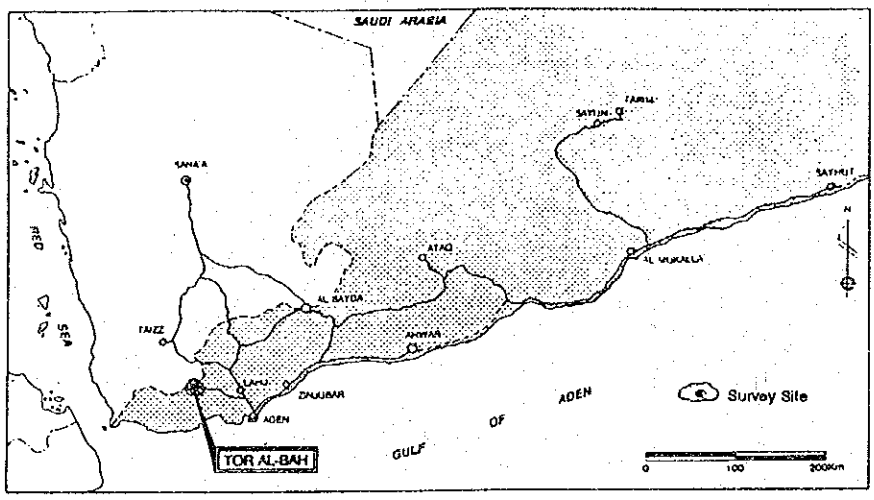
3.3.7 Tor Al-Bah

Site Number	1	Site Name	Tor Al-Bah

Administrative Division	Governorate : Lahj District : Tor Al-Bah Sub-district : Tor Al-Bah				
No. of Villages	16	No. of Houses	10,650	Present Population	78,800
Planned Area	56 km²	Population Density		1,392 persons/km²	
Income Sources	Rank 1: Remittances (50%) Rank 2: Agriculture (20%) Rank 3: Others (30%)			Average Monthly Income	YR4,000
Medical Facilities	Hospitals/Clinics	4	Educational Facilities	Primary School	45
	Medical Staff	7		Intermediate School	4
	No. of Beds	30		Secondary School	
Shops/Restaurants		7	Mosques		40
Water Purchase Practice	Quantity	200 lit/1 day/15 persons: 13 lcd			
	Price	YR50/100 gal : YR111/m³			
	Source				
Existing Water Facilities	Water Source	4 Nos.(deep well, 160ft)			
	Reservoir	5 Nos.(60,000gal x 1 No., 30,000gal x 1 No., 21,000gal x 1 No.) and 2 Nos.			
	Pipeline	6" - 2", Apx. 50 km			
	Water Rate	Household YR 3/100gal, Restaurant,Commerce YR 9/100gal			
	Consumption	20 lcd			
Electric Power Facility		3 Nos.(300Kw, 200Kw, 70Kw)			



1. Location

Tor Al-Bah district occupies the northernmost mountains zone of Lahj governorate bordering on the territory of the former North Yemen. It has been one of the critically important regions to connect the northern and southern parts of the country. Traffic to this region has significantly improved after a 90-km-long paved road is completed (120 km from Aden), passing through the desert on the coastal plain from Lahj city where the governorate office is situated. The objective of the project for the site is to enhance the capacity of water sources for the large-scale water system for the district capital, Tor Al-Bah, and the surrounding communities, currently under control of the NWSA Tor Al-Bah branch (former PWC branch), and the field survey was conducted for the basic design study, concentrating on the hydrogeological features of the planned water basin and water transporting facilities from the basin to the district capital.

2. Present Water Supply System

The existing water supply system for Tor Al-Bah is large in scale and complete, except for critical problems in its water sources. The whole system was completed during the period from 1984 to 1986, covering the district capital, Tor Al-Bah, and as many as 40 surrounding communities for a planned population of 47,000. Its service area is largely divided into three zones of Tor Al-Bah, Wadi Shaap and Al-Fershah, each of them provided with its own individual system under management and control of the NWSA Tor Al-Bah Branch.

a. Water Source

Each of the three service zones depend upon the deepwells as its water source. The regional hydrogeological conditions confine drilling locations in an area of approximately 40,000 km^2 at the confluence of the Wadi Shaap, Wadi Mafris and Wadi Mabak, which is called the "Tor Al-Bah Well Field". Nine deepwells so far have been drilled in this basin, but only four wells are now working. The list of nine wells is shown in the table below.

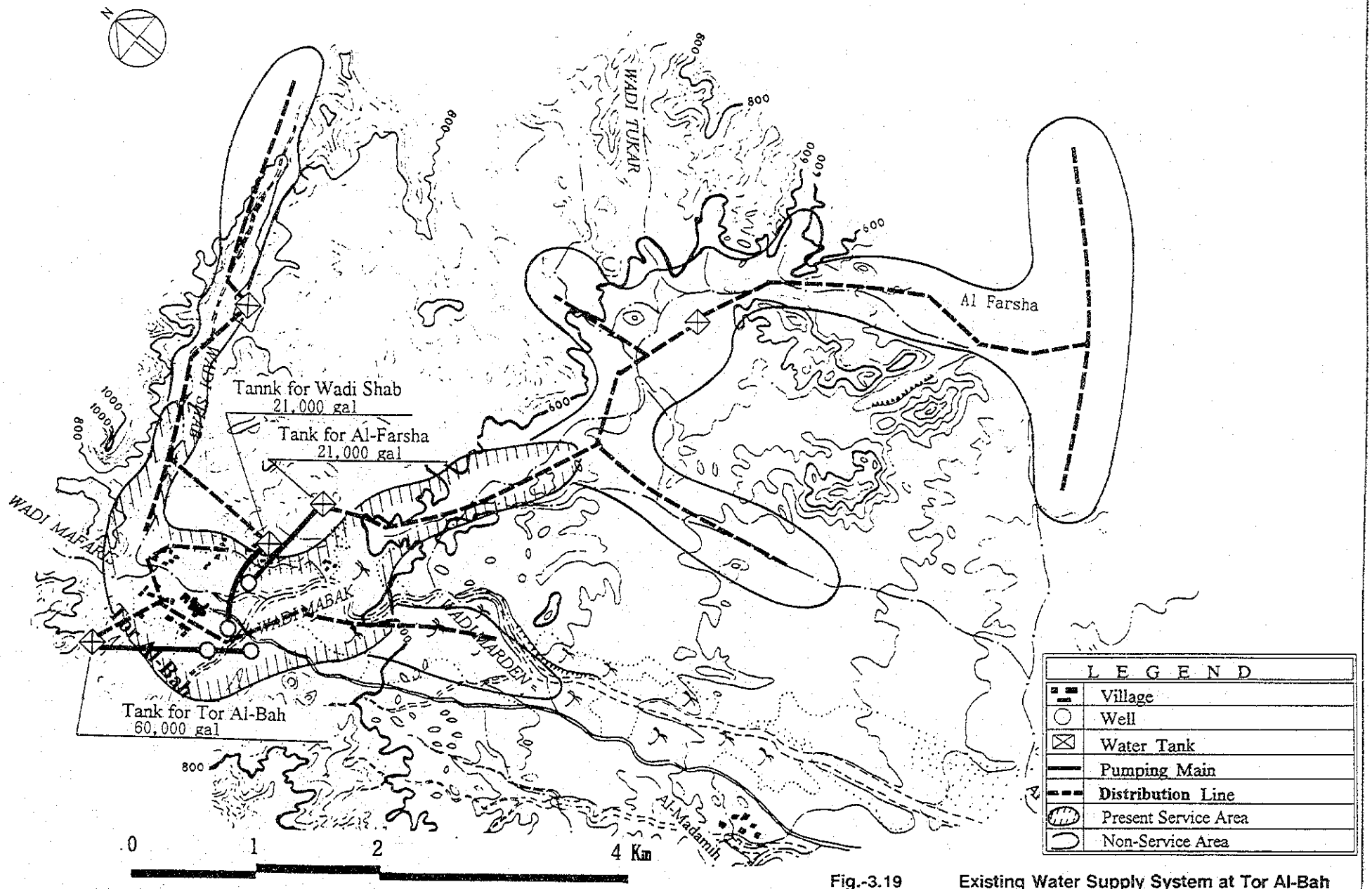


Fig.-3.19 Existing Water Supply System at Tor Al-Bah

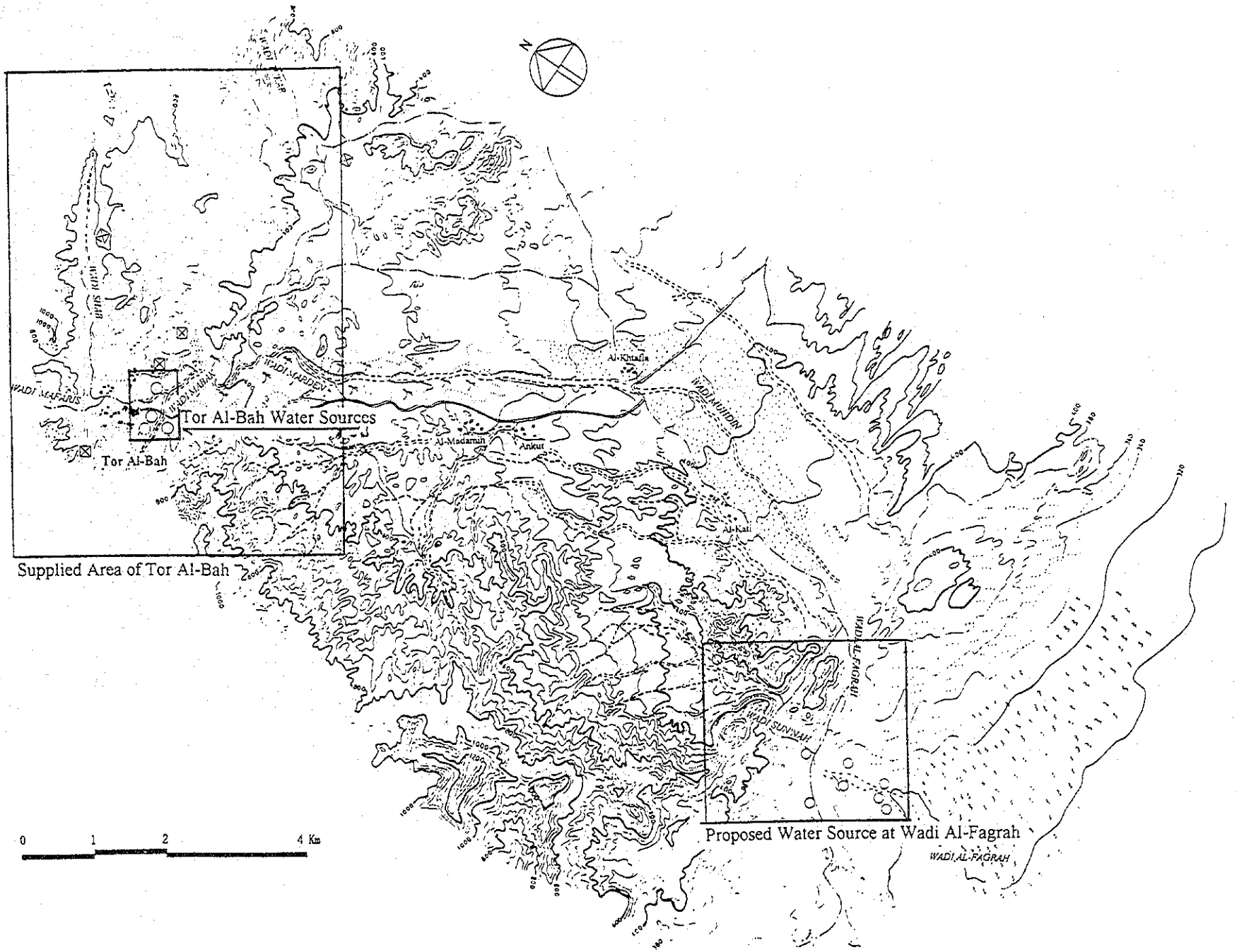


Fig.-3.20 Water Source Reinforcement Plan for Tor Al-Bah

Table-3.17 Existing Wells of Tor Al-Bah

Well Number	Diameter (inch)	Depth (feet)	Drilled in	Current Situation
1.	11	160	1973	Dried up since 1991
2.	11	160	1977	Dried up since 1988
3.	12	160	1984	Operating 10hr/day × 300 lit/min
4.	12	160	1984	Operating 10hr/day × 400 lit/min
5.	12	160	1984	Dry well
6.	12	160	1985	Dry well
7.	12	160-800	1985-1993	Dry well. Drilled to 800ft, to no effect.
8.	12	160	1990	Operating 10hr/day × 380 lit/min.
9.	12	160	1986	Operating 10hr/day × 420 lit/min.

b. Water Supply Facility

The discharge from each well is pumped up to a reservoir for each service area through 6" pumping main (asbestos cement or steel pipe). Three reservoirs for the three service zones are all installed on the top of hills surrounding the basin of Tor Al-Bah city. Water to the city is directly served by gravity from one of these reservoirs. However, the Wadi Shaap and Wadi Fershah service areas are so distant from the city that water is transported from these reservoirs through a system of booster stations on their way. As a result the total length of pipelines to both areas reaches approximately 50 km. The following table shows the list of the facilities for each service area.

Table-3.18 Existing Water Service Facilities in Tor Al-Bah

Service Area	Water Source	Reservoir (gal.)	Pumping Main	Distribution Line
Tor Al-Bah	No. 3 No. 9	60,000	6"×2,000m	6"~2"×11,100m
Wadi Shab	No. 4	21,000 × 2	6"×1,300m	6"~2"×10,300m
Al-Fershah	No. 8	21,000 30,000	6"×1,500m	6"~2"×26,100m
Total	4 wells	5 units	4,800m	47,800m

The above-listed pipelines do not include the branches to the standpipes and house connections, making the overall system a huge one. In addition to house connections, public water taps have been installed at 500 locations, together with 3,000 water meters.

c. Current Water Supply Conditions

Although the system is vast and complete, the problem is that the areas where water is actually served have been limited to only part of the whole system due to lack of adequate water sources. Furthermore, this situation has forced the Tor Al-Bah water office to restrict the service time and day for the respective service areas. The Tor Al-Bah area can receive a four-hour supply every day thanks to the assignment of two of the four operating wells for this area. If one well is shut down, the other one can manage the situation. Both the Wadi Shaap and Wadi Fershah service areas intend to supply for four hours a day, but a single well assigned to them has frequently kept them from following the intended schedule. The areas currently receiving the service, though the time and day for it has been limited, are shown in Fig-3.19. Each household in these areas has a water meter, and each tap of public fountains has also a meter assigned to a household. The water billing system is classified into two groups, as shown in the table below, and bills are collected every two months.

Table-3.19 Water Rate in Tor Al-Bah

Division	Rate
Domestic Use	YR 3/100 gal.
Commerce, Industry,School	YR 9/100 gal.

