coastal Area																
for Mixed Farm (mm/ha/month)			206	240	232	215	219	213	191	203	190	113	155	166		
for Dates palm Farm (mm/ha/month)			138	137	203	133	83	127	95	140	95	55	45	70		
(1) Coastal Area (Barka)																
Mixed Farm 2/ (69%)	1,442.1	1,081.6	2,228	2,596	2,509	2,325	2,369	2,304	2,066	2,196	2,055	1,222	1,676	1,795	25,341	
Dates Farm 2/ (31%)	647.9	485.9	671	666	986	646	403	617	462	680	462	267	219	340	6,419	
Sub-Total	2,090.0	1,567.5	2,899	3,262	3,495	2,971	2,772	2,921	2,528	2,876	2,517	1,489	1,895	2,135	31,760	
Unites Water Use in the Gravel plain and Mountain Area (mm/ha/month)			348	308	296	270	260	264	240	216	224	238	232	212		
(2) Gravel plain & Mountain Area																
village Al-Ajai	43.7	43.7														
Hibra	116.4	116.4														
Afi	137.6	137.6														
Muslimat	111.7	111.7														
Nakhal	236.5	236.5														
Others	55.0	49.5														
Sub-Total	700.9	695.4	2,420	2,142	2,058	1,878	1,808	1,836	1,669	1,502	1,558	1,655	1,613	1,474	21,613	
Total	2,790.9	2,262.9	5,319	5,404	5,553	4,849	4,580	4,757	4,197	4,378	4,075	3,144	3,508	3,609	53,373	

Note: 1/ The existing irrigation areas are estimated as follows according to the present land use.
Coastal Area ; Farm Area x 75%
Gravel Plain & Mountain Area; Village ... Aerial Photograph
Others .... Farm Area x 90%

2/ In the coastal areas, land use allocation is made for mixed farm by 69% and dates farm by 31% based on the results of Sample Survey for Musanaah and Saham.