This water supply facility is operated and maintained by the NWSA Tor Al-Bah branch. It has a total of 38 staff members, including 20 technicians and 18 clerks.

d. Current Problems

A comparison of the water production for the Tor Al-Bah system with the consumption is presented in Table-3.20, based on information obtained from the NWSA Tor Al-Bah Branch.

Table-3.20 Water Source Productivity

Service Area	Productivity	Consume
Tor Al-Bah	Well No. 3: 300 lit/minx10hr=180,000 lit Well No. 9: 420 lit/minx10hr=252,000 lit Total =430,000 lit	20,000 persons x40 lcd =800,000 lit
Wadi Shab	Well No. 4 400 lit/minx10hr=240,000 lit	12,000 personsx40 lcd =480,000 lit
Al-Fershah	Well No. 8 380 lit/minx10hr=228,000 lit	15,000 persons x40 lcd =600,000 lit
Total	1,330,000 lit	1,880,000 lit

Note 1) Calculations assume that the average water consumption is 40 liters per capita per day.

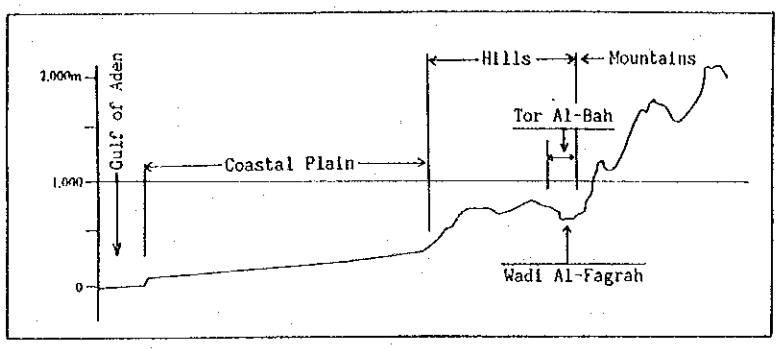
The above calculation shows that the current production accounts for only 70% of the consumption on the basis of an average per capita per day consumption at 40 lcd. The actual situation, with leaks and occasional suspention of the well operation, is suspected to be closer to the level of 50%, and the shortfall has probably been compensated by the purchase of vending water.

3. Water Sources

a. Natural environment

The Project site is a hilly zone extending several kilometers wide along the southern fringe of the mountains soaring to heights over 2,000 m, which bordered the former North Yemen. Cutting down those mountains, the Wadi Tor Al-Bah abruptly turns its course southward near the project site, uniting numerous tributaries and meandering through hilly areas, eventually to reach the Gulf of Aden via the coastal plan. No surface streams can be seen in the channels of the Wadi Tor Al-Bah and its tributaries except during the rainy season. The coastal plain is dotted with hilly blocks of the Quaternary basalt lava flows 50 to 70 m high, breaking monotonousness of the scenery.

Fig.-3.21 Topographic Section of Tor Al-Bah



The mountains are composed of Pre-Cambrian granite, gneiss, biotite schist and the kind, while the hilly area mainly consists of sandstone and conglomerate of Tawilah Group. These rocks, both Pre-Cambrian and Tawilah Groups, are torn apart by east and west/north and south faulting. In contrast is the coastal plain mantled by eolian sand, with sand dunes highly developed east and west. Wadis have belts of alluvial sand and gravel, although their channels are thinly covered with eolian sand. At the junction of the Wadi Al-Fagrah and the Wadi Sun'nah in the Project site is observed an ancient fan of floodplain.

Table-3.21 Geological Features of Tor Al-Bah

AGE	FORMATION	LITHOLOGY
Quaternary	Alluvium	Sand, Gravel
	dune sand	Eolian sand
	Floodplain deposit	Sand, Gravel
Cretaceous	Tawilah Group	Sandstone,
Precambrian	Precambrian system	Granite, Gneiss, Schist

b. Hydrogeological Features

As already described in Para. 2, the office of NWSA Tor Al-Bah Branch so far installed 9 deepwells of 50 m in depth in the wadi reaches near the city, 5 of which resulted in dry holes, with the other 4 being far from enough to serve the regional water system for all the villages within the radius of 10 km. In recent years, therefore, they set up a new program to reinforce the water

sources by drilling wells near the junction of the Wadi Al-Fagra and the Wadi Sun'nah roughly 30 km away south of the city of Tor Al-Bah.

The northern mountains of the Wadi Al-Fagra are of Pre-Cambrian group such as granite and gneiss, while its southern hilly area features Tawilah sandstone, striking NW80° to EW, dipping southerly 24° to 28°. The southern area beyond the hilly zone form sand dunes ranging east and west (Refer to Fig.-3.22).

Seven deepwells have so far been installed in the survey site around the confluence of the wadis, with one existing open well. The deepwells have been closed with steel well caps. Installed with the government fund, six out of these 7 existing wells are new, intended for reinforcing the water supply of Tor Al-Bah by transporting collected water through about 30 km-long pipeline, distributing some portion to the villages on the way.

The GAREW Aden Branch has had no detailed data about these wells as yet, but knew that they were drilled to the depths of 80 to 350 m with the yields from them at no less than 15 lit/sec on average. While the yields seemed enough, the office staff was skeptical about the water quality, since there was no reliable data. (Actually the yields are skeptical as well, since the contractors in this country have no test pumps and testing is normally performed with air-lifting equipment.)

Under such circumstances, the survey team aimed to get on-site information about water quality of these wells by sampling as well as to carry out the hydrogeological study in and around the area. In addition, the team made a trip upstream the main wadis, tracing the existing wells dotted along their channels. The results of the survey are summarized in Table-3.22.

The main points of the survey results are described as follows:

1) Groundwater in these deepwells are fissure water occurring in Quaternary basalt, sandstone of Tawilah Group and Pre-Cambrian metamorphic rocks.

2) The static water levels of the wells ranges from 10 m to 30 m below ground level. The yields from them need to be re-examined by a process of accurate pumping tests.

3) The yields based upon the results of air-lifting, if correct, are estimated to be quite enough for the planning for Tor Al-Bah water system. On the other hand, the quality seems anything but suitable for public water supply, according to the results of on-site testing by the team during the survey which showed an extremely high range of electrical conductivity of 3,500 to 10,000 μS/cm (converted rates at 25°C).

   According to the results of the team's study about the characteristics of the existing wells in the site, groundwater in the basin of the Wadi Al-Fagra appears to contain high salinity, and this basin is judged not to fit the purpose of the project intended to serve the demand of a large population.

5) The groundwater in some section of the Wadi Sun'nah showed a lower salinity of 2,449 μS/cm(at 25°C). The result is interpreted to indicate that the shallow groundwater zone in this section had been diluted by fresh surface runoff which might have occurred after heavy rain.

   The open well near the cluster of deepwells in question also showed an especially low rate of salinity less than 900 μS/cm (at 25°C). This may be a special case of groundwater lens floating over saline water zone.

As a result of the field survey in the site, the team reported to the GAREW during the meeting late in December 1993 that the deepwells

intended for the project could not be employed for the planned water supply because of high salinity so that the Tor Al-Bah project should be canceled. In response to the team's proposal, the GAREW expressed its intention to do accurate testing of these wells for itself and asked for a concerted effort on the Japanese side to realize the project in view of the importance of the Project site. As a conclusion, it was agreed between both sides that the Japanese side might consider the possibility of taking up the project once again, provided that the Yemeni side would complete its efforts and offer the team any successful results around the end of January 1994 (Refer to Chap.4, Sec.4.3.1 about the final results).

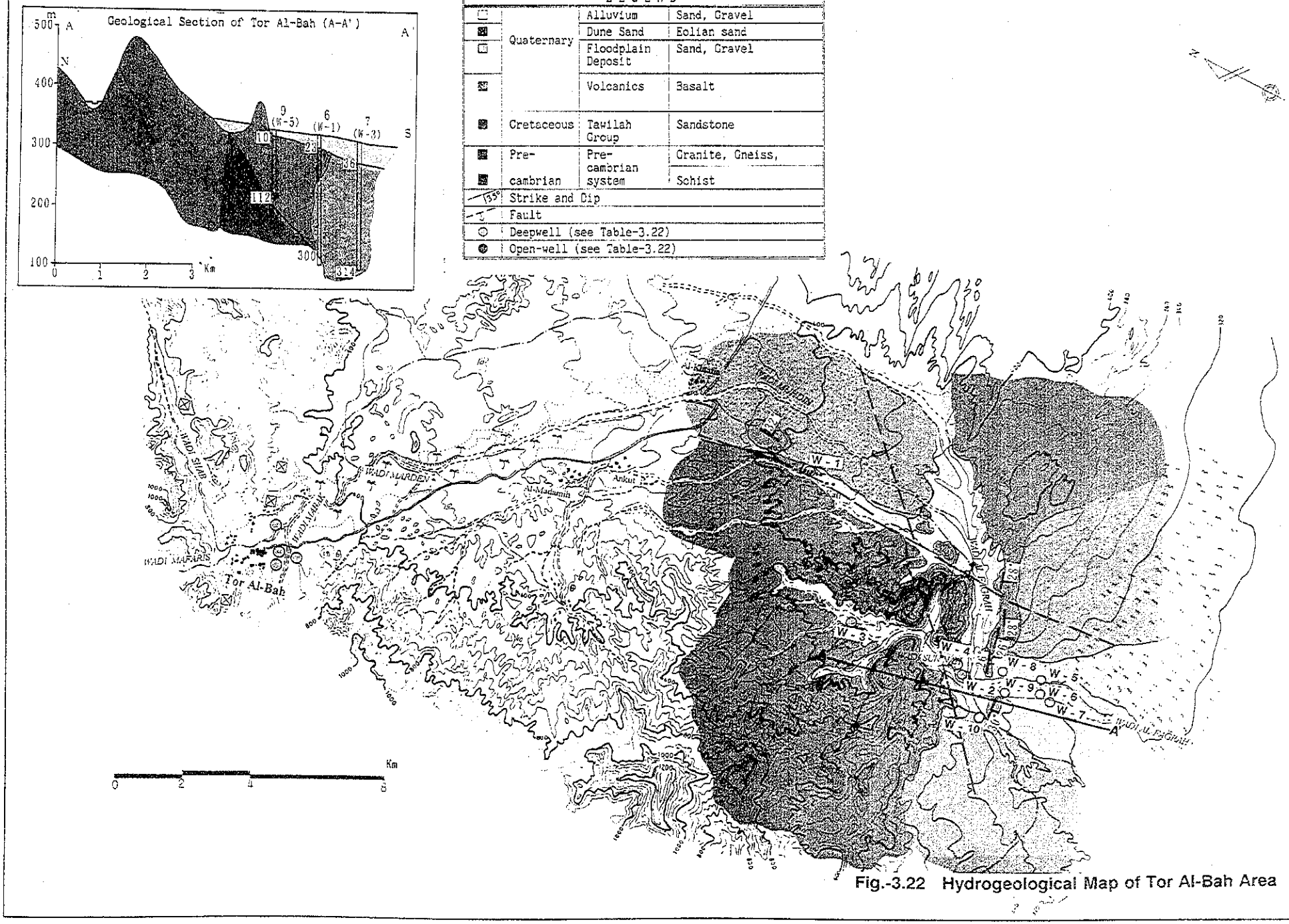
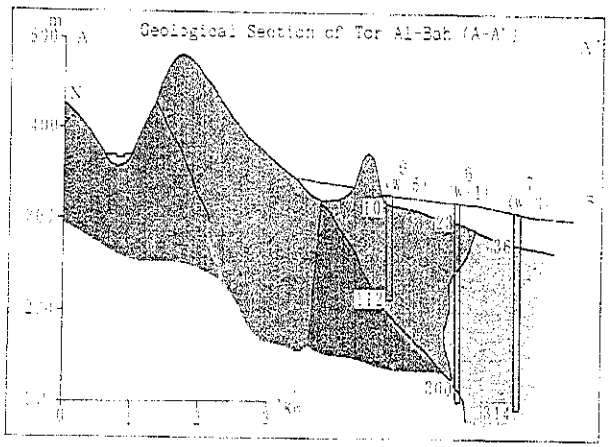


Fig.-3.22 Hydrogeological Map of Tor Al-Bah Area



LEGEND			
	Quaternary	Alluvium	Sand, Gravel
		Dune Sand	Eolian sand
		Floodplain Deposit	Sand, Gravel
		Volcanics	Basalt
	Cretaceous	Tawilah Group	Sandstone
	Pre-cambrian	Pre-cambrian system	Granite, Gneiss, Schist
	Strike and Dip		
	Fault		
	Deepwell (see Table-3.22)		
	Open well (see Table-3.22)		

Fig.-3.22 Hydrogeological Map of Tor Al-Bah Area

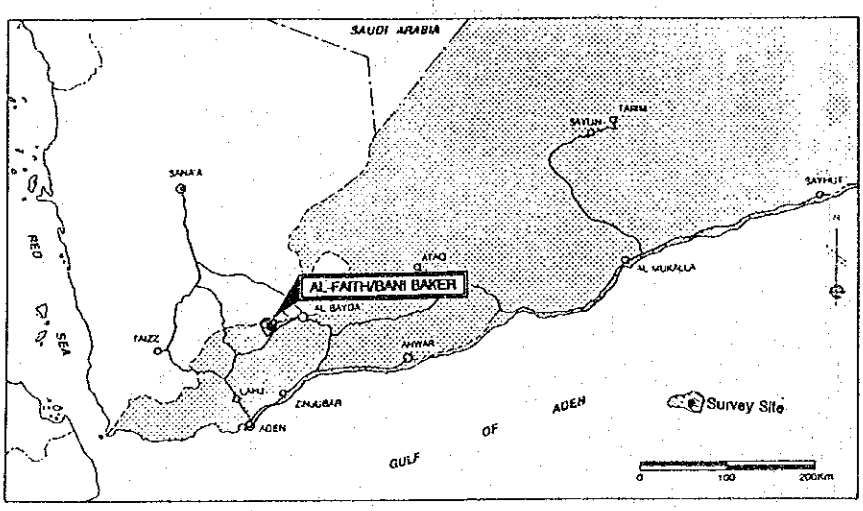
Table-3.22 List of Existing Wells(Tor Al-Bah)

No.	Type	Place	Dia. (m)	Depth (m)	Pump	Aquifer	SWL (m)	DWL (m)	Q (l/min)	T (°C)	pH	EC (μS/cm)		Remark
												Measured	Corrected at 25°C	
W1	Open well	AL-Kati	3.0	23.0	Hand drawn	Pre-Cambrian	20.0	-	-	31.5	7.9	4,350	3,537	Domestic use
W2	"	Al-Fagrah/Private	2.5	21.9	"	Alluvium	17.8	-	-	32.0	8.1	1,030	831	
W3	"	Wadi Sun'nah/Priv.	2.5	15.0	"	"	10.2	-	-	28.5	8.1	2,620	2,449	"
W4	Deep well	Al-Fagrah/Private	0.2	?		?	15.8	-	-	31.0	8.0	4,370	3,902	Unused
W5	"	Al-Fagrah/PWC No.2	0.2	?		Basalt	?	-	-	30.0?		>10,000	>9,901	"
W6	"	Al-Fagrah/PWC No.1	0.2	* 300.0		"	15.3	*27.0	*480.0	"		3,932	3,575	"
W7	"	Al-Fagrah/PWC No.3	0.2	* 314.0		"	?	-	-	"		>8,000	>7,273	"
W8	"	Al-Fagrah/PWC No.4	0.2	* 82.0		Tawila Group	?	-	-	29.0	8.0	4.840	4,481	"
W9	"	Al-Fagrah/PWC No.5	0.2	* 112.0		"	16.0	-	-	34.0	7.9	7,700	6,525	"
W10	"	Al-Fagrah/PWC No.6	0.2	* 344.0		Pre-Cambrian	17.0	-	-	29.0	8.1	4,840	4,421	"

3.3.8 Al-Faith/Bani Baker

Site Number	2	Site Name	Al-Faith/Bani Baker

Administrative Division	Governorate : Lahj District : Al-Rabous Sub-district : Al-Hadda				
No. of Villages	4	No. of Houses	1,927	Present Population	28,000
Planned Area	17.5 km²	Population Density		1,600 persons/km²	
Income Sources	Rank 1: Remittances (70%) Rank 2: Wages/Salaries (20%) Rank 3: Agricultire (10%)			Average Monthly Income	YR5,500
Medical Facilities	Hospitals/ Clinics	4	Educational Facilities	Primary School	16
	Medical Staff	32		Intermedi-ate School	1
	No. of Beds	100		Secondary School	
Shops/Restaurants			Mosques		16
Water Purchase Practice	Quantity	lit/ day/ persons: lcd			
	Price	YR / lit : YR /m³			
	Source				
Existing Water Facilities	Water Source	1 No.(Open-well)			
	Reservoir				
	Pipeline	4" - 2"			
	Water Rate	YR6.5/month/Person			
	Consumption	15 lcd			
Electric Power Facility	Generators in every villages				



1. Location

Bani Baker is the capital of Al-Hadda subdistrict of Al-Rabous district in Lahj govenorate and Al-Faith is a neighboring community of Bani Baker, located on the highland platform about 30 km west of the former North Yemen's border city of Al-Bayda. Situated at an elevation of 2,000 to 2,500 m, the region is dominated by a climate similar to the one prevailing in the Central Mountains Zone of the northern part, which develops a natural environment to fit the growth of qat shrubs, a special cash crop in Yemen with mild stimulant effect, as well as coffee trees. Upon the opening of a new paved road linking the former two countries through Al-Bayda in 1993, traffic to and from the region has dramatically improved.

2. Present situation of the water supply

This site consists of four large communities (Bani Baker, Al-Faith, Kholagah and Al-Firdah) with its population totaling 28,000. Water service system exists only in Bani Baker. In other three communities, water from open wells must be fetched by whuman power or by donkey. The present situation of the Bani Baker water system is as follows.

a. Servoce area: Bani Baker
b. Water source: Open well x 1 (in the Wadi Garrar)
c. Reservoir: 1 No. with a capacity of 35,000 gal.
d. Pupmping main: 4" steel pipe x approx. 1,000 m (water source to water tank)
e. Distribution network: 4" - 1-1/2" x approximately 4,300km

The above facilities were installed in 1978 and have since been operated and maintained by the water office by five staff members from the district office branch in Bani Baker. Based upon the recent experience of break of water service due to the engine trouble, the water office has acquired a standby engine for the intake pump to ensure the sustained operation of its water service.

The community has no house connections, and water is served at the standpipes positioned at every corner of the distribution network. According to the water office staff, overall demand in the community with so many population (12,000 persons) cannot be met by a production from a single well. They are thinking house connection can be installed if a new source could successfully be developed. Under the present circumstances with the yield from the well limited, the

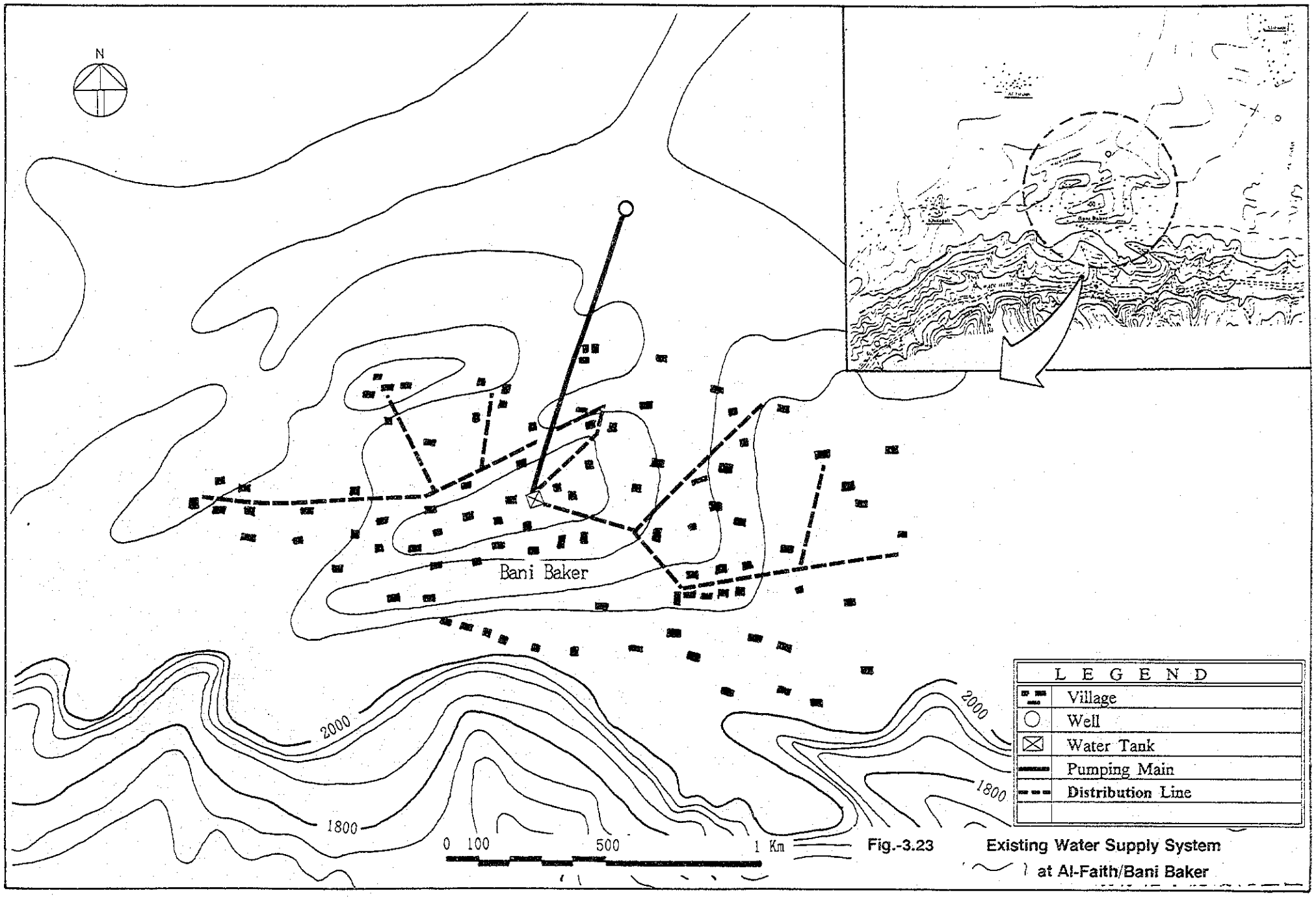


Fig.-3.23 Existing Water Supply System at Al-Faith/Bani Baker

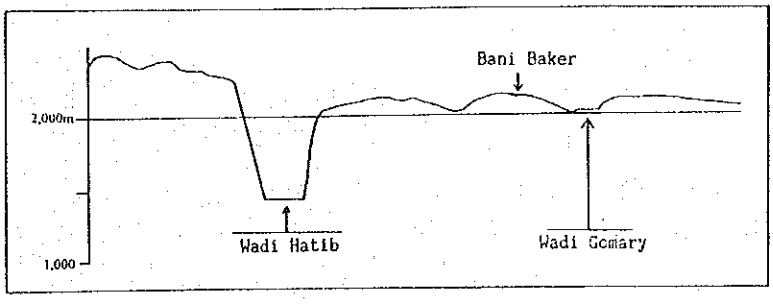
community is divided into two service zones, and water is alternately supplied through valve operations for only 15 minutes every other day, in the morning and at night. The daily volume of water to be supplied is controlled at 90 m^3 for half of the total population, namely 6,000. The water rate is a flat one: 5 shilling (YR 6.5)/person/month. The water office has been strugging not to suspend the service, even though the production is low. The community had bad times during the drought several years ago, when the well did get dry, and the residents had to purchase water brought by truck from Al-Albayda, which cost them as much as 2,500 shillings (YR 3,250)/truck=6 m^3 (=YR 550/m^3).

3. Water Sources

a. Natural Environment

Al-Faith/Bani Baker is located on the southern edge of the Central Mountains Zone near the former border with North Yemen, at an elevation ranging from 2,000 to 2,500 m. The platform at the top where the communities are situated is part of a gently rolling vast terrain continuing to Al-Bayda city in the east. The southern fringe of Bani Baker forms a steep cliff of 500 m, along which runs the deep gorge of the Wadi Hatib westward, with a greater part of its wadi bed now being occupied by thriving coffee-tree plantaions. Another wadis cut onto the platform, with the Wadi Gomary to the north of Bani Baker and the Wadi Garrar to its east, and join to the northeast of Bani Baker, running further northeastward. The catchment area of the confluence of two wadis has rather a small scale of catchment basin - roughly 24 km^2, as is the case with the Wadi Darah which runs northward through the neighboring village of Al-Faith.

Fig.-3.24 Topographic Section of Bani Baker



The entire region is formed of Precambrian rocks such as gneiss, biotite schist, etc., except for belts of thin alluvium on the wadi beds.

b. Hydrogeological Features

The Wadi Garrar, cutting northward to the east of Bani Baker, has about 15 open wells along its reaches, including one for the public water supply of Bani Baker. The public open well is 3.5 m wide and 15 m deep, with its static water level at 5.85 m. Water is pumped up with a vertical-shaft pump to the distribution reservoir of 180 m^3 installed at the highest point of the community. Since it takes about 10 hours to fill this reservoir, the pumping rate is estimated to be roughly 300 lit/min (5 lit/sec). The aquifers for this well involve the lower section of the wadi deposits as well as the uppermost weathered horizon of Precambrian basement where cracks form a network to transport groundwater flow. The Wadi Darah also has as many as 20 open wells for both domestic and agricultural use. Groundwater in this wadi seems less, since pumping used to be suspended in 2 or 3 hours due to a sharp fall of the water level.

Such conditions of wadis on the platform with smaller catchment areas and limited yields may well suggest the difficulty to secure enough water by open wells to meet the demand of a large population for this site.

On the other hand, the Wadi Hatib, forming a deeply-cut gorge 500 m high down the southern edge of Bani Baker, has also open wells along its westward course. The village of Al-Malky down the valley installed two open wells of 50 to 80 m in depth, with their static water levels standing at 36 to 37 m mainly for irrigation. The yields from these wells, however, are not much. Al-Malky and other nearby villages now receives piped supply of domestic water from the public facilities installed about 3 km upstream to collect the wadi underflow emergeing there as surface runoff due to the outcrop of hard gneiss on the wadi bed. However, the volume of the runoff is estimated to be as little as 350 lit/min, although it appears to be nearly the entire volume of underflow passing this section of the Wadi Hatib.

Gawah, another village 8 km downstream Al-Malky, has an open well 4.2 m wide and 22.9 m deep, with its static water level at 10.3 m. The vertical-shaft pump installed there discahrges about 250 lit/min in yield for domestic and agricultural use by the villagers. The owner usually operates the pump for just several hours a day, saying the well can be operated continuously for 24 hours when the rains come.

The results of the hydrogeological study thus carried out for the site are summarized as follows:

(1) Groundwater in this region is of unconfined type occurring in the lower section of alluvial deposits as well as the upper horizon of weathered Precambrian basement with networks of developed cracks, which tends to be affected by the climate. Water quality, however, is good.

(2) In the basins of the Wadi Garrar and the Wadi Darah running westerly to the east of Bani Baker, it is hardly possible to obtain a volume of water to meet the planned supply under this Project. One of the possible measures to improve the current situation of the public supply on the platform is to build a subsurface dam at the junction of both wadis where the channel of the wadi gets remarkably narrower due to the expansion of Precambrian rocks from both sides.

(3) Groundwater in the Wadi Hatib is found much less than the one this size of the wadi may be capable of producing. The available volume is estimated to be far less than the planned supply rate. To pump up water from apparently unstable sources to the community on the platform 500 m higher than the wadi is not effective as well as economical.

(4) The Wadi Hatib unites with the Wadi Bana, one of the largest wadis in the Southern part of Yemen, roughly 6 km downstream the village of Gawah. Although the Wadi Bana has already been developed in full scale by numerous projects for diverse purposes including the water supply for Aden, another new project, financed by the Arab Fund and other agencies and executed by the NWSA Aden Branch, is now underway at this

junction of the Wadi Bana with the Wadi Hatib: water supply project for the district capital area of Al-Rabous. (Bani Baker is one of the Sub-districts (Markazs) belonging to the District of Al-Rabous). Since under the present circumstances the Bani Baker area is and will be suffering from lack of water sources, the regional development and use of water resources is proposed to be fully reviewd by the concerned institutions and agencies so that a practical solution leading to establishing feasible water sources for Bani Baker could be worked out among them.

(5) As a result of the field survey, it has been concluded the site currently has no appropriate candidate for water development in its vicinity.

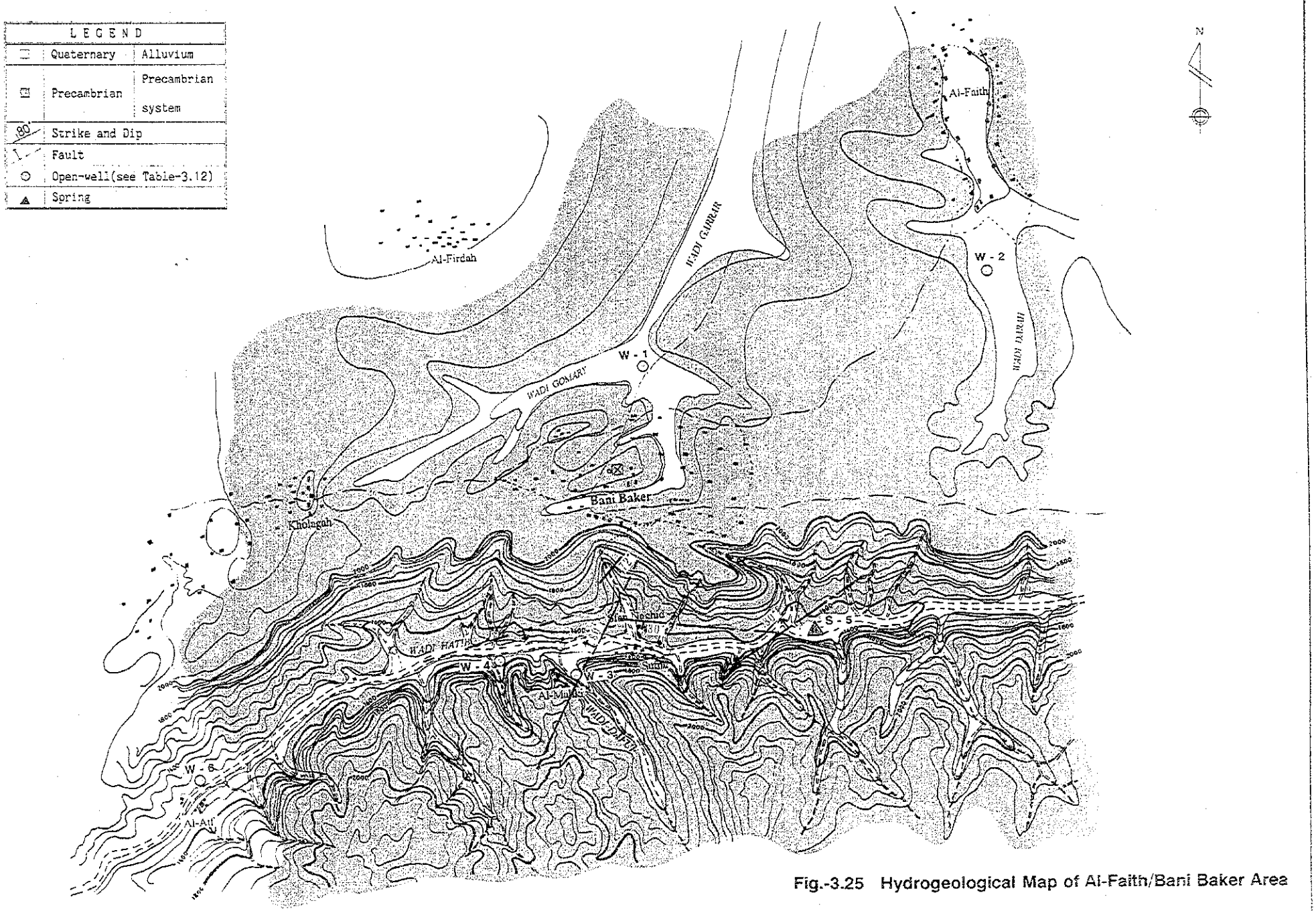


Fig.-3.25 Hydrogeological Map of Al-Faith/Bani Baker Area

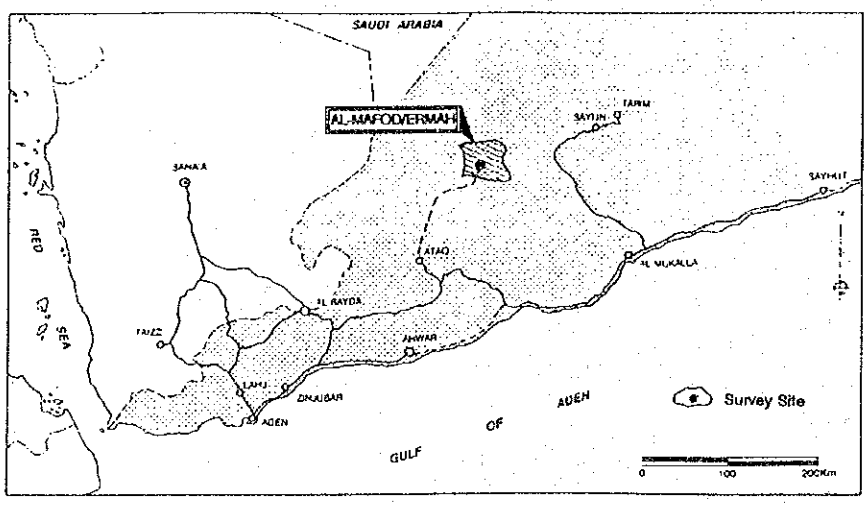
Table-3.23 List of Existing Wells (Bani Baker)

No.	Type	Source	Dia. (m)	Depth (m)	Pump	Aquifer	SWL (m)	DWL (m)	Q (l/min)	T (°C)	pH	EC(μS/cm)		Remark
												Measured	Corrected at 25°C	
W1	Open well	Bani Baker	3.5	15.7	Borehole pump	Alluvium and weathered basement	6.50	-	300	21.3	8.0	1,091	1,178	Water Supply
W2	"	Al-Faith/ Private	2.9	20.8	-	"	9.50	-	-	25.6	7.8	607	600	General use
W3	"	Al-Maliki/ Private	1.4	80.0	-	"	36.80	-	Dry up in 2hr	22.5	7.9	998	1,051	"
W4	"	"	2.2	50.0	-	"	37.20	-		26.0	7.5	1,095	1,074	"
S5	Surface	Wadi Hatib			-	Alluvium		-	350	25.9	7.9	862	847	"
W6	Open well	Gawa/Private	4.2	22.9	Borehole Pump	Alluvium	10.30	-	250	23.5	7.2	1,109	1,143	"

3.3.9 Al-Mafod/Ermah

Site Number	6	Site Name	Al-Mafod/Ermah

Administrative Division	Governorate : Shabwa District : Ermah Sub-District : -				
No. of Villages	15	No. of Houses	1,499	Present Population	8,470
Planned Area	19 km²	Population Density		445 persons/km²	
Income Sources	Rank 1: Remittances (50%) Rank 2: Daily Income (25%) Rank 3: Agriculture (10%)			Average Monthly Income	YR6,000
Medical Facilities	Hospitals/ Clinics	1	Educational Facilities	Primary School	2
	Medical Staff	26		Intermedi-ate School	1
	No. of Beds	30		Secondary School	
Shops/Restaurants			Mosques		15
Water Purchase Practice	Quantity	6,800 lit/30day/12persons: 19 lit/d/p			
	Price	YR520/6,800 lit : YR77 /m³			
	Source	Al-Mafod			
Existing Water Facilities	Water Source	Deepwells x 1 No.			
	Reservoir	3 Nos. (40,000gal-1, 10,000gal-2)			
	Pipeline	3" - 1-1/2"			
	Water Rate				
	Consumption	35 l/day/person			
Electric Power Facility					



1. Location

The name of the site, Al-Mafot/Ermah, represents the district capital of Al-Mafot and the surrounding villages in the Ermah district of Shawb governorate. The district of Ermah is located north of the governorate capital of Ataq in a hilly to mountainous area facing the desert. Ermah can be reached by an oil exploration road (unpaved) stretching to the northern desert area, constructed by a petroleum company. Because of the harsh natural environment, remittances from migrant workers in foreign countries has been a major source of income in this underpopulated area. The site involves the district capital of Al-Mafod and 12 surrounding villages.

2. Present Situation of Water Supply

There is one deepwell drilled in the late 1970s near Al-Mafod, continuously providing water to the population of Al-Mafod and the surrounding villages for a long time. The PWC formerly prepared a design for the water supply to the region to use this well as a water source. The following facilities have so far been constructed based on this plan.

Table-3.24 List of Existing Facilities in Al-Mafod

Facility	Specification	Remarks
Water Source	4 deepwells (Only one well can produce water.)	One was drilled near the existing well by PWC in 1989 (dry). In 1993 another 2 wells were drilled by Shabwa Governorate (dry).
Reservoir	20,000gal×1unit	Constructed near the existing well, used by nearby villagers
Distribution Tank	40,000gal×1unit 10,000gal×2units	2 units of 10,000gal installed within Al-Mafod for distribution for the community
Pipeline	4" - 1-1/2"=4Km	

The yield from the existing well during the field survey was estimated at approximately 150 lit/min. The pump installed in the well does not have a sufficient capacity to pump up water to the distribution tank of 40,000 gal. capacity on the nearby hill. Although various water facilities have so far been constructed based upon the former PWC's design, all of them have been left idle because the yield from the well is scarce. Under such circumstances, piplines have also been

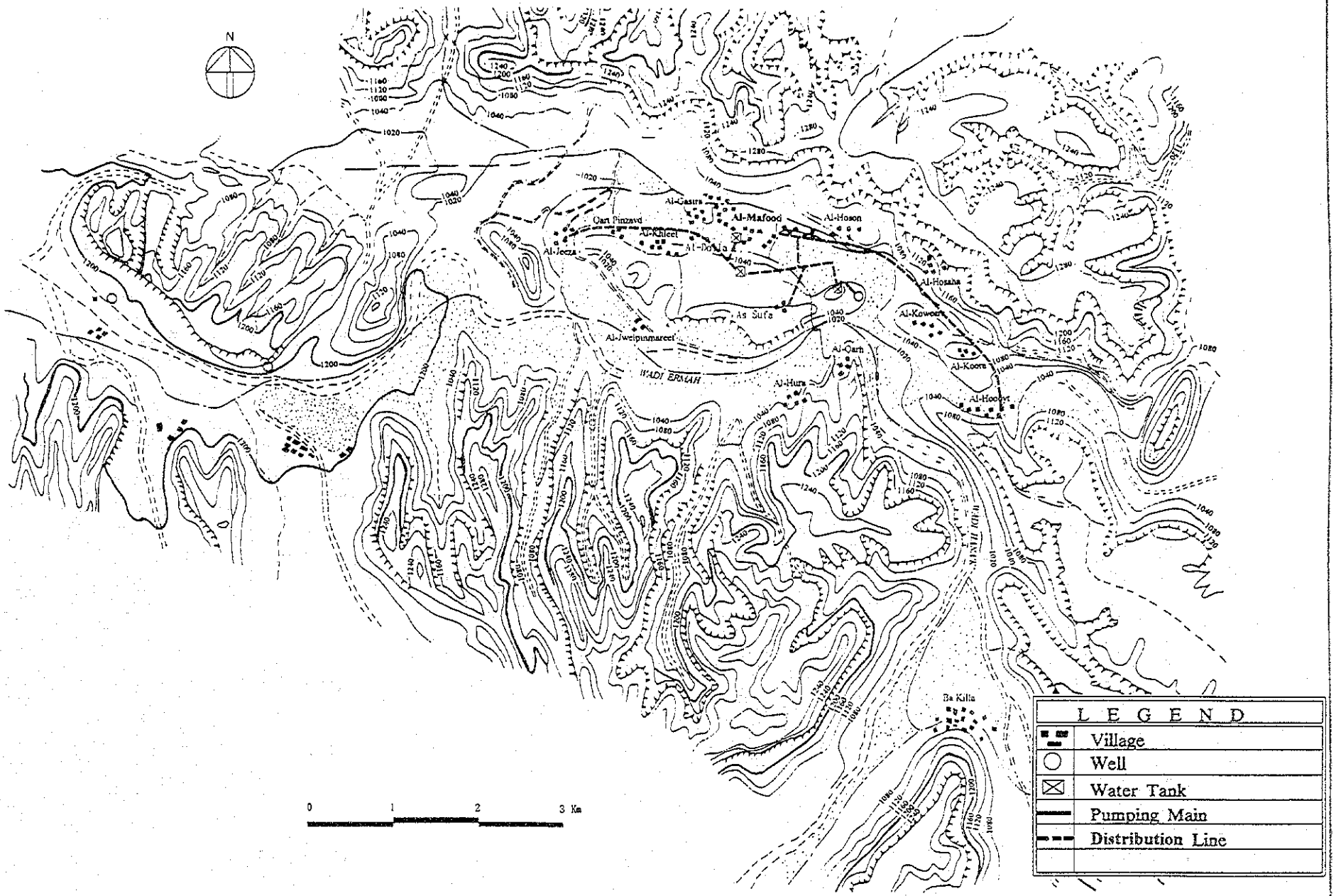


Fig.-3.26 Existing Water Supply System at Al-Mafod/Ermah

left unconnected or disconnected in many locations, some of them with damages inflicted on them.

b. Water Supply Condition

The existing well in Al-Mafod has been operated under control of a committee of 5 members at the district office, but the production from the well is entirely carried on tanker trucks for sale to the villages in this district, with the income covering the cost of pump operation. Therefore, the only means to acquire water in this region is to purchase water. Payment for water varies from YR 500 to 1,000/month, according to the number of family members, and even if it is in the lower level, it still is a heavy burden for the residents.

There are no open wells since shallow groundwater is not available in this region due to either a very deep water level or complete lack of water presence. In an effort to overcome their hardships, the people have constructed reservoirs collecting rain water called "Caliph," at many locations, based on their traditional knowledge. The storage in the reservoirs could be used for several months a year, although the peirod depends on the volume of rainfall. Another effort is illustrated by a facility to transport water from a small spring emerging in the nearby hill, which were installed with donation from the successful emigrant in Saudi Arabia. This facility consisting of pipeline from the spring and a small storage tank near one of the villages is used alternately by three villages, but can be used only for 5 months a year at longest.

3. Water Sources

a. Natural Environment

The district of Ermah with its center at Al-Mafod lies where the southern fringe of the Rub Al-Khali desert meets the hilly to mountainous zone of 1,000 to 1,300 m in elevation. The Wadi Ermah flows westerly across the area of the Project site, having continuous walls of precipitous cliffs of 50 to 70 m in height along both sides of its channel, with its strange scene conjuring up an image of the Grand Canyon, albeit much smaller in scale. The Wadi Ermah slopes gently down with its gradient at about 1/300, its width extending about one kilometer at maximum. No surface water is present along the course of the wadi except during spells of heavy rainfall.

The area of the Project site is composed of Umm Er-Rudhuma Formation - Paleocene marine sediment, overlain by Eocene Rus Formation, with belts of alluvial deposit over the wadi courses. Both rock series predominantly consist of limestone, with interbeds of marl and dolomite. Their bedding is nearly horizontal, forming a massive solid rock without any faults or cracks.

Throughout the whole area of the site is only one water well capable of providing drinking water, which was drilled nearly 15 years ago with the order of the then President along the Wadi Ermah between the villages of Al-Hoson and Al-Talluha.

b. Hydrogeological Features

Umm Er-Rudhuma and Rus Formations in this area display a monotonous, nearly flat bedding structure, barely influenced by tectonic movements so far, so that any conspicuous faults and cracks can hardly be observed. Such geological features suggest rare occurrence of groundwater across the area.

There is one deepwell of 178.6 m in depth on the right side of the Wadi Ermah between the villages of Al-Hoson and Al-Talluha, which was drilled by the government 15 years ago. Its static water level is reportedly 125 m. It is currently producing water of roughly 150 lit/min with a vertical-shaft pump, with its service time by 5 hours in the morning and 4 hours in the afternoon. This is the sole water source across the area. Its static water level is reportedly 125 m. (The depth of the level seems to be much deeper than anticipated, but has been judged to be correct through information from the village of Bakeira, where the people formerly dug an open hole by hand to the depth of about 100 m, to find a trickle of water on the bottom. This open well was used for a while in this water-poor village, but was shut down after it collapsed.)

In 1989, the PWC drilled another deepwell along the wadi channel, just 150 m downstream of the first deepwell. The alluvial deposit of sand and gravel continued from ground level to 43.2 m, limestone followed to 240.8 m and finally sandstone replaced it until the bottom of 243.9 m. Sandstone encountered in the

drilling is probably Mukalla Formation of Cretaceous period. Testing of the drilled well, however, resulted in little yield, and the well has since been closed.

Another drilling effort was made by the Shabwa government at a point about 10 km downstream of the working well, in 1994 just before the survey visited the site. Drilling reached to a depth of 250 m, but was again unsuccessful (The team found the air with bad odor rising up the dry hole.)

There is a small spring in the mountainous area north of the site, from which a pipeline reaches a storage tank, exclusively used by the three villages of Al and Al Hoobyt. This spring is available for only five months through the year, leaving the villagers to depend upon water vending for the rest of the year.

In view of the conditions of the existing wells and the hydrogeological structure of the region, the groundwater development for this site is judged to be extremely difficult. One suggestion is that drilling of about 250 m could be tried at a point through a small fault of NW 10° to 80° on the steep cliff near the village of Al Jwelpirmareef. However, the probability of hitting a promising aquifer is not high. For reference, the data and information obtained by the survey are shown in Fig.-3.26 and Table-3.25.

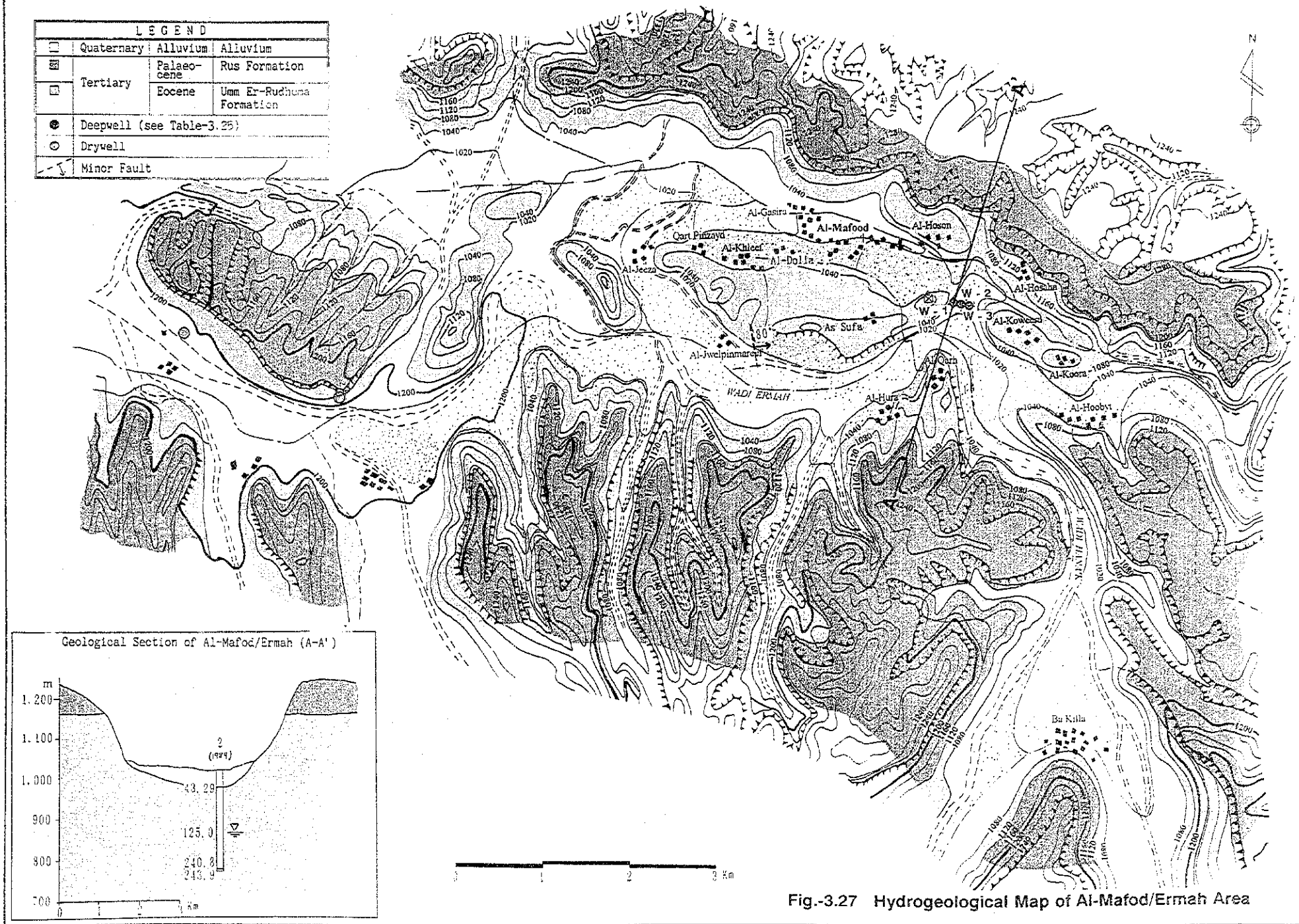


Fig.-3.27 Hydrogeological Map of Al-Mafod/Ermah Area

Fig.-3.27 Hydrogeological Map of Al-Mafod Emar[illegible]

Table-3.25 List of Existing Wells (Al-Mafod/Ermah)

No.	Type	Source	Dia. (")	Depth (m)	Pump	Aquifer	SWL (m)	DWL (m)	Q (l/min)	T (°C)	pH	EC(μS/cm)		Remark
												Measured	Corrected at 25°C	
W1	Deepwell	Al-Mafod well	8"	187.6	Borehole pump	Limestone	125		150	28.1	7.3	927	873	Operating for Water source
W2	Deepwell	Al-Mafod well 1989	8"	243.9		Limestone and Sandstone	?	?						Abandon
W3	Deepwell	Al-Mafod well old well	8"	?										Abandon

3.4 Water Quality

During the field survey in 9 sites, water sampling and on-the-spot analysis were carried out at the water sources which would be incorporated into the project as well as those which seemed helpful in evaluating the overall groundwater environment. On-the-site testing was made with an electrical conductivity meter along with a pH meter, and the testing results are shown in the tables appearing in the foregoing sections for the hydrogeological environment of the respective survey sites. The chemical analyses of significant samples were later entrusted to the official testing laboratories in both Yemen and Japan, and the results are shown in Table-3.26.

The testing has revealed that four (4) sites among 9 surveyed, namely Ahwar, Moodeyah, As Sadarah and Tor Al-Bah, have more or less problems with the qualities of their water sources. It indicates that the degraded qualities in these sites are caused by one or a combination of such chemicals contained in water as (1) total hardness, (2) chloride and (3) fluoride. These elements are known to be contained in groundwater widely throughout the country. Particularly high concentrations of hardness derived from high calcium and magnesium are widespread. Yet the people in the broader areas of the country have no choice but to use water with contents of hardness far beyond the allowable limit stipulated by the WHO, due to lack of alternative sources.

One of the special features of water quality in the country's southern part is that groundwater with high concentrations of chloride is distributed over greater part of the region. It is the main culprit degrading qualities in the aforementioned four sites as well. The causes for such high chloride contents vary with the regions, but more often than not groundwater picks up chloride which is contained in the geological formations through which it moves. Furthermore, saline water occurs along the seaboard of the Gulf of Aden where various types and sizes of major communities in the southern part including the great cities like Aden, the former capital of South Yemen, and Al-Mukalla, the second largest city, are situated. Ahwar, one of the project sites, is such a coastal town. Under such a situation, the major

cities along the coast presently manage to secure fresh water supply through lengthy transporting lines from the sources in remote mountainous areas. (Even after such hard efforts for fresh water, the qualities of water services in Aden and Al-Mukalla remain at a level of electrical conductivity exceeding 2,000 μS/cm.) In fact, compliance to quality standards often gives way to practical needs of water in various parts of the southern areas under harsh water environment.

As a result of the field survey under the basic design study, the situations of the four sites concerning water quality are described as follows:

1) Ahwar

The chemical analysis shows that a water sample from the existing public well for the town of Ahwar contains chloride as high as 844 ppm, while those at two wells installed by a Russian agricultural project less than its half, as indicated in Table-3.26. (Electrical conductivity of the former was 4,000 μS/cm, whereas those of the latter less than 2,000 through the on-the-site testing.) It is possible, however, that the qualities at the latter wells might change to some extent when pumping starts, since the samples were taken this time from the uppermost zone of standing water column in these unused wells after their welded well-caps were removed. Even in such a case, a change in quality is not expected to amount to much, since the existing wells along the same reaches of the Wadi Ahawar such as those in the villages of Al-Hanad and Ambusty are supplying drinking water to inhabitants at levels less than 2,500 μS/cm in electrical conductivity. The adoption of the Russian wells is based upon such actual situation of the site. In this site, only chloride raises a problem, with other constituents like hardness and fluoride complying to the requirements of the WHO.

2) Moodeyah

As already described in the foregoing section for the outline of the site, Moodeyah's groundwater is highly saline as well.

According to the results of the chemical analysis, however, water qualities at five deepwells along the Wadi Wajar (two working wells, Chinese well and a nearby private one, and three unused ones for this project) have proved to fit drinking purpose, as are indicated by data in Table-3.26. Water samples at three unused wells were taken in the same manner as those in Ahwar by opening the well caps. This sampling manner may have been the cause of some inferior qualities in the data: hardness at (A-1) Well and an extraordinary high concentration of iron at (A-2) Well.

3) As Sadarah

The comparison of the results of the chemical analysis between the sample from the upper stream of the Wadi Hager and that from the hot spring within the village of As Sadarah reveals that the contents of chloride and sulfide increase in the latter, suggesting a possible progress of artificial contamination within the community.

4) Tor Al-Bah

To secure additional water sources for this site, six new deepwells had been drilled in the Wadi Al-Fagra by the end of 1992. During the field survey, water samples were taken from these still-unused wells by opening the welded well-caps. The results of chemical analysis indicate that groundwater in this basin is extremely inferior in quality, with high concentrations of hardness, chloride and even fluoride. Such water sources are judged not to fit to the public supply purpose.

The chemical analysis shows that other five sites surveyed had no problems in terms of quality, even hardness confined to levels lower than the limit of the WHO requirement.

Table-3.26 List of Water Analysis Results for Existing Water Sources in Project Area

Site Name	Sampling Point	Well No.	Water Source	Water Temp.(°C)	pH	Total Hardness (mg/l)	F (mg/l)	Cl (mg/l)	SO_4 (mg/l)	Na (mg/l)	Ca (mg/l)	Mg (mg/l)	Fe (mg/l)	Elec. Cond. (μs/cm)
1. Tor Al-Bah	Wadi Al-Fagrah	W-2	Ground-Water	32.0	7.9	230 (235)	1.65 (0.6)	80 (74.2)	155	89.79	52	31.2	-	904
	Tor Al-Bah No.4	-	Ground-Water	25.0	6.7	714	1.3	306	330	200.20	132	92.16	-	2,230
	Wadi Al-Fagrah No. 1	W-6	Ground-Water	30.0	7.1	844	1.42	592	675	434.70	-	-	0.08	3,575
	Wadi Al-Fagrah No. 4	W-8	Ground-Water	29.0	8.0	950	3.06	680	1,075	647.68	-	-	-	4,481
	Wadi Al-Fagrah No. 6	W-10	Ground-Water	29.0	8.1	1,248	2.02	820	1,075	616.86	-	-	0.01	4,481
	Al-Khati	W-1	Ground-Water	31.5	7.9	640	2.05	460	600	379.73	-	-	0.32	3,850
2. Al Faith Band Baker	Al-Faith	W-1	Ground-Water	21.3	8.0	(358)	(0.8)	(111)	-	-	(80.3)	(38.3)	(0.03)	1,178
3. Ahwar	Ahwar	W-1	Ground-Water	33.7	7.8	(1,006)	(0.7)	(844)	-	(508)	(226)	(107)	(0.03)	4,046
	Russian-Well I	W-2	Ground-Water	33.1	9.0	48 (55.2)	0.35 (0.2)	442 (446)	110	365.4 (334)	12 (8.8)	4.32 (8.9)	(10.1)	1,788
	Russian-Well II	W-4	Ground-Water	30.4	8.7	100	0.34	174	130	143.06	20	12	-	876
	Private Well	W-3	Ground-Water	30.8	8.5	576	0.59	336	500	313.72	158.4	43.2	-	2,222
4. Moodeyah	Chinese Well	W-4	Ground-Water	29.9	7.5	(331)	(1.0)	(132)	-	-	(78.7)	(32.8)	(0.02)	1.133
	Well A2	W-2	Ground-Water	35.3	7.7	(257)	(0.9)	(103)	-	-	(59.4)	(26.4)	(13.2)	910
	Private Well	W-5	Ground Water	31.0	8.3	300	0.5	180	80	-	200	100	0.3	1,071
	Well A1	W-1	Ground Water	34.4	7.1	700	0.4	225	140	-	250	450	0.25	1,503
	Well A3	W-3	Ground Water	28.1	7.3	350	0.8	220	100	-	240	110	0.3	1,281
	Al-Grawnah	W-10	Ground Water	29.9	7.5	800	0.1	280	160	-	450	350	0.4	2,368
	Moodeyah No. 4	W-15	Ground Water	29.7	6.7	900	0.1	490	180	-	490	410	0.2	2,505
5. Gaishan	Al-Marwah	W-1	Ground Water	36.0	7.7	(426)	(0.4)	(86.0)	-	(55.6)	(116)	(32.8)	(0.07)	1,008
6. Al-Mafod Ermah	Deep Well	W-1	Ground Water	28.1	7.3	(368)	(0.4)	(72.8)	-	-	(108)	(23.5)	(0.05)	873
7. Al-Aidah Shamalya	Deep Well	W-1	Ground Water	30.0	8.1	(307)	(1.2)	(88.4)	-	-	(66.2)	(34.5)	(0.11)	815
8. As Sadarah	Wadi Bagar Up-stream	R-2	Surface Water	27.9	8.5	(393)	(0.8)	(216)	(170)	-	(90.3)	(40.8)	(0.09)	1,233
	As Sadarah	S-1	Spring	26.2	7.1	(399)	(0.7)	(326)	(216)	(206)	(102)	(34.7)	(0.02)	2,275
9. Al-Radood	Al-Radood	W-1	Ground Water	33.0	7.4	(317)	(1.2)	(64.8)	-	-	(63.8)	(38.3)	(0.16)	864
Standards	W H O				6.5-8.5	500	1.5	250			-	-	0.3	2,000
	JAPAN				5.8-8.6	300	0.8	200			-	-	0.3	-

( )Analyzed by Japan Industry Water Association.

CHAPTER IV

PROJECT PLANNING

CHAPTER IV PROJECT PLANNING

4.1 Objective of the Project

The objective of this project is to install effective water supply systems, complete from water sources to service facilities among twenty sites, four each from five governorates of the southern and eastern part of the Republic of Yemen, where the provision of such facilities is urgently needed to meet the BHN of the residents who have long been suffering from acute shortages of drinking water due to harsh natural environment and social conditions, as well as to improve environment for their health and sanitation leading to the enhancement of their overall living standards.

4.2 Examination of the Request

4.2.1 Appropriateness and Necessity of the Project

Yemen's rural water sector has virtually been centralized with the installation of the Aden branch of the GAREW in 1993 which is held responsible for the promotion of nationwide rural water supply project. Through this measure to reinforce a unified government agency covering the entire regions of the country, the GAREW is expected to take effective action for the development of this sector. This project is in a position to provide substantial support for the first time for rural areas in the southern part of the united Yemen which have been left behind in development, compared to their northern counterparts.

Since no less than 80% of the population in Yemen live on agriculture and stockbreeding in rural areas, the governments of the former two countries continued to put top priority on the rural development policy. It was not an easy task, however, for the central government of South Yemen to extend full support for development of rural infrastructure, since its vast land with an area of 33,300 km^2, slightly smaller than Japan, was sparsely populated with 1,200 thousand people in total. Being well aware of such situation, the united government

underscored the necessity of development of water resources nationwide and promotion of rural water supply, particularly for the hard-hit remote villages in its first announcement of the economic agenda on June 16, 1990 just after the unity. This project is aimed to contribute to the improvement of rural life in line with such government's policy.

Although the situation varies widely, one of the characteristic features of current water practice is the prevalence of water vending in most of the project sites, partly because they have no adequate water sources, and partly because they cannot afford to install relevant water systems due to tight financial situation. The hard-hit areas have no choice but to depend on water vending. Although the prices of water transported by tanker from various water sources differ widely, depending on the distance between the sources and the consumers, an average one is as costly as about YR 100 (900 yen) for 1 m^3. The consumption of one household with 7 to 12 family members on average varies with the sites, but the one in hard-hit areas would have to purchase no less than 6 m^3 a month, the cost of which falls on it as a heavy economic burden. Furthermore, digestive organ disorder is sweeping all the sites, taking casualties mainly from infants and children. One of the possible reasons for the situation seems to stem from the practice of water purchase which brings in various pathogenic bacteria from water sources and/or small family tanks of thin steel sheet where purchased water is stored. Once the water project is undertaken in these areas, health troubles as well as resident's economic burdens are anticipated to be dramatically alleviated.

The project sites under the current circumstance are acutely in need of imminent execution of the project. Its contribution and effect are estimated to be highly significant for enhancing the welfare of residents in these rural areas. The project, therefore, is judged to be appropriate for implementation with grant aid.

4.2.2. Examination of the Project Sites for the Basic Design Study

The project request by the government of Yemen included 20 project sites in five governorates of the country's southern and eastern part. However, as a result of the detailed examination of current conditions in these project sites prior to the field survey, nine candidate sites

were agreed to be surveyed for the basic design study. (The selection of these nine sites was based on the review of the results of the "Project Formulation Study" and the joint examination of the site conditions with the Yemeni side.)

The subsequent technical field survey for this basic design study revealed that three sites out of nine surveyed had extreme difficulty securing relevant water sources for the implementation of the project. The three sites in question are listed below. (The outline of features about these sites are referred to in Chap.3, Sec. 3.3.)

1. Tor Al-Bah (Lahj governorate)
2. Al-Faith/Bani Baker (Lahj governorate)
3. Al-Mafot/Ermah (Shabwa governorate)

The matter was discussed during the meeting upon completion of the field survey, and the Yemeni side expressed its intention to examine their own countermeasures to solve it as these three areas were the critically important sites. The following points were agreed between the Yemeni side and the team on the occasion:

1. The field survey has revealed that Tor Al-Bah and the other two sites have great difficulty in ensuring relevant water sources for the project. Under the present circumstance, it is judged to be difficult to involve these three sites in the basic design study, although these sites are admitted to rank the highest among the survey sites in the level of acuteness of lack of safe water as well as urgent necessity of proper facilities.

2. These three sites require a large-scale water supply project. The new water source development, therefore, needs a detailed long-term survey over a wide area. For this type of development, technical cooperation such as a social development study is considered more appropriate.

3. If the efforts on the Yemeni side could produce a feasible solution for these sites in time for the schedule of the basic design study, the team will reconsider the possibility of including these sites in the study. The Yemeni side is requested to forward the results to the team in writing around the end of

January, 1994.

In accordance with the agreed schedule for this matter, contact was made between the Yemeni side and the team around the beginning of February in 1994, when the Yemeni side provided an official reply to the team that they did not consider favorable results could come out any time soon, and that the team might proceed to the next step as had been agreed. As a result of this process, the sites for further study were determined to be reduced to six in number.

The current situations and specific conditions of these six sites are compared in Table 4.1, focusing on such factors as the water sources, necessity of facilities and effectiveness of investment.

Table 4-1 Comparison of the Project Candidate Sites

A:Investment Effect
B:Urgency
C:Evaluation

Site Name	Population	Current Problems	Countermeasures of this Project	Remarks	A	B	C
1. Ahwar (Abyan)	33,029	Ahwar is the subdistrict capital located on the coastal plain. The water source for its service facility is only one deepwell. The yield is insufficient, and the water quality is deteriorated due to high salinity. The site has no alternative for the current inferior service. Water office management, therefore, has been in bad shape.	Two existing wells drilled along the Wadi Ahwar 4-6km north of Ahwar are planned to be used for the project, since their productions are adequate and the qualities are acceptable. The improvement of service with boosted supply and improved quality will normalize management and finance of the Ahwar water office.	The requested target population includes the surrounding villages. The optimal scale of the project will be determined by examining factors such as the possible yields of wells.	Large	(1)	(1)
2. Moodeyah (Abyan)	37,120	This site is divided into several service zones, and each zone has problems with water quantity and quality. In particular, the service in the central zone of Moodeyah (district capital) is in the worst shape, and residents are heavily depending on expensive water vending. Under such circumstance, the bottomline of Moodeyah water office continues to be critical.	The project plans to use three unused deepwells and additional new one along the wadi basin 10 km east of Moodeyah, where groundwater has high potential and good quality, in order to strengthen the existing service system. Improved service will be able to restore the Moodeyah water offices's management and finance to good shape.	The requested target population covers the entire site. The optimal scale of the project will be determined by examining factors such as the possible yields of wells.	Large	(1)	(1)
3. Al-Raidah /Shamalya (Hadramout)	9,450	This site is located in the highland platform where water resources are hardly available. All the villages except one heavily depend on expensive water vending. The economic burden is huge and the purchased water is causing health problems.	Recently a deepwell was successfully installed near one village in the site, and this project plans to develop another well. With these two wells as water sources, a relevant water system is designed for the seven villages in the site for easing the present hard conditions in the site.	Vending water from cisterns is a possible source of bilharzia spreading among the villagers in the site.	Middle	(1)	(2)
4. As-Sadarah (Hadramout)	11,050	This site lies along the uppermost stream of Wadi Hagar having surface flow throughout the year. Hot springs abound within the villages. Residents use these sources of water for domestic, irrigation and other purposes. Because of recent development of the subdistrict capital of As-Sadarah, contamination of the surface and shallow water has grown a great concern. Therefore, the villages are badly in need of an appropriate water facility.	The surface water in the upstream of the Wadi Hagar, about 5 km north of the subdistrict capital of As Sadarah, is planned to be used for this project, since it has the best quality around the site. This project provides the first water system for the site, intended to improve the basic infrastructure and health/sanitation environment of the villages.	The planned system is a facility to be installed in the site for the first time ever.	Middle	(2)	(3)
5. Al-Radood (Hadramout)	8,980	This site is located in the Wadi Hadramout basin where groundwater is abundant. Although all the villages have their own facilities using open wells as water source, some of them are unstable. Along with the expansion of residential areas, water source pollution has also become a concern. Residents desire a regional water system for the entire area with a deepwell as its water source.	An integrated water system with a deepwell as its source is planned for the villages under the project to provide a safe and stable water to the population of the site.	The optimal scale of a planned integrated system is to be determined, based upon the review of current water service conditions of the respective villages as well as their locations.	Middle	(3)	(4)
6. Gaishan (Abyan)	4,490	This site is divided into the Wadi Uddamar area where the groundwater quality is good and the Wadi Rhab area where groundwater is highly saline. The government has established a facility for the latter area, while this project will plan a water supply facility in the former to complete the facility to cover the entire area.	Due to the geological features of the region, a new open well is planned for this site as a source for the additional service area along the Wadi Uddamar. The new system mainly consists of distribution network along the Wadi extending from the existing reservoir.	Although it is the subdistrict capital, Gaishan is in the midst of rugged mountainous area and the number of beneficiaries from the new project is small.	Small	(3)	(5)

The six sites under the study are divided into two groups: three sites intensely suffering from the shortfall of water due to the plight in water resources; and the other three sites enjoying favorable natural conditions where residents have developed their specific water use practice. There is no denying that the former is so acutely and imminently in need of water facilities that they can be the target of first priority for the basic design study. Among the other three sites, As Sadarah would be a possible candidate for the study, whereas Al-Radood and Gaishan are deemed to rank far lower in priority, because necessity and urgency is thin, and the latter two sites may well be excluded from the targets of the study. The reasons for this decision are explained below.

1. As-Sadarah

This site can utilize flowing water from the Wadi Hagar as well as the discharge of hot springs in and around the villages. Villagers draw water from these sources and use it for domestic purpose and irrigation to support a joint farming operation. The water resources in this site are viewed as rich, compared with other sites.

As-Sadarah is the central community of administration for the subdistrict of As-Sadarah belonging to the district of Hagar in Hadramout governorate. The hot spring source utilized by a population of 5,000 in this community emerges in the crowded corner of the streets close to the mosque. With the expansion of the communities in recent years, pollution of this water source has become a growing concern among the community members. With the its temperature over 36 C and conductivity at 2,300 /cm^2, the hot spring cannot be said to be a relevant source for permanent public supply, even though water quality tends to be poor in general across the southern part.

The site consisting of seven villages with a total population of 10,000 forms a considerably large community. Nevertheless, as the residents can easily obtain water, there is no water supply facility yet. Women and children engage in fetching water. The district office branch, therefore, has been promoting a water project in order to improve the welfare and sanitation of the residents. The office has a primary candidate for the future

water system: surface water of the wadi 5 km upstream north of As Sadarah, where water quality is the best across the region. The residents have a willingness to pay water fee once the facility is completed. Given the present situation, there is a definite demand at the site. Therefore, it is meaningful to promote the project for supporting this developing community.

2. Gaishan

The PWC has already built a water supply facility for the villages along the Wadi Rhab, where water problem had been critical due to high salinity of groundwater. On the other hand, although there is no public water facility, the villages along the reaches of the Wadi Uddamar, where groundwater is relatively easy to get, are in a position to be able to use lots of private open wells. They have no difficulty in securing water with good quality. Even one village has created their own small-scale water supply network by laying pipes to each household in the village.

A new project to provide a public facility to the villages in the Wadi Uddamar basin needs an additional open well and distribution network. However, since the reaches of this wadi has already been fully developed by plenty of private wells, using one of the existing wells is considered more practical and economical than installing an additional open well. The regional water office in charge of public supply assured it is not so difficult to secure a patch of land to install a new well. Yet it is not considered as a practical solution to add another well to an excessive number of existing wells in this congested basin.

As the existing reservoir constructed by the former PWC is located in the uppermost reaches of the wadi, distribution network requires the extension of pipeline about 10 km long to cover the villages along the wadi where the population to be benefitted by this facility is some 2,000. The effect of investment for this project, therefore, is much lower than those for the other sites in comparison. From the viewpoint of the initial policy of site selection to expect higher cost effectiveness, this site is deemed to be difficult to remain in the list of the project sites.

3. Al-Radood

Al-Radood is in far better shape concerning water supply than the other sites, thanks its location in the Wadi Hadramout having rich groundwater resources. The site forms a community involving 13 villages in which open wells are abundant. Public and private facilities exist together in most of the villages and residents receive water service through house connections from these public or their own small systems. In general there seems to be no shortage of water, and in recent years a plan to upgrade the system integrating individual small ones have been springing up.

As mentioned above, most of the water systems in Al-Radood are being operated without any serious problem, and the implementation of a new project is not urgently required. Upon completion of the field survey, the study team reported to the Yemeni side that the priority of this site is low due to the satisfactory conditions witnessed during the field survey, and such a view was basically consented by the Yemeni side. Through the process of the subsequent review of the survey results, the team's view on the stance of Al-Radood has had no change.

As a final result of the evaluation of the candidate sites, therefore, the four sites in Table 4.2 have been selected:

Table 4.2 Basic Design Study Sites

No.	Site Name	Governorate
1	Awhar	Abyan
2	Moodeyah	Abyan
3	Al-Raidah/Shamalya	Hadramout
4	As-Sadarah	Hadramout

4.2.3 Operation Plan for Implementation

In regard to rural water supply projects in Yemen, the law stipulates that the GAREW will supervise capital investment projects, including planning, surveying and construction. The benefiting local governments or the water offices in the sites are responsible for the operation and maintenance of the water supply facilities. After entrusting the completed facility to a local government, the function of the GAREW is to provide technical support related to the operation and management of the system. However, its technical support is limited to the kind which does not require budgetary measures, and all of the operation and maintenance costs are paid by the local government or by the water offices. For this project too, the GAREW acts as the executing agency until facility construction is complete, while the water offices at the project sites will be responsible for the operation of the facility after its completion.

The communities in the four project sites, varying in size, type and function, differ in their water supply conditions. Two of them (Ahwar and Moodeyah) have long experience of running water service systems for the communities, while the other two (Al-Raidah/Shamalya and As Sadarah) have scarcely any service facilities. Current services to residents are also diversified. The following table shows the present situation of the water supply.

Table 4.3 Present Water Supply Facility Operation at the Project Sites

	Site Name	Settlement Classification	Situation of the Water Supply Service
1	Awhar	Sub-district Capital	The Electricity and Water Office (13 staff members for water) of the district office branch in Ahwar runs the water service for the town of Ahwar. As the community is located near the coast, served water is highly saline, and the drinking water is mostly purchased. The water facility has been dilapidated and is severely in need of repair. The management of the water facility operates on an independent accounting basis and receives no incentives from the Abyan local government. Even the salaries of its employees depend on the collection of fees, making it very difficult for the management to make ends meet.
2	Moodeyah	District Capital	The existing facilities are operated by the Electricity and Water Office belonging to the district office (10 water section employees). The target population for service is 34,000 including the district capital and the 20 surrounding settlements. Because of the shortages in the existing water sources, water service even for the town has grown into the poorest shape, with the majority of the citizens heavily depending on purchased water and the management of the water office slumping. The local government pays the salaries of the employees, but the support for maintenance costs are ad-hoc at best because of the tight financial conditions.

	Site Name	Settlement Classification	Situation of the Water Supply Service
3	Al-Raidah/ Shamalya	Settlement compound	This site consists of seven villages. The existing facility is limited to one deepwell and one reservoir. The village near the facility has organized a water committee within its community and carry out the operation and maintenance of the pump and fee collection from the users. If a water supply facility is developed for the entire villages in the site, the water committee will be reorganized with representatives from each settlement.
4	As-Sadarah	Sub-district Capital	Every village in the site including the central community of As-Sadarah, uses hot spring sources. Under this situation, there is neither a public water system nor a water office. With the execution of the project, the district branch office in As Sadarah plans to set up a water office within its organization under the control of the district deputy director. Since the communities run an huge oil palm farm (the number of oil palms is approximately 500,000) through a cooperative union, the district deputy director assured no problem would be raised for cooperative operation, even for water service.

Among the project sites, Al-Raidah/Shamalya and As-Sadarah lack experience in water supply management. According to the results of the field survey, however, these communities maintain strong tribal ties, forming a closely-knit society with firm unity between each family and each village within a community. It seems possible, therefore, to create a union system through the cooperation of the residents.

Meanwhile Awhar and Moodeyah, which have been running large-scale water systems for a long time, have now fallen short of providing a satisfactory water service because of the scarce yields from the water sources. This situation has often caused troubles in the collection of fees, affecting their management of the system. These sites wish to urgently improve management through the execution of the project which could make a normal water service possible.

The law stipulates that the governorates under the control of the Ministry of Local Government should support the operation and management of the water facilities operated by a local government or a regional community. Therefore, facility expansion and part of the construction cost are sometimes funded by the local government, although allocations have been ad-hoc and details have never been disclosed. The billing and collection of water fees are entirely at the discretion of the operating agency, which is usually under control of director general of the district. The acquisition of budget funding seems largely dependent on the political skill of the district director general who negotiates with the governorate office.

The site of Moodeyah is the only site among four sites that has ever been given subsidies from the governorate office. The following are the results from recent years.

1) 1989 SL 100,000 (= YR130,000)
2) 1992 YR 100,000

This point was considered during the field survey conducted at this time. During an interview with the representatives of Lahj, Abyan and Shabwa governments, an effort was made to draw their attention to this project, and support was requested.

In case of a cluster of villages like the site of Al-Raidah/Shamalya,

the routine process is to create an independent operations/maintenance system within the regional society. According to this study, a small water committee has already been established in a single village located near the existing deepwell in Al-Raidah/Shamalya, and a community water service by the committee is being run for the village without any support from the local government office. Even in the central administrative areas, such as Moodeyah and Awhar, where urbanization is in progress, the water offices are not so powerful, and the surrounding communities have installed their own facilities with their own funds which usually cover several villages adjacent to each other.

The establishment of these community water offices is the trend throughout the nation in regard to water supply facility operation. This system is usually recommended in this project as well. Furthermore, it is necessary to enhance the system through the direction of the GAREW, which is a top government agency, as well as the local governments. (As a reference, the water facilities constructed with loan and grant aid from the government of Japan in the former North Yemen adopt this system. According to the follow-up survey in 1988 conducted by the expert dispatched from Japan to the RWSD, the original body of the GAREW, the efforts for operation and maintenance by such community water office at each site were confirmed.)

In regard to the operation and maintenance of water sources, pumping equipment and pipelines which will become of concern when the facility operation begins, full-time operators are attending the daily operation of existing facilities at the project sites except for As Sadarah. In terms of unexpected failures, such as that for pumps, technical instruction was requested of the former PWC if repairs were technically difficult for the union. The survey at the nine project sites observed that spare parts are difficult to obtain and that interruptions in repair frequently occur. Therefore, it is necessary for this project to consider countermeasures for this problem. (For facilities completed during Phase 1 to Phase 3 in the grant aid for the former North Yemen, a follow-up survey was conducted by the Japan International Cooperation Agency ten years later in 1992. Spare parts were provided in 1993. It was confirmed that the operation and maintenance of the water supply facilities was generally good.)

As a comprehensive judgement, the operation and maintenance system of this project will follow the present system in Yemen. At the same time, the organizations of the water offices in the beneficiary communities will be strengthened and the technical support from the GAREW will be enhanced. It is necessary to put the management of the water supply unions on a smoother operating basis by providing the appropriate scale of operation and maintenance equipment through this project.

4.2.4 Examination of the Requested Facilities and Equipment

The former PWC had conducted the survey, planning, and design of the water supply facilities for a majority of the 20 candidate sites by 1990. Based on this planning, a portion of the water supply facilities have been constructed in part of the sites. The following table shows the progress of the PWC's water supply plans at the four project sites.

Table 4.4 Contents and Present Situation in the Four Project Sites

	Site Name	Contents of Previous Planning by the Yemeni Side	Present Conditions of the Existing Facilities
1	Ahwar	The PWC formulated a regional water supply plan which covered all 23 villages within the subdistrict, including the central area of Ahwar. The planning documents and designs are available .	Based on this plan, two wells were drilled in 1991, but turned out unsuccessful. The implementation of this plan had been suspended until the government requested grant aid from Japan.

	Site Name	Contents of Previous Planning by the Yemeni Side	Present Conditions of the Existing Facilities
2	Moodeyah	The PWC carried out the survey several times, and the outline drawings are available. However, only the water source enhancement plan which targets the central area of Moodeyah can be obtained at the present time. The regional water supply scheme to cover all of the villages has not been completed.	As the regional water supply plan to cover the whole area of Moodeyah has not been completed, facility construction was not started.
3	Al-Raidah/ Shamalya	The drawings for the basic planning by the PWC are available.	One deepwell was drilled by the government of the governorate. With fund donated by an individual successful in business in a foreign country, a reservoir and small service facilities has been constructed. The PWC designed to construct a public water supply system in this community of seven villages by using these existing facilities.

	Site Name	Contents of Previous Planning by the Yemeni Side	Present Conditions of the Existing Facilities
4	As-Sadarah	Only the preliminary study has been conducted.	No water supply facility.

Each project site has its specific conditions at present, as is clear from the above table, and its present situation are classified as follows:(1) Ahwar and Moodeyah - Although the water service areas have expanded in the sites, normal service has become impossible due to the water source problems. The main objective of the project is to strengthen the water sources with new source development. (2) Al-Raidah/Shamalya - Although some facilities exist, the major objective is to develop a regional water supply system, including the development of additional water source. (3) As-Sadarah - Development of a completely new system for regional water supply is necessary.

The following is an examination of the water (groundwater) source facility and the water supply facility requested for each project site:

(1) Water Source Facility

Based on the field survey, Both Al-Raidah/Shamalya and As-Sadarah located in Hadramout are considered to be the sites where water sources can be secured to meet the demands of the entire targeted population. The other two project sites, Ahwar and Moodeyah in Abyan are limited by either the water source or the water quality or both. If the volume of the water supply is increased beyond the current limit, water source depletion and/or water quality deterioration are highly probable. An outline of the two areas where these problems exist is shown below.

1) Ahwar

This site is located on a sand dune along the coast of the Gulf of Aden, and a majority of the groundwater in this area contains high salinity. The shallow groundwater (Wadi Ahwar's underground flow), whose quality is relatively good, is found in narrow belts along the reaches of the

Wadi Ahwar, which runs through the site. This project proposes to employ the two existing wells drilled in the belt of good quality water zone. In this case if the groundwater level is lowered because of overpumping, the inflow of highly saline groundwater is feared to take place. Therefore, maintaining the high water level is necessary by means of restricting the pumping rate from the wells.

2) Moodeyah

Although this site is located inland, groundwater is mostly brackish because of the prolonged natural process of salts concentration which occurs in high temperatures in a dry climate. In the surrounding seven settlements west of the central area of Moodeyah, water is supplied through an independent water supply system. However, as the water source is highly saline, the water is used for miscellaneous use only, and all of the drinking water is purchased.

Under such circumstances, groundwater with relatively good quality occurs only in a narrow wadi basin more than 10 km away from the central area of Moodeyah, and as there is no other candidate for the water source than this, the three wells already drilled in this remote basin become the sole sources to be used for this project. However, to make the matter more complex, there are two other existing wells already in service along this narrow basin: if five pumps will be operated simultaneously upon completion of this project, a probable excessive pumping in the same basin is deeply feared to prompt the deterioration of the water quality. Therefore, it is necessary to maintain and control the water sources by restricting the pumping rate in order to prevent a abrupt drop in the water level in this area.

Furthermore, as this site has a large planned population, additional water sources are necessary, other than these three wells. The groundwater development situation was examined for the overall site, including the agricultural

water. The only possibility considered is the drilling of one additional well, one kilometer downstream from the area where water source wells are concentrated.

The existing wells at the two project sites in Ahwar and Moodeyah have been left unused since their construction, with their casings closed by steel plates. During the field survey for this study, their water quality was confirmed by opening the wells, but pumping tests could not be performed in this survey. During the discussions with the Yemeni side, therefore, the team requested the GAREW to undertake an accurate pumping test in both the sites as soon as possible, and this request was agreed to. According to the notice from the Yemeni side at the end of January 1994, however, pumping tests to allow further analysis by the survey team could not be performed because GAREW's test equipment was inoperative. Therefore, an analysis of available information as well as the field observation of pumping in this area were used to estimate the safe yields from the wells.

In regard to Al-Raidah/Shamalya in Hadramout highland platform, a deepwell drilled over 400 m has successfully hit the deep-seated aquifer at this project site. Since information related to the distribution of the deep aquifer is limited, it is important to elaborately examine the surrounding geological conditions when determining a drilling location for new development.

(2) Water Supply Facility

1) Water Supply Method

In the planning by the former PWC, the water service for each village was designed to be made at public water taps (called standpipes or standposts in the South), with an average supply rate at 40 liters per capita per day (lcd). As a recent trend, water supply to each household has become the norm, even in the rural villages; therefore, water supply to each house has been requested as a basic design policy for this project. In this case, a level of an average supply rate required is 60 lcd. In the sites of Ahwar and Moodeyah where urbanization is underway, house

connections have been common even among the surrounding smaller villages.

On the other hands, in the case of Al-Raidah/Shamalya and As-Sadarah, which do not have distribution networks, it is most relevant to install public taps as the service facility to allow residents to use the water immediately upon completion of this project. The constituent villages at these sites are packed with houses, respectively having large service populations. In such a pattern of villages, it is highly probable that water will soon be served directly to a portion of better-off families through house connections linked to distribution lines by the residents themselves.(In fact, the representatives of the villages at the sites have expressed their intention to do so.) In view of such a trend in a probable shift of supply method, distribution lines for these villages are necessary to be designed to maximize the convenience for the residents in the future, namely for easiness for house connections by themselves. Instead, the number of public taps could be restricted to a minimum.

If house connections becomes the basic pattern, the yields of water sources in relation to the water demand will present a problem. In regard to this point, it has been agreed between both sides that the unit supply rate for the sites like Ahwar, where the possible yields are limited, will be determined within the range of the available quantity of water.

2) Range of the Service Area Under the Project

All of the four sites in the project are large-scale service areas, covering part or whole of their administrative divisions comprised of a central community and many scattered villages. However, in case the water source is limited like Ahwar and Moodeyah, a water supply plan to cover all of the villages in such a large service area becomes utterly impractical. Furthermore, a large service area often involves smaller independent supply

systems which have been installed with the fund from the benefitted villages themselves, working in good conditions, frequently serving to each house through house connections. These individual systems are encouraged to remain as they are now so as not to strain the planning of this project, as is the case with the sites like Ahwar and Moodeyah. While available water sources are decisively scarce in these sites, they have excessively a large population to serve, part of which belong to the villages with the aforementioned individual systems. Under such a situation, top priority for water supply will have to be placed on the central community of the site, part of supply shared with some of the surrounding villages to which connections do not strain the possible yield from the water source. In this case, it is possible to increase the benefits to the surrounding areas by adjusting the water supply rate or the operation times. (Details for each site are discussed in Chapter 5.)

3) Water Supply Facility

This project is aimed to install an effective water supply facility including water transporting facilities and distribution facilities such as reservoirs and distribution mains as basic requirements. However, since the villages are scattered in every project site, a lengthy distribution line is required to meet the needs of each site. The design, however, leads to heavily straining the investment. During the discussions with the Yemeni side on this point, the self-help efforts on their side were encouraged, and this policy was basically agreed to. In order to support their efforts, therefore, the supply of materials for installing distribution branches will have to be arranged under this project, based upon the formulation of the effective design. The water offices in the project sites are believed to be capable of undertaking this line of work, since they have expertise and experience, formerly installing piping materials supplied by the PWC. The details on the supply are proposed during the draft final discussions, and the measures to be taken will be agreed on that occasion.

4.2.5 Examination of the Necessity of Technical Cooperation

As a view of the basic design study team, technical assistance for the execution of this project is not required. Apart from direct connection with the project, the GAREW is desirous of survey equipment which will require technology transfer in connection with their activity for hydrogeological study (refer to APPENDIX 1a. Minutes of Discussions). This request is considered, however, to be dealt with in other opportunities which could more effectively undertake to achieve the intended objective than this project.

Although not directly related to this project, the Japanese government previously dispatched two experts on water administration to the RWSD of the MEW, a government agency preceding the GAREW, followed by another one to the present GAREW, who has already been stationed for the current third term.

4.3 Outline of the Project

4.3.1 Project Sites

As was discussed in the previous section, the project sites for the basic design study are 4 sites located in two governorates of southern Yemen. These sites have high priority and urgency for implementation.

The served population for each site is determined from the basic design standards and possible pumping rates, which will be discussed in detail in Chapter 5. In two sites of Ahwar and Moodeyah including scores of villages in their initial plans, the development of new groundwater sources has been found so much limited that it is deemed necessary to confine the water supply under this project to the villages having priority within the sites. In the project sites, independent service areas which operate their own water supply facilities (although small in scale) on a continuous basis will not, in general, be included in the project service areas, unless special problems occur in those areas. In areas where limited groundwater is the water source, if dispersed water resources can be used separately in this manner, effective groundwater conservation will be possible, and therefore, small-scale cluster-type water supply facilities are recommended for the project sites, rather than a comprehensive large-scale planning. The following table lists the names of project sites, the optimal service area for each site, and the served population, as a result of the present study. (The consideration on the optimal service area is discussed in section 4.3.3 "Outline of Facilities and Equipment.")

Table 4.5 List of Project Sites

Site Name	Governorate	Served population (1993)	Design population (2008)	Service area/ villages
Ahwar	Abyan	13,900	20,400	Ahwar and surrounding 5 villages
Moodeyah	Abyan	22,900	32,000	Moodeyah service area and part of Al Qurath service area
Al Raidah /Shamalya	Hadramout	9,400	12,700	All 7 villages in the initial plan
As-Sadarah	Hadramout	11,000	14,900	All 7 villages in the initial plan

4.3.2 Executing Agency and Management System

This project will be managed according to the present system organized in Yemen, where the GAREW is responsible for the construction of facilities and technical support thereafter, and each of the water offices in the respective project sites is in charge of the management, operation and maintenance of each facility. This system is already in operation for the existing facilities in three project sites, other than As-Sadarah, with the basis of their water services depending on fees collected from the beneficiary residents. The facilities to be completed under this project are anticipated to improve their water services to a great extent, and it will not take long for them to ensure sound management, although the maturity of these organizations varies.

According to this study, the services of the existing water supply agencies, though with an adequate number of full-time employees at present (such as the water offices in Ahwar and Moodeyah), have been in bad shape because of the problems with the water sources mentioned earlier. As a result, the management of the water supply operation has been on the verge of bankruptcy. The governorates which control and support these offices lack the financial resources and the technical background to resolve these problems at the project sites. Therefore, the governorates have requested that appropriate measures be taken by the former PWC, and this has lead to the request for grant aid from the Japanese government.

In regard to the quality of the employees of the water offices at each project site, a majority of the employees are residents of the project sites (some of them were the trainees under the former PWC). Their major responsibilities include the management of the water supply ledger, clerical work related to fee collection, and the operation and maintenance work, such as daily facilities operations, which do not require a high degree of skill. Employees are hired based on the circumstances surrounding each facility, but no office owns maintenance equipment, such as welding machines and lathes. Therefore, repairs and maintenance works are entrusted to local specialized shops, especially to automobile repair shops commonly found at each site. Among the daily-operated equipment, diesel engines require the most attention,

but because of the growing number of cars throughout the nation, mechanics, although of varying levels of skill, who can treat these problems are available in all sites, and as long as spare parts are secured, most troubles can be resolved. For more complex troubles requiring a level of expertise beyond that of a local mechanic, technical guidance used to be requested to the PWC. With a new setup of the government water agencies, the GAREW Aden branch will replace the former agency for these matters from now on. Taking such local situations into account, facilities and equipment for the rural water systems should be of simpler structure allowing easy operation as much as possible.

The following table shows the major points in regard to the present management system and the predicted future system at each site. (Refer to Section 4.3.4 "Operation and Maintenance Plan" for the details of the necessary increase in employees.)

Table 4.6 Important Points of the Present Management System and Project Implementation System

No.	Site Name	Present Water Supply Agency	Present Operation System	Important Points for the Implementation System
1	Ahwar	Electricity and Water Office	Manager (1) Clerks (2) Fee collecting personnel (2) Electrical Technicians (5) Water supply Mechanics and plumbers (6)	The organization has 10 years experience in operating the water supply facility in Ahwar. This organization handles the plumbing and repair. When this project is implemented, this organization will act as the managing agency. For the new facilities though service facilities did not previously exist, 6 electrical technicians can handle the generators. However the mechanics have to receive training related to the operation and maintenance of multi-stage pumps.
2	Moodeyah	Water Office	Manager (1) Clerks (2) Fee collecting personnel (2) Plumbers (4) Mechanics (4)	As in Ahwar the organization has sufficient experience and number of employees. As the number of water sources will increase rapidly, an experienced chief engineer will be necessary for the comprehensive operation and maintenance. Securing a chief engineer is planned.
3	Al Raidah /Shamalya	Water Office	The office consists of 5 employees who only operate the facility at Al-Ka'a. The operation of the existing facility is handled by 1 of the 3 trainees who received training at the former PWC Al-Mukalla branch. The other 2 employees are substitutes.	Select 1 to 2 representatives from the 7 villages, and reorganize the office. The three persons who have received training will become full-time employees, and additional employees will be hired. The 4 villages with a large water supply population will have separate distribution systems, therefore, it is appropriate for these 4 systems to be maintained under the responsibility of each village.
4	As-Sadarah	No Water Office exits	Non-existent	When this project is implemented, a water office will be established in the district office branch. The vice-director at the As-Sadarah branch (central area), as the chief administrator, will also function as the superintendent. Although machine mechanics and plumbers will be available at the site, it will be necessary to hire an overall technical supervisor from the outside.

4.3.3 Outline of the Facilities and Equipment

From results of the study, the following table outlines the facilities and equipment necessary as well as appropriate in each project site for each broad category of the water supply system.

1) Site Number 1: Ahwar

Category	Main Facilities and Equipment	Q'ty	Remarks
Water source facilities	1. Deepwell (existing well) 2. Deepwell pump 3. Pump house 4. Pumping Main 4" : 2,800 m	2 Nos. 2 Nos. 2 No.s 2,800 m	1. As this site is located on a coastal sand dune, groundwater is highly saline in general. Only two existing wells producing relatively good water in quality can be the possible water sources for this project. According to the existing information, the safe pumping rate from the two wells is estimated at 1.2 m3/min (20 lit/sec), but even this rate can only cover the service to the central area of Ahwar and several nearby villages. However, this project could reveal the detailed features of these water sources, which might allow further development of new sources in this basin, leading to a possible expansion of network to other villages in the future by the Yemeni side. 2. This project has the characteristics of an emergency project to reduce intense difficulties in securing domestic water for the people in Ahwar.
Transmission facilities	1. Booster tank : 100 m^3 2. Booster pump : 3. Booster station 4. Pumping Main 8 ": 1,614 m 6 ": 2,500 m	1 No. 2 Nos. 1 No. 1,614 m 2,500 m	
Distribution facilities	1. Elevated tank 250 m^3 x 20 mH 2. Distribution mains 6" - 3" : 5,185 m 3. Distribution branch lines 3" - 2"	1 No. 5,185 m	1. Both existing distribution mains and branch lines have been critically deteriorated, heavily leaking. The Japanese side will undertake to replace the mains requiring large-scale works. 2. For the branch lines, the materials will be supplied by the project, and the Yemeni side will carry out the installation works.
Service facilities	-		House connections are already existent in this site, and re-connections to replaced new branch lines shall be done by individual households.

2) Moodeyah

Category	Main Facilities and Equipment	Q'ty	Remarks
Water source facilities	1. Deepwell (existing) 2. Deepwell (new well) 3. Deepwell pump : 11 Kw 4. Pump house 5. Pumping Main 4" and 3"	3 Nos. 1 No. 4 Nos. 4 Nos. 2,160 m 200 m	1. This site is located inland, but groundwater is similar to that at Ahwar in that its saline content is high. The water sources with relatively good water quality are found only along the wadi belt where three wells to be employed for this project already exist. One new additional well will be constructed downstream, and the safe pumping rate is judged to be 1.36 m3/min (22.5 lit/sec) from these four wells. However, even with this flow rate, the water supply will be limited to the central area of Moodeyah and its surrounding villages. As there are no other appropriate water sources available at this site, restricting the supply rate is the only means to meet the demand of the large water supply population. 2. This project has the characteristics of an emergency project to alleviate acute hardship in securing domestic water for the residents of Moodeyah.
Transmission facilities	1. Booster tank : 100 m3 2. Booster pump 3. Booster station 4. Pumping Main 8"	1 No. 2 Nos. 1 No. 1,245 m	
Distribution facilities	1. Distribution tank 300 m^3 2. Distribution mains 8" and 2-1/2" : 11,895 m	1 No. 11,895 m	1. 8" main is distribution line linking the main reservoir to the service area of Moodeyah. The other distribution line is connected to the existing network of Al-Qurath service area to decrease the current water shortage in the area. 2. The existing distribution main and branch lines within Moodeyah has been well maintained. Their replacement is not required.
Service facilities			Since house connections are already established at this site, water supply is possible by connecting the existing lines to the new 8" line.

3) Al-Raidah/Shamalya

Category	Main Facilities and Equipment	Q'ty	Remarks
Water source facilities	(No. 1 Area) 1. Deepwell (existing) 2. Deepwell pump (existing) 3. Existing reservoir ($15\ m^3$) 4. Booster pump 5. Pump house (for both deepwell & booster pumps) 6. Pipes 4" (No. 2 Area) 1. Deepwell (new well) 2. Deepwell pump 3. Pump house (for both deepwell & booster pumps)	 1 No. 1 No. 1 No. 2 Nos. 1 No. 1 No. 1 No. 1 No.	1. As the service area and the served population are both large, one well cannot meet the demand. Therefore, the entire area will be divided into two service areas, with construction of a new additional well in one of the areas. No. 1 Area: Al-Sufilah, Al-Assadof, Al-Ka'a, Al-Oygar, Al-Asaeb (5 villages) No. 2 Area: Al-Rahabah, Al-Nuwaidara (2 villages) These sites use the deep-seated aquifer developed in recent years. 2. The water level for deep-seated groundwater is extremely deep at 300 m or more; therefore, a special pump with a maximum capacity is necessary. As Japan does not have this type of pump, it must be procured from a third country. 3. A transmission pump is necessary to convey water from the existing reservoir to the existing distribution tank. 4. As the existing well equipment is exposed at the present time, the equipment will be housed in the transmission pump station for protection.

Category	Main Facilities and Equipment	Q'ty	Remarks
Transmission facilities	(1st Area) 1. Booster and service tank (existing 750 m^3) 2. Booster pump (Booster tank to Al-Sufilah) 3. Pump house 4. Pumping main, 6" to 4" (No. 2 Area) 1. Booster tank 50 m^3 2. Booster pump 3. Pumping main, 4" - 3"	 1 No. 2 Nos. 1 No. 7,490 m 1 No. 2 Nos. 2,650 m	(No. 1 Area) 1. A huge water tank, which also acts as a storage reservoir, has been constructed through self-help efforts by the village community. This tank will be used as a booster tank as well as a distribution tank for No. 1 Area. 2. Water will be pumped up from the existing tank to a new distribution tank in the village of Al-Sufilah, which is located approximately 7 km southeast from the former tank location. (No. 2 Area) 1. For No. 2 Area, a booster pump station will be constructed beside the new well, and water will be pumped up to a new tank located in Al-Rahbah.
Distribution facilities	(No. 1 Area) 1. Existing water tank 750 m3 2. Al-Sufilah water tank 200 m3 3. Distribution lines (mains) 6" - 3" (No. 2 Area) 1. Al-Rahbah distribution tank 100 m3 2. Distribution lines 4" - 3"	 1 No. 1 No. 1 No.	(No. 1 Area) 1. Water is distributed to Al-Sufilah from the new water tank installed within the village. On the other hand, Al-Asaeb is served directly from the existing tank of 750 m3.
Service facilities	1. Public Water Stand 6 tap type 4 tap type	 7 Nos. 2 Nos.	A number of public water stands are planned for Al-Sufilah, Al-Rahabah, Al-Asaeb, and Al-Ka'a.

4) As-Sadarah

Category	Main Facilities and Equipment	Q'ty	Remarks
Water source facilities	1. Infiltration gallery 2. Intake pump 3. Pump house 4. Pumping Main 6"	1 No. 2 Nos. 1 No. 590 m	Intake from the upper stream of Wadi Hagar is located approximately 5 km north of the central area of As-Sadarah.
Transmission facilities	1. Booster tank No.1 50 m^3 2. Booster pump No.1 3. Pump house No.1 4. Pumping main 6": 5. Booster tank No.2 50 m^3 6. Booster pump No.2 7. Pump house No.2 8. Pumping main 6"	1 No. 2 Nos. 1 No. 3,090 m 1 No. 2 Nos. 1 No. 3,447 m	
Distribution facilities	1. Distribution tank 300 m^3 2. Distribution lines 6" - 2"	1 No. 11,659 m	
Service facilities	1. Public water stand 6 taps type 4 taps type	 9 Nos. 4 Nos.	Public water stands will be installed in each village. A multiple number of public stands will be planned in the central village of As-Sadarah and the large village of Hosn Basilaman.

4.3.4 Operation and Maintenance Plan

(1) Organization for Operation and Maintenance

The organization to centralize the operation and maintenance will be the water offices presently in operation at each of the project sites. With the exception of As-Sadarah which does not have an office, these offices, though each has varying degrees of maturity, have experience and expertise in management, operation and maintenance of existing facilities, and their knowledges and experiences will be useful for the facilities to be constructed in this project.

As an illustration, the situation of operation and maintenance by the LCCDs (Local Councils for Cooperation and Development) of in the country's northern part can be explained with reference to the operation and maintenance conditions of rural water facilities implemented by the Japanese loan project from 1979 to 1983 in the former North Yemen.

The construction works at 42 sites were completed in 1983. Then in 1985, the Overseas Economic Cooperation Fund, agency of the Japanese government for loan projects, carried out an evaluation study. This was followed by a follow-up survey by a Japanese expert on water administration dispatched to the RWSD in 1989, in which the following comments and recommendations were reported.

1) Although a majority of village communities had no experience in facilities management, water offices were newly formed and operation and maintenance is being carried out by full-time operators (most of them are village residents).

2) At each site, through the self-efforts of the Yemeni side, distribution networks were installed to enable house connections that could enhance the benefits of water service.

3) At each site, through fees collected from beneficiaries, independent water management is being executed. Remunerations to operators and other operation and maintenance costs are being met by the water fees.

4) Fees are charged either on a fixed rate basis or a metered rate

basis. Since these rates are all found to fall in ranges less than 5 % of household incomes, they are judged to be reasonable.

5) In most of the villages, although the practice of saving a portion of the collected fees for future repairs has taken root, complaints on the shortage of spare parts and high costs of repairs are often given.

6) At some sites, operations has been suspended due to equipment breakdowns and water source drying; and so the RWSD must take urgent steps to remedy these situations.

The original plan of this project was to drill deep wells as water sources and construct reservoirs and public water stands beside the wells, thus having no intention of providing networks within the sites. However, due to the strong requests by the villagers, design changes were made during the implementation, and the required additional works were undertaken by the Yemeni side. The follow-up survey ultimately concluded that the efforts had remarkable effects to enhance the convenience of the facilities.

As compared to the situation in the North where the residents started with no experience in management facilities, the sites for the present project do have experience and appropriate response is anticipated for operation and maintenance of facilities. Yet a review of the present conditions and reinforcement of the operation and maintenance formation is needed.

Although differences are apparent due to characteristics of each site, the hierarchy for management, operation and maintenance according to the present institutional system is as follows: