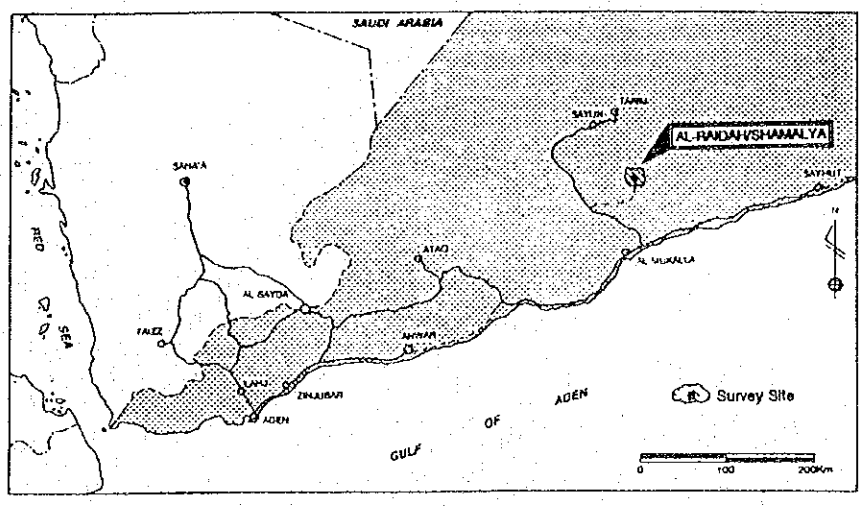
3.3.3 Al-Raidah/Shamalya

Site Number	7	Site Name		Al-Raidah/Shamalya	
Administrative Division	Governorate : Hadramout District : Ash Sheher Sub-district : Qailbin Yemen				
No. of Villages	7	No. of Houses	800	Present Population	9,300
Planned Area	14 km²	Population Density		664 persons/km²	
Income Sources	Rank 1: Remittances (50%) Rank 2: Daily Income (30%) Rank 3: Agriculture (20%)			Average Monthly Income	YR4,000
Medical Facilities	Hospitals/Clinics	1	Educational Facilities	Primary School	3
	Medical Staff	2		Intermediate School	1
	No. of Beds	0		Secondary School	
Shops/Restaurants			Mosques		11
Water Purchase Practice	Quantity	6,000 lit/30day/ 12 persons: 17 lcd			
	Price	YR 780/ 6,000 lit : YR 127/m³			
	Source				
Existing Water Facilities	Water Source	1 No.(deep well, 418m)			
	Reservoir	1 No.(150,000gal)			
	Pipeline	None			
	Water Rate				
	Consumption	23 lcd			
Electric Power Facility					



1. Location

This area is a cluster of villages located in a corner of the expansive Hadramout highland platform which is over 1,000 m higher than the port city of Al-Mukalla facing the Gulf of Aden. Both Hadramout and Shabwa governorates in the south have been meccas of oil exploration in recent years, and the latest development at Al-Mashilah, which reportedly has just launched the prodution of oil, is located not far from this site. An oil exploration road also runs through the area. As a large geological structure, the platform drops northward into the Wadi Hadramout where groundwater resources are remarkably rich. In the western part of the project site runs the top stream of the Wadi Idim, which is one of the main tributaries of the Wadi Hadramout. There is an existing well in the site, drilled to a depth of 400 m by a petroleum venture, Canadian Oxe'y under the request of the Hadramout government, and the former PWC's Al-Mukalla branch prepared a design for the water supply project for this site, with this deepwell as its water source.

2. Present Water Practice

The site consists of seven villages, with a total population of 9,300. None of these villages have water service as yet, although the village of Al Ka'a has recently acquired a deepwell and built a reservoir as huge as 150,000 gal. All the other villages are still heavily relying on vending water as well as rainfall.

The deepwell drilled by a petroleum company with the request of the government is close to the village of Al-Ka'a. It penetrated a total depth of 412 m, and the static water level reportedly was 320 m. Since the water level was so deep that an Italian-make submersible motor pump with a specially high lifting capatiy (motor output 18.5 kw) has been installed to get a discharge of 300 lit/min. Two units of generators (Italian and Chinese-made with a capacity of 50KVA and 70KVA, respectively) have also been installed to drive the submersible pump.

A small water tank with a capacity of 3,300 gal. and a public fountain are located beside the well to supply water to the residents at the well point. A booster pump is connected to this tank, and water is pumped up to a large-capacity reservoir (150,000 gal.) recently constructed on top of the plateau (30 m higher thatn the location of

the well). The facilities other than the well were recently constructed through donation offered by a former village resident who has successfully established himself in Saudi Arabia. The large reservoir has just been completed, and there is no pipeline yet. Only the residents in Al-Ka'a settlement use water from the well, although anyone can take water if money is paid.

The facilities are now under control of a committee consisting of five representatives from the Al-Ka'a village. Before starting operation, three persons from Al-Ka'a had trained for the operation and maintenance of equipment at the former PWC Al-Mukalla branch. Curently, one of these trainees directs the operation of the facility on a full-time basis. The committee of Al-Ka'a collects monthly YR 6,500 from the villagers to cover the salary of the operator and fuel costs.

All the other villages use rain water, and some of them, open wells which have water only for several months a year. Under such circumstance, the villagers have been heavily dependent on water vending all the year round. The average monthly consumption of one family is roughly 6,000 lit/month at a cost of YR 520 to YR 1,000. Residents expressed their wish that water billing based on meter reading is better than a flat rate when the water project is implemented, since the case of the latter will intensely strain the poor, giving them a heavy economic burden. Their argument was that without any industry in the area the people depend on remittances from emigrant workers, which have been deepening a gap between the rich and the poor.

There is another exisitng well 240 m deep, located midway between the villages of Al-Ka'a and Al-Rahbah, which was drilled during the 1970s under a UNDP project. The well has been abandoned due to scarcity of the yield and the damage with the manual piston pump. During the days when the pump was operating, water was daily distributed to each household at a rate of 20 liters.

3. Water Sources

a. Natural Environment

Al-Raidah/Shamalya lies on a vast platform of 980 to 1,600 m in elevation, a gently rolling terrain in the last stage of the old

age, differing in height by 50 to 60 m. The Wadi Adden and the Wadi Bieka runs north-northeastward through this site, and join near the Al-Nuwaidara village to form the upstream of the Wadi Idim, which runs down the mountainsides and is eventually united with the Wadi Hadramout. The wadis are as wide as 1.5 km, both sides of which form rolling hillsides.

The outcrops of rocks are scarce, except for those of limestone of on the hillsides. At the confluence of the two wadis around the Al-Nuwaidara village is a limestone cliff of 5 m in height. Limestone in this region is Rus Formation, marine deposit during the Tertiary Eocene period, with thin interbeds of marl and dolomite. The strikes of this rock series range from NE20° to 30°, with the gentle dips of 4° to 6° eastward. The conditions of faulting and cracks are not clear due to lack of outcrops, yet the Wadi Adden and the Wadi Bieka are suspected to be fault valleys.

There are two deepwells and two open wells in the region. One of the deepwells (W-1 in Fig.-3.12) now yields water of about 300 lit/min (5 lit/sec), which are pumped with a submersible motor pump, to the villagers of Al Ka'a; the other one (W-2) has long been abandoned, although it formerly produced water with a manual piston pump. The open wells exist in the Al-Sufilah village; one is used for drinking, but the other for washing only due to its inferior quality. The two wells are only 100 m apart in the village.

b. Hydrogeological Features

The deepwell now in service (W-1) is reportedly 418 m deep, with its static water level at 320 m. The pump was installed at a depth of 350 m. The study team confirmed the pumping rate is at a level of 300 lit/min, which reportedly could continue for 24 hours. According to information given by the GAREW Aden Branch, the lithology as a result of drilling was as follows:

0 - 350 m	Rus Formation (limestone)
350 - 418 m	Sandstone

Sandstone penetrated to the well bottom is believed to be

Cretaceous Mukalla Formation where significant groundwater occurs through networks of cracks. Water quality is also good, with electrical conductivity of 815 μS/cm. The abandoned deepwell was 244 m and did not reach this Mukalla Formation yet. Water obtained from this well is supposed to have been fissure water moving through limestone, and if drilled to a similar depth, it could have produced a similar yield as the one from (W-1) well.

Since this site has a population of about 9,300, an additional well is proposed to be drilled for the Project. The location of this new well is proposed near the abandoned well, with a planned depth of 450 m.

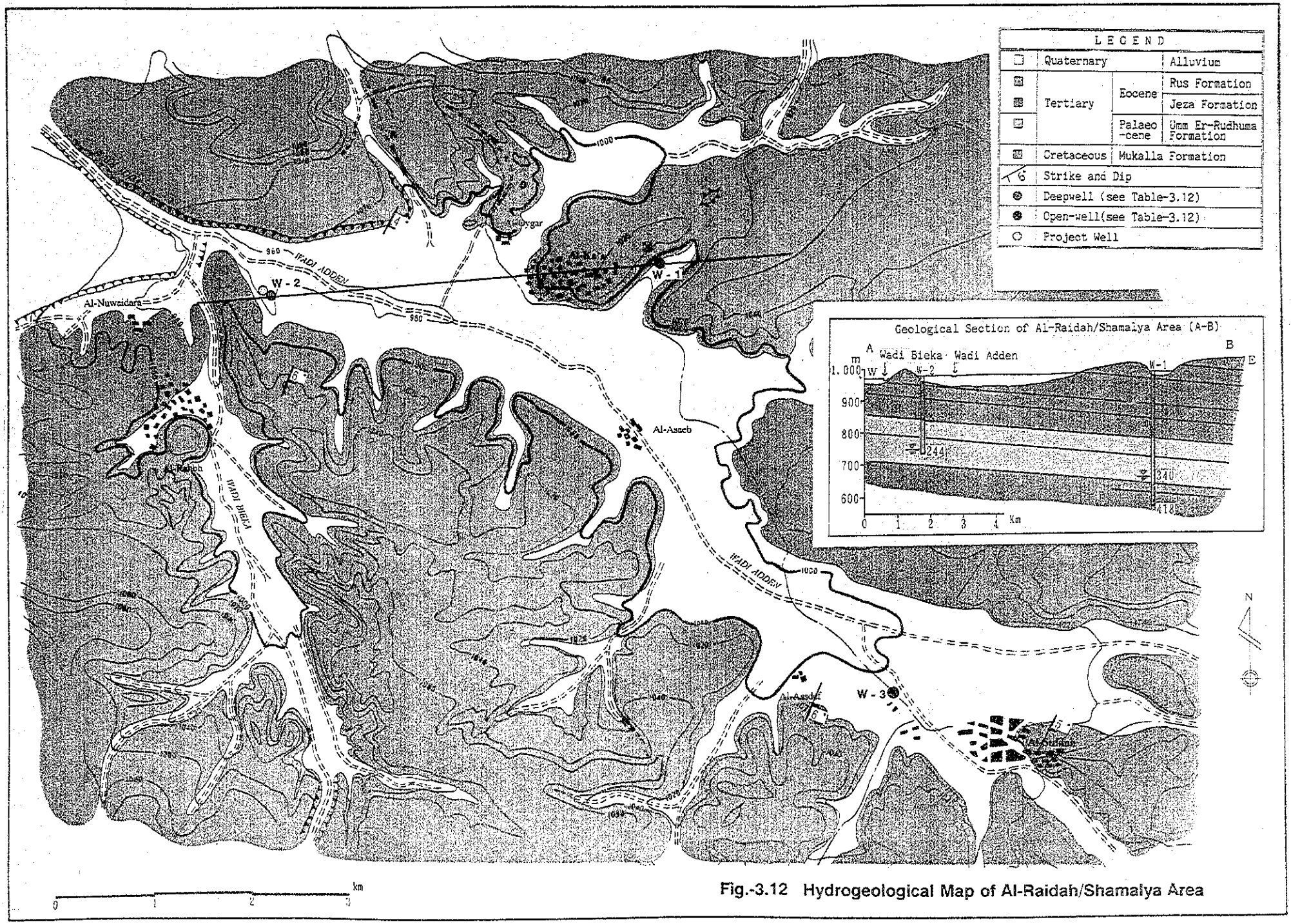


Fig.-3.12 Hydrogeological Map of Al-Raidah/Shamalya Area

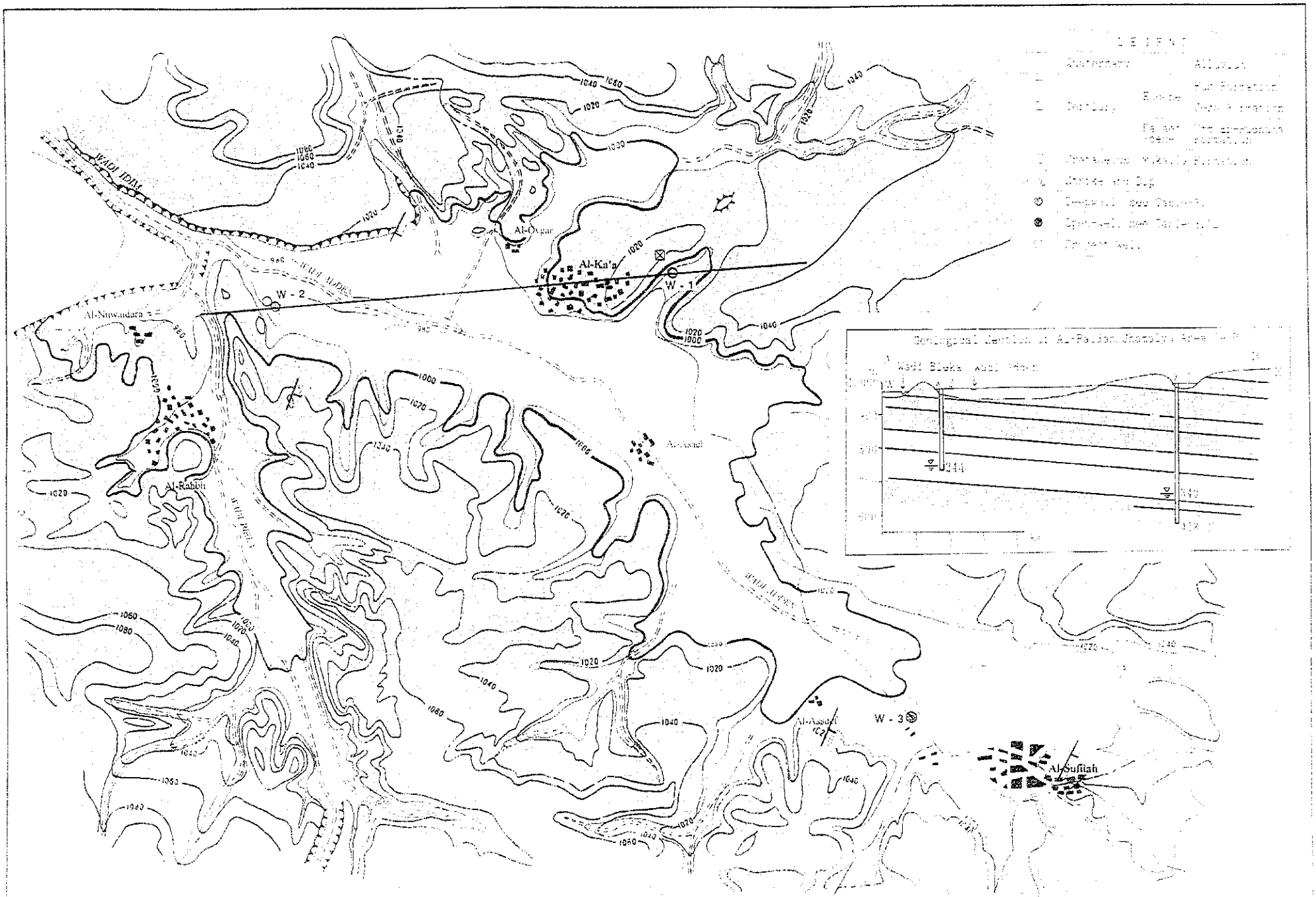


Fig.-3.12 Hydrogeological Map of Al-Raidah Shamaiya Area

Table-3.12 List of Existing Wells (Al-Raidah/Shamalya)

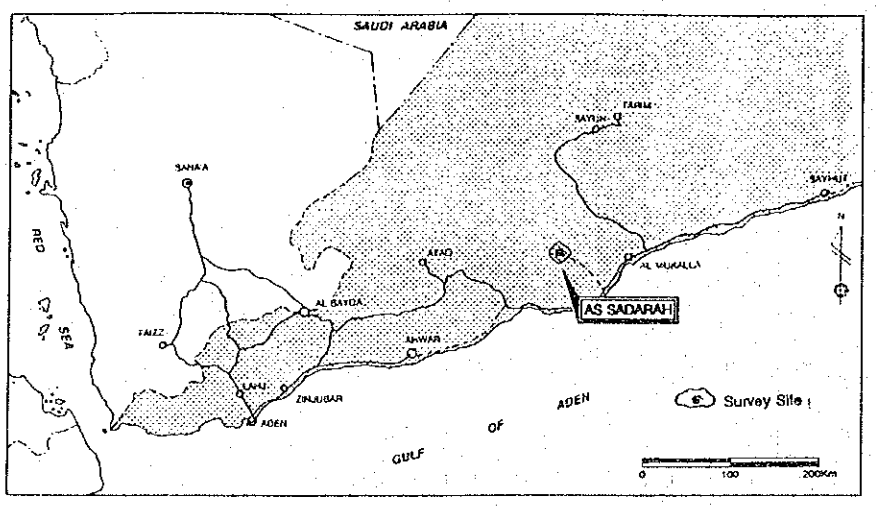
No.	Type	Source	Dia. (")	Depth (m)	Pump	Aquifer	SWL (m)	DWL (m)	Q (l/min)	T (°C)	pH	EC(μS/cm)		Remark
												Measured	Corrected at 25°C	
W1	Deepwell	W-1	8"	418.0	Submersible pump	Sandstone in Mukalla Group	340.0	above 350	300	30.0	8.1	897	815	Operating for Water source
W2	Deepwell	W-2	8"	244.0		Limestone in Rus Group			600.0					Abandon
W3	Open well	Al-Sufilah	8"	76.21		Alluvium	7.36		152.0	28.8	7.6	2,810	2,612	Drinking
W4	Open well	Al-Sufilah	8"	70.0	-	Alluvium	6.40		300.0?	26.5	7.5	3,840	3,728	for laundry

3.3.4 As Sadarah

Site Number	8	Site Name	As Sadarah

Administrative Division		Governorate : Hadramout District : Hager Sub-district : As Sadarah			
No. of Villages	7	No. of Houses	1,485	Present Population	11,050
Planned Area	12 km²	Population Density		929 persons/km²	
Income Sources	Rank 1: Agriculture (90%) Rank 2: Wages/Salaries (10%) Rank 3:			Average Monthly Income	YR 10,000
Medical Facilities	Hospitals/ Clinics	2	Educational Facilities	Primary School	2
	Medical Staff	4		Intermediate School	
	No. of Beds	0		Secondary School	
Shops/Restaurants			Mosques		9

Water Purchase Practice	Quantity	lit/ day/ persons: lcd
	Price	YR / lit : YR /m³
	Source	
Existing Water Facilities	Water Source	(hot springs/surface flow of the Waji Hajar)
	Reservoir	None
	Pipeline	None
	Water Rate	
	Consumption	50 lcd
Electric Power Facility		None



1. Location

As Sadarah is a subdistrict capital of Hajar district in Hadramout governorate, located in a mountainous area 100 km north of a seaboard town of Mayfa which is about 60 km west of Al-Mukalla city, the governorate capital. The region is in the upstream area of the Wadi Hagar, which flows down to discharge west of Mayfa into the Gulf of Aden. The Wadi Hagar is one of the exceptional rivers in Yemen having surface flow all year-round. Surface flow never ceases in this upstream area of As Sadarah. Furthermore, a geothermal zone runs across this region, producing lots of hot springs within the villages composing this subdistrict. Such affluent water resources are effectively used not only for living but for the large plantation of oil palms which is jointly operated by the member villages. The number of oil-palm trees is said to be no less than 500,000.

2. Present Water Supply Practice

The site consists of seven villages, with its population totaling 11,000 people. The centeral community of the region is the subdistrict capital, As Sadarah, with a population of approximately 5,000. As the area have plenty of hot springs due to the occurrence of a geothermal belt, water is easily obtainable, regardless of its quality. Formerly two villages, Al-Rahraja and Thilone, had small-scale water facilities utilizing spring water as their sources, both of them in similar sizes and with similar structures. Hot spring water was obtained in an hand-dug hole just 2 m deep, where a small submersible pump and a generator were installed. For distribution, a small stone reservoir of 1,000 gal. capacity was installed on the top of a nearby hill and water was distributed by gravity through a pipeline reaching the standpipe for the common use by the villagers. Both facilities were built around 1985, and the construction costs were shared by the residents in each village. At the time of the construction of these facilities, almost all the families in the two villages lived on remittances from their kins working in Kuwait, and collecting water bills presented no problems. The Gulf war, however, has deprived the villagers of the opportunities to work outside Yemen, and both facilities have since been left decayed: In Al-Raharja the hole collapsed in 1988, inflicting the damage on the pump in it; In Thilone the pump was broken down in 1992 and has since been left unrepaired because of lack of fund. Both settlements are quite small

with about 15 houses, and the operation and maintenance costs after the Gulf war are suspected to have raised a problem among the villagers.

Currently, six of the seven villages use spring water and the other one, Bamesiblin, uses the stream flow of the Wadi Hagar. Although hot springs emerge wherever the ground is opened up by digging to 1 to 3 m, the residents try to hit those with lower temperatures. These springs have effectively been used for drinking, miscellaneous use, domestic animals and agriculture. Even a public bath has been constructed at the spring near the mosque in the central part of the community. Although As Saradah residents are presently content with their water in terms of volume, all of them displayed a strong dissatisfaction with the water quality (electrical conductivity 1,660 to 3,500 μc/cm; temperature 27-45.1), and are acutely in need of water with good quality. Concerning water rates, they say they are willing to pay if the amount is determined among themselves.

3. Water Sources

a. Natural Environment

As Sadarah is a longitudinal fault basin about 20 km long north and south and 4 to 5 km wide east and west, formed along the Wadi Hagar. Its elevation ranges from 440 to 500 m. The eastern and western parts of the site is a mountainous area varying from 650 to 800 m in altitude, presenting dissected, gently rolling figures of ridges in the latter stage of maturity. Numerous dissected valleys of dendritic shape cut down the mountainsides.

The region of the site is constituted mainly of Jeza Formation and Rus Formation Groups of the Peleogene Eocene time and Shihr Formation Group of the Neogene Pliocene time, with a fan of floodplain sediment spreading in the area of the As Sadarah community and its southern part, together with belts of the alluvium along the Wadi Hagar.

Jeza and Rus Formation Groups are dominantly limestone with interbeds of marl and dolomite, with the latter group containing abundant fossils of coral and sealily. Shihr Group is a consolidated conglomerate. The Tertiary rocks on the right side

of the Wadi Hajar strikes NS - NW10° and dip easterly 16° to 20°, while those on the left one strike roughly NW20° and dip westerly 10°, suggesting a syncline structure along the axis extending in the direction of the course of the Wadi Hajar. Clusters of small faults and cracks striking NW 10° to 20° are widespread, created under influence of techtonoic movement which formed the syncline structure. These cracks seem to provide passages of hot springs occurring in abundance along the Wadi. The floodplain sediment is covered with eolian sand, probably with its lower section consisting of sand and gravel.

Table-3.13 Geological Features of As Sadarah

AGE		FORMATION	LITHOLOGY
Quaternary	Holocene	Alluvium	Sand, Gravel
	Holocene - Pleistocene	Floodplain deposit	Sand, Gravel, Clay
Tertiary	Pliocene	Shihr Formation	Sandstone
	Eocene	Rus Formation	Limestone, Marl
		Jeza Formation	Limestone, Marl, Dolomite

b. Hydrogeological Features

In the basin along the Wadi Hajar are lots of hot springs emerging at depths of 3 to 4 m, which are broadly in service for various domestic uses of residents. There is a public bath at the premise of the mosque in As Sadarah, using a discharge of hot spring there, and the stream flow of the Wadi Hajar is led through the ditch into the huge plantation of palm trees. The villagers of Bamesiblin, one of the villages in the site, take this irrigation water for their domestic use. The other villages within the basin are all using hot springs emerging at depths of 3 to 4 m underground.

The testing data of these hot springs and the Wadi stream in various locations shown in Fig.-3.13 are listed in Table-3.14. The temperatures of springs range from 27° to 45.1°C, and their qualities represented by electrical conductivity, after corrected at 25°C, fall into the range from 1,454 to 2,780 μS/cm. The

surface flow of the Wadi Hajar was measured at 1,233 μS/cm in its upstream about 5 km north of As Sadarah and at 3,145 μS/cm downstream around the village of Bamesiblin about 7 km south of As Sadarah, indicating its flow degenerates the quality as it runs down. The irrigation water coming from the Wadi was 2,212 to 2,308 north of As Sadarah, where the flow still preserves a relatively good quality. Fig.-3.13 includes the geological section of the site, along with the isoline maps of electrical conductivity and spring temperatures. According to this map, the zone of the temperatures higher than 44°C lies along the base of mountain on the left side of the Wadi Hajar.

As a result of the survey, the new water source for this site is proposed as follows:

(1) One of the possible water sources is a hot spring source occurring at a depth of about 5 m at the deepest, because a deeper spring is likely to have a higher temperature. This source should be developed in the upstream of the Wadi, since the downstream area is vulnerable to artificial contamination.

    The existing sources in the site are observed to have capacities to yield 250 lit/min on average. To meet the demand of a planned total population, therefore, it is required to develop new springs at three locations.

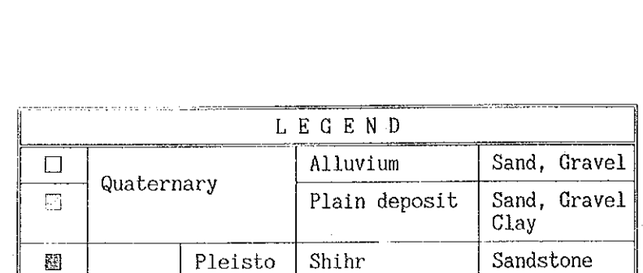
(2) An alternative plan is to install an open well about 10 m deep at a site between the irrigation channel and the Wadi Hajar, which is sure to produce an ample volume of water through recharge from the channel and the wadi. One well is enough.

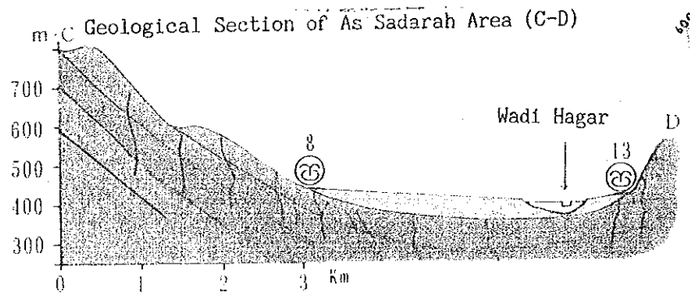
(3) Irrigation water in the channel could directly be served.

(4) The stream flow in the upstream of the Wadi Hajar is the purest source of water in the surroundings of the site.

Of four alternatives, the As Sadarah branch of the Hajar district office strongly wants the last one, because this flow is most hygienic water source available in the area. Although this plan costs by far more than the other ones due to its location more distant from the community area, it would be the most practical way to assure safe water in view of the future of the site now developing.

LEGEND				
	Quaternary		Alluvium	Sand, Gravel
			Plain deposit	Sand, Gravel Clay
	Tertia -ry	Pleisto -cene	Shihr Formation	Sandstone
		Eocene	Rus Formation	Limestone
			Jeza Formation	Limestone, Marl, dolomite
6°	Strike and Dip			
	Syncline			
	Fault			
	Electrical Conductivity (μs/cm)			
	Hot Spring (see Table-3.14)			
	E.C. Measured Point			
	Water Source (surface water)			





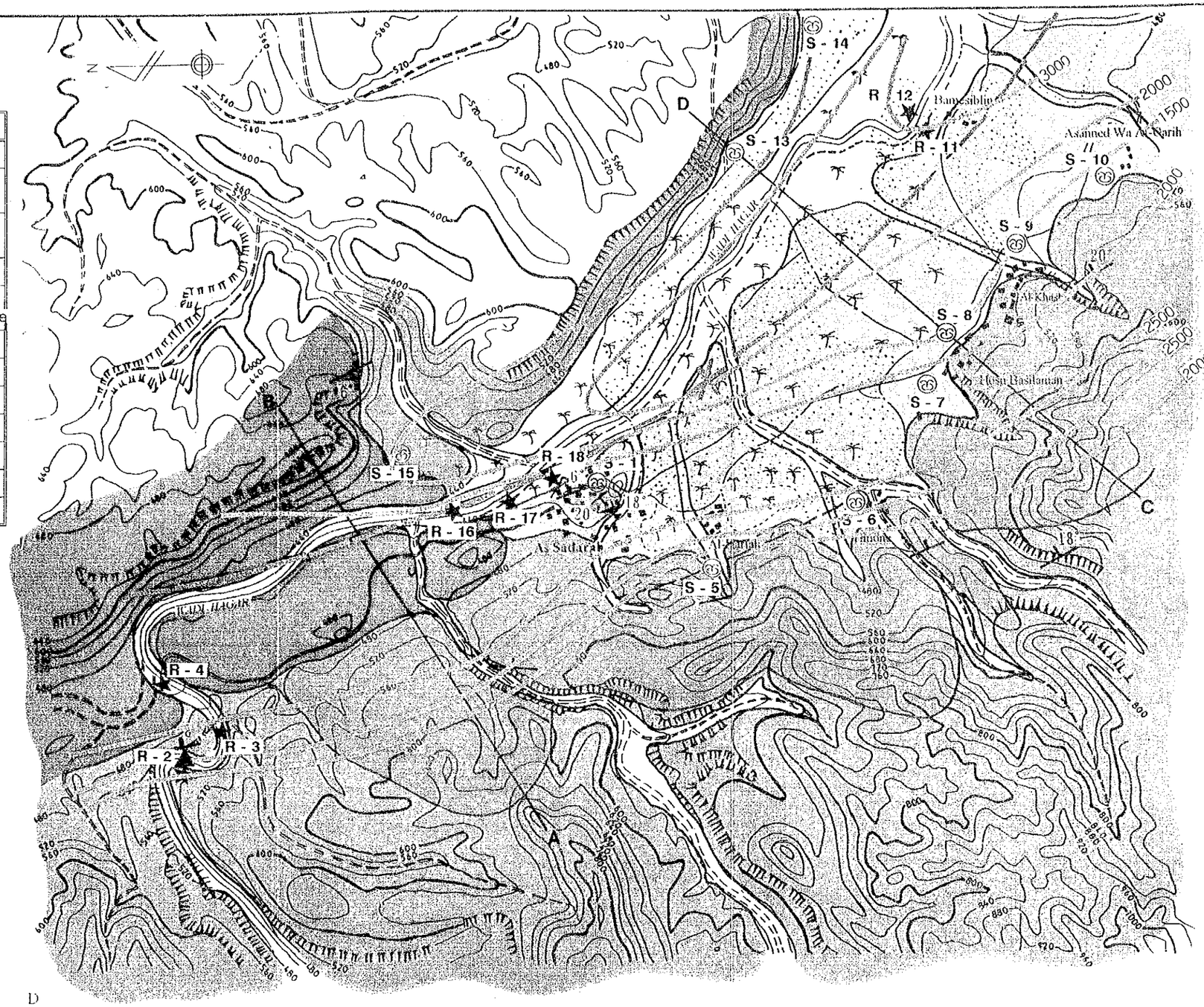


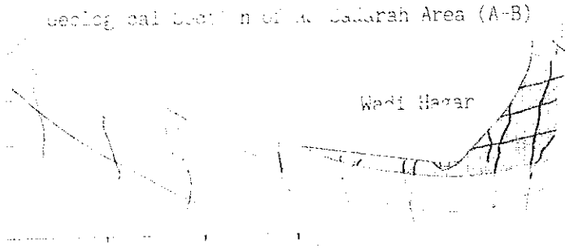
Fig.-3.13 Hydrogeological Map of As Sadarah Area

L E G E N D

Quaternary		Alluvium	Sand, Gravel
		Plain deposit	Sand, Gravel Clay
Tertiary	Pleistocene	Shihr Formation	Sandstone
	Eocene	Rus Formation	Limestone
		Jeza Formation	Limestone, Marl, dolomite

- Strike and Dip
- Syncline
- Fault
- Electrical Conductivity (μs/cm)
- Hot Spring (see Table-3.14)
- E.C. Measured Point
- Water Source (surface water)

Geological Section of As Sadarah Area (A-B)



Geological Section of As Sadarah Area (C-D)

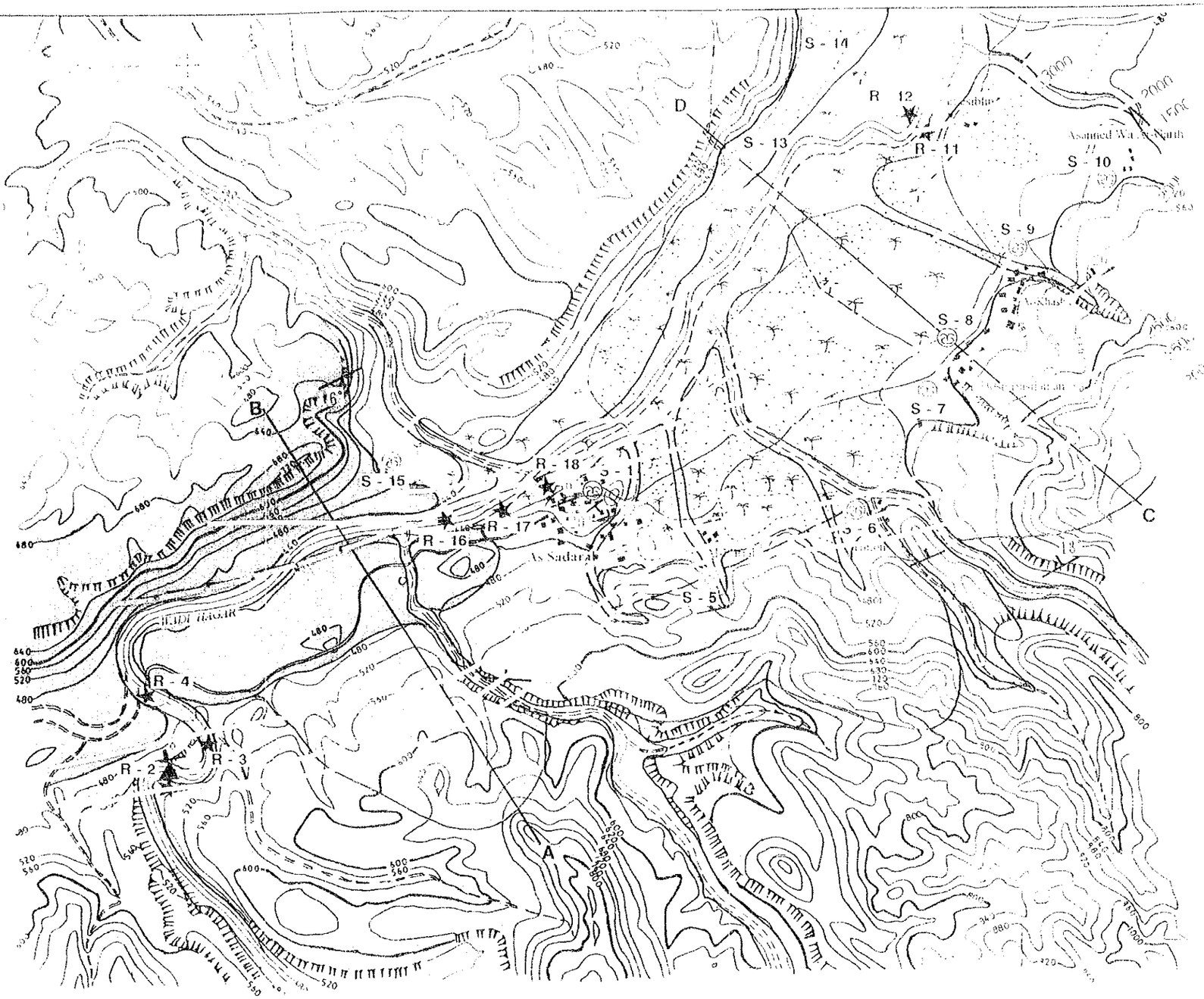


Fig.-3.13 Hydrogeological Map of As Sadarah Area

Table-3.14 List of Existing Wells (As Sadarah)

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	
S1	Springs	As Sadarah, Springs of Mosque	4x4	3.0	Bore-hole pump	Limestone	2.0		11.0	36.2	7.1	2,330	2,275	General use
R2	Surface Water of River	Up-stream of Wadi Hajar							2,000	27.9	8.5	1,305	1,233	Unused
S3	Springs	Beside down-stream of Wadi Hajar				Alluvium				35.6	6.9	3,510	2,896	Unused
R4	Surface Water of River	Down-stream of Wadi Hajar, Parking area								28.0	7.3	2,200	2,075	General use
S5	Springs	Al Harja				Limestone			3,000	38.6	7.1	2,260	1,777	Under construction
S6	"	Thilone	3X3	2.0		Alluvium				25.0	8.2	2,780	2,780	General use
S7	"	Hosn Basilaman (1)	3X3	2.0		Limestone			3,000	36.0	6.9	2,840	2,313	For drinking
S8	"	Hosn Basilaman (2)	3X3	2.0		"			2,000	35.1	6.9	2,116	1,760	General use
S9	"	Al-Harjah	3X3	2.0		"			2,000	36.2	6.7	1,668	1,363	"
S10	"	Asanned-wa Al Garih	3X3	2.0	Bore-hole pump	"			50.0	34.0	7.0	2,097	1,777	"

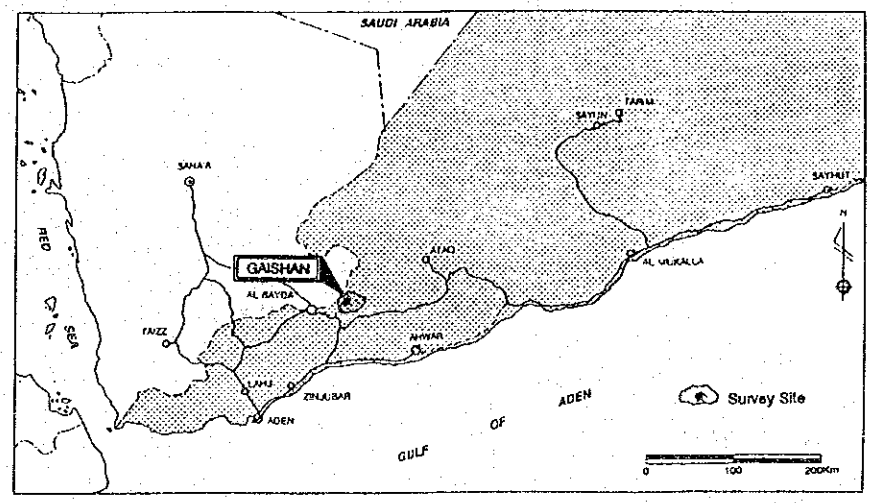
No.	Type	Source	Dia. (m)	Depth (m)	Pump	Aquifer	SWL (m)	DWL (m)	Q (l/min)	T (°C)	pH	EC(μS/cm)		Remark
												Measured	Corrected at 20°C	
R11	Water-cource for Agri-culture	Bamesiblin		13.30	-					27.0	7.6	2,940	2,827	General use
R12	Surface-water of River	"								27.3	8.0	3,290	3,145	Unused
S13	Springs	Al hamara	3X4	1.0	Bore-hole pump				50.0	44.5	7.5	2,021	1,454	General use
S14	Springs	Al Qarh	3	4.0	Bore-hole pump	Limestone				40.4	6.9	2,066	1,580	"
S15	Springs								3.0	45.1	7.3	2,770	1,970	General use for private houses by pipes
R16	Surface-water of river									30.7	7.9	2,560	2,298	
R17	Water-cource for Agri-culture									29.7	7.9	2,420	2,212	
R18	Water-cource for Agri-culture									29.6	7.9	2,520	2,308	

3.3.5 Gaishan

Site Number	5	Site Name	Gaishan

Administrative Division	Governorate : Abyan District : Moodeyah Sub-district : Gaishan				
No. of Villages	24	No. of Houses	446	Present Population	4,490
Planned Area	22 km²	Population Density		204 persons/km²	
Income Sources	Rank 1: Agriculture (60%) Rank 2: Daily Income (30%) Rank 3: Wages/Salaries (10%)			Average Monthly Income	YR4,000
Medical Facilities	Hospitals/ Clinics	4	Educational Facilities	Primary School	6
	Medical Staff	5		Intermediate School	1
	No. of Beds	0		Secondary School	1
Shops/Restaurants			Mosques		24

Water Purchase Practice	Quantity	lit/ day/ persons: lcd
	Price	YR / lit : YR /m³
	Source	
Existing Water Facilities	Water Source	1 No.(Open well, Installed in 1989)
	Reservoir	1 No.(60,000gal, Constructed in 1989)
	Pipeline	4" - 1"
	Water Rate	YR 100/month/House
	Consumption	40 lcd
Electric Power Facility		Only 2 villages own small generators.



1. Location

This area constitutes a subdistrict involving 33 villages in the rugged northern mountainous area in Abyan governorate. Most of the villages are small, and the total population does not reach 5,000. Public institutions including the district office branch and a small market (souk) are located in Gaishan. The entire area is divided into three zones by the three channels of wadis running in parallel in the east and west direction through the area. The villages are mainly scattered in the two reaches of the wadis, one along the Wadi Uddamar and the other along the Wadi Rhab.

2. Present Water Supply Condition

a. Existing Facilities

The public water facility including one open well and a water tank with a capacity of 60,000 gal. were constructed in the upper stream of the Wadi Uddmar by the PWC in 1989. The quality of groundwater occurring along the Wadi Uddmar is good, and the water production is relatively stable. Lots of open wells have been installed by the villagers along the course of this wadi. On the contrary, groundwater in the Wadi Rhab is not usable because of its extremely high contents of salts. In view of such situation, the government took a measure as a first step to install the distribution network for the villages along the Wadi Rhab. (Pipe materials were provided by the PWC, and the construction cost was shared by the beneficiaries.) AT present the existing facility is in service only for the residents in this area. The total length of the 4"- 1" steel pipeline reaches approximately 10 km, and each village receives water from the public water tap. The layout of the existing public water system is illustrated in Fig.-3.14.

b. Water Supply Conditions

The water service from the public facility continues while the pump is operating: Water is supplied twice a day from 6:00 am to 9:00 am and 2:00 pm to 4:00 pm. The water tank is located on the top of a mountain in the upstream. Thanks to its high location, service pressure is enough even to the settlement located at the end of the pipeline.

This public facility is managed by five employees of the water office belonging to the Gaishan branch of the Moodeyah district

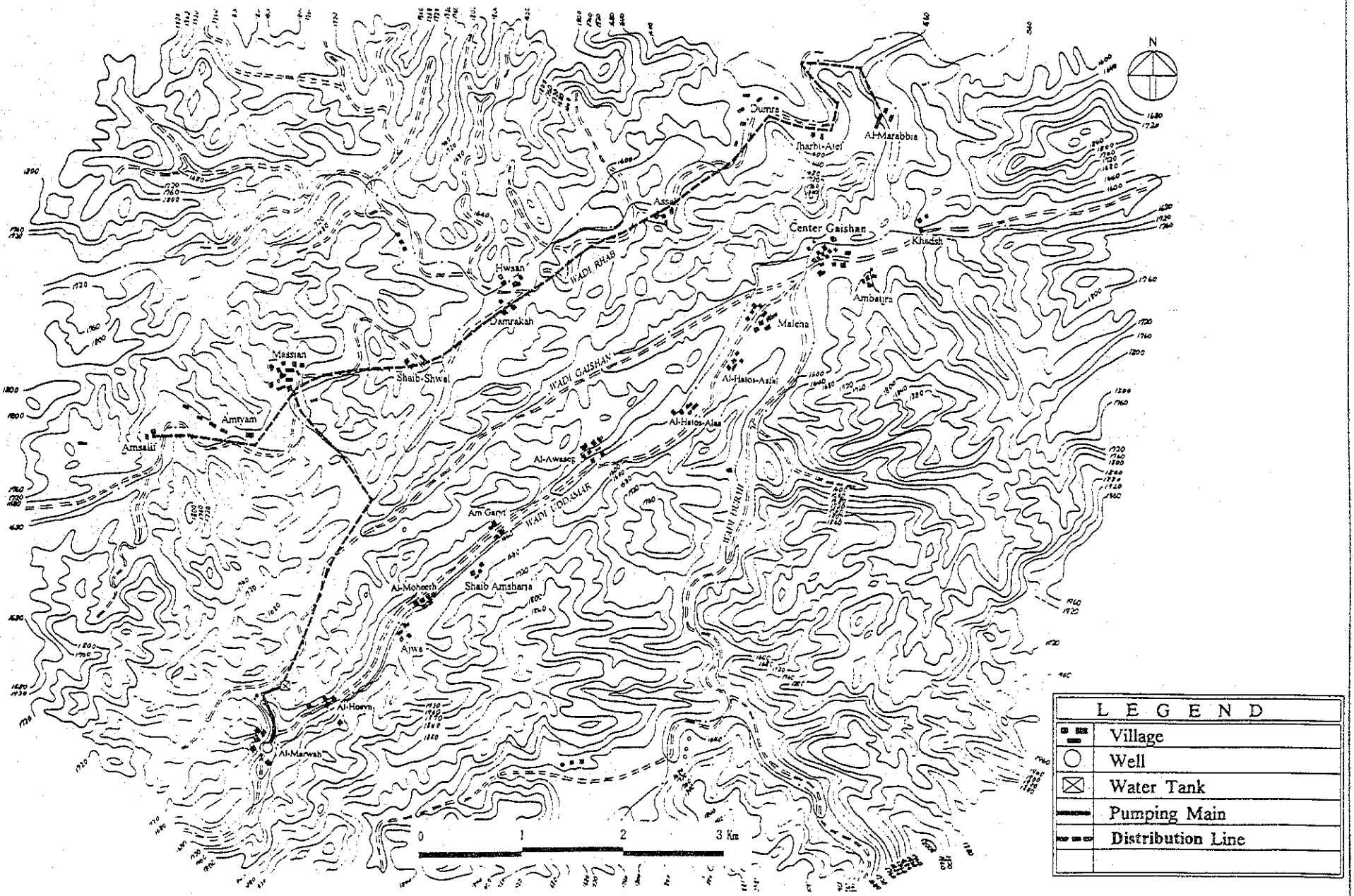


Fig.-3.14 Existing Water Suuply System at Gaishan

office. Since the planning and design of facilities for Gaishan by the PWC include the villages along the Wadi Uddamar as well as those along the Wadi Rhab with a population of 1,300, the size of the constructed facilities at present is larger than is required for the latter only, and the monthly revenue from water billing is no more than YR 3,600, which is mainly spent on fuel costs. The salaries of the employees, therefore, are paid by the local government.

On the other hand, the villages in the Wadi Uddmar have traditionally depended on their own individual open wells. In some villages a pipeline has been extended from the well to the inside of the villages for the convenience of all residents, yet a majority of them still continue to fetch water by hand. The owners of the wells normally collect water rates from the users and the money is spent on the operation and maintenance costs. The rates differ with the villages, ranging from YR 78 to 286/month/household.

3. Water Sources

a. Natural Environment

Gaishan is nestled in the midst of a rugged mountainous area near the former border with North Yemen to the east of Al-Bayda city. The highland platform where Al-Bayda is located west of Gaishan, replaced with a terrain of late maturity represented by sharp ridges and deep gorges. In Gaishan area, three dendritic valleys, the Wadi Uddamar, Wadi Gaishan and Wadi Rhab, run in parallel northeastward, dotted with small villages alongside their channels. The wadis flow in an average slope of 1/130, with a width of 500 m at maximum.

The region is constituted of Precambrian biotite schist, gneiss, hornblende, dolerite and the kind, with alluvial belts along the wadis. Precambrian schistosity strikes NE70° to 80°, and dips 68° to 72° northward. In the Wadi Uddamar are normal faults running in parallel with the channel and dipping northward. The outcrops of the faults near the village of Al-Hosyn are observed to have been clogged with fault clay and fault breccia (See Fig.-3.15).

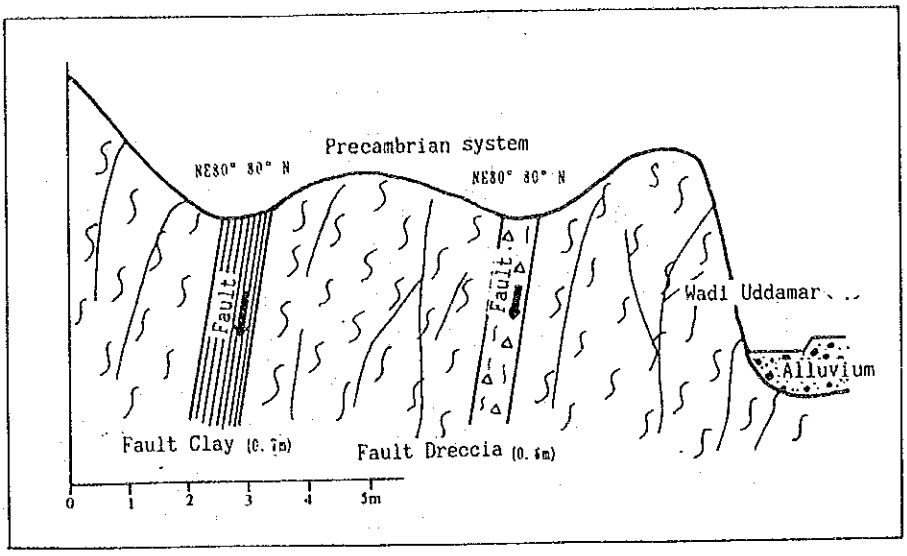


Fig.-3.15 The Sectional View of Faults of Al-Hosyn

Faulting system in Yemen is divided into two main groups: one in the EW direction and the other in the NS direction. Although the former is usually seen to have been filled with fault clay or breccia, the faults in this direction along the Wadi Uddamar are accompanied with networks of cracks, through which groundwater can be transported. On the other hand, cracks are rare along the Wadi Gaishan and the Wadi Rhab.

b. Hydrogeological Features

There are nearly 30 open wells along the Wadi Uddamar in service for villagers' domestic use and for irrigation, with groundwater flowing in much more quantity than the geological features may suggest. The wells are 11 to 24 m deep, with the alluvium 5 to 8 m thick and their water levels ranging from 5.8 to 15 m. In the village of Al-Maruwah, a public water well was installed to supply water to the villages along the Wadi Rhab. It is 20.4 m deep, with the water level standing at 14.7 m. The horizon of Precambrian basement is seen outcropping at a depth of 7.5 m in this well, indicating groundwater occurs in its upper weathered zone associated with a network of cracks. Other existing wells also have a similar structure of water occurrence.

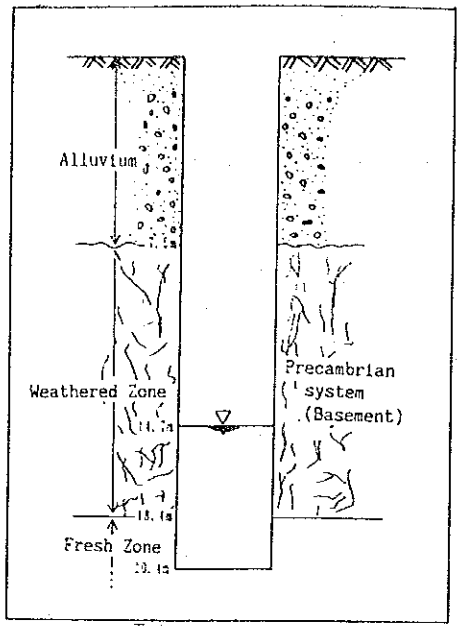


Fig.-3.16 Lithology of Borehole in Al-Maruwah

The results of the survey on the existing wells are shown in Table-3.15, Fig.-3.16 and Fig.-3.17 together with information on water quality revealed by testing of electrical conductivity. They are summarized as follows:

(1) Groundwater in the Wadi Uddamar shows an electrical conductivity less than 1,000 μS/cm.
(2) Groundwater in the Wadi Gaishan has an electrical conductivity as high as 7,400 μS/cm.
(3) Groundwater in the Wadi Rhab has an extremely high electrical conductivity over 12,000 μS/cm.

Based upon the survey results, it is clear that groundwater in the Wadi Uddamar only can be used for water service. The public open well in Al-Maluwah currently produces roughly 200 to 250 lit/min, and an additional well is needed for serving a total population of 4,490 in the site. The location of a new open well is proposed at a point about 1 km downstream the existing public well, with its depth to 25 to 30 m.

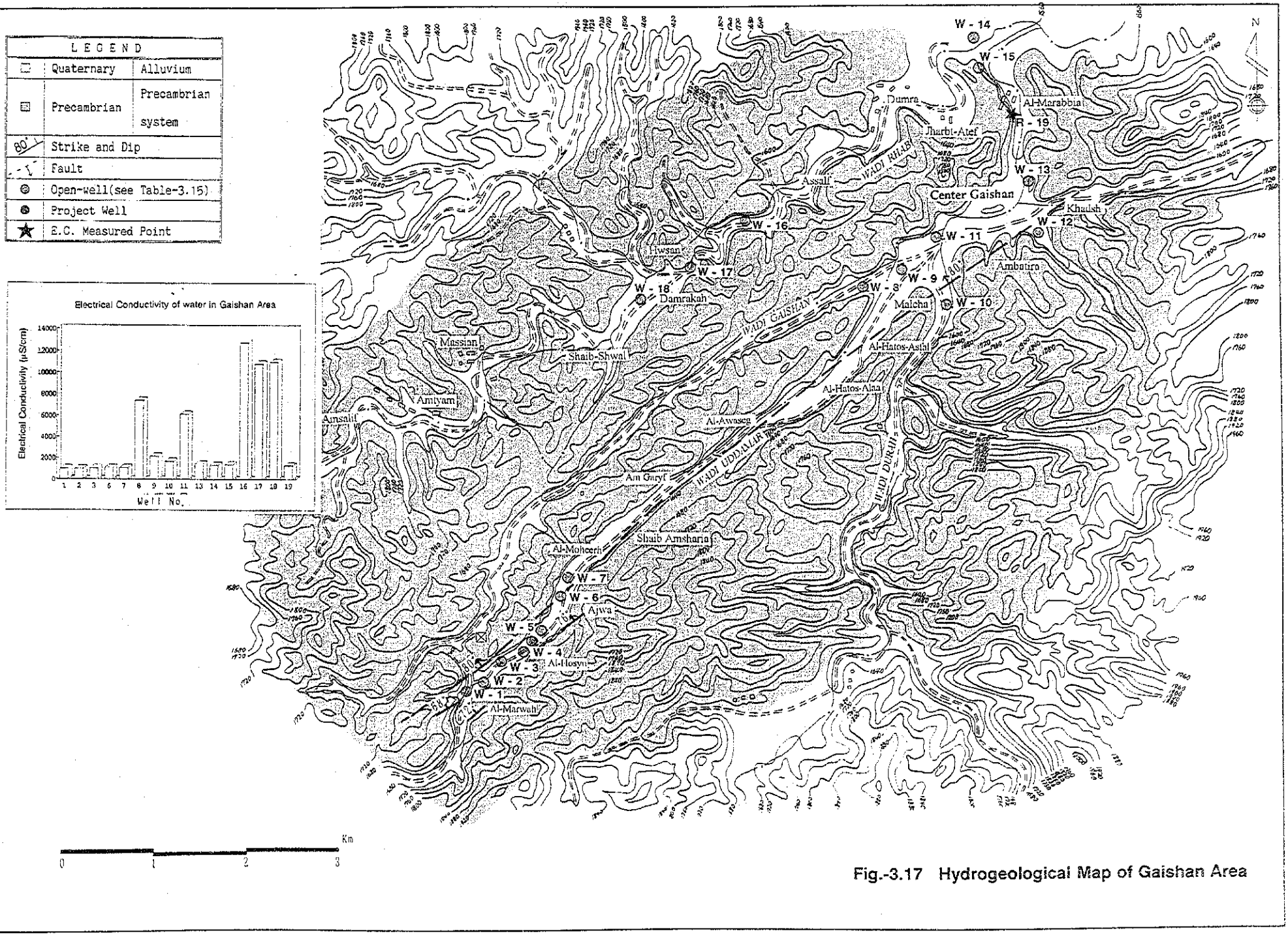


Fig.-3.17 Hydrogeological Map of Gaishan Area

Table-3.15 List of Existing Well (Gaishan)

No.	Type	Source	Dia. (m)	Depth (m)	Pump	Aquifer	SWL (m)	Q (l/min)	T (°C)	pH	EC (μS/cm) Measured	EC (μS/cm) Corrected at 25°C	Remark
W1	Open well	Al-Marwah	3.7	20.4	Bore-hole	Weathered Schist	14.7	200.0	36.0	7.7	1,230	1,008	Domestic use
W2	"	Agric. use/private		18.3	pump	"	17.2	-	31.2	7.4	1,100	979	"
W3	"	"		22.2	"	"	17.8	150.0	26.3	7.2	1,044	1,018	"
W4	"	"		23.2	"	"	15.2	-					"
W5	"	"		19.4	"	"	11.7	-					"
W6	"	"		20.5	"	"	12.1	200.0	28.6	7.2	1,160	1,082	"
W7	"	"		24.0	"	"	12.1	-	24.4	7.1	1,060	1,073	"
W8	"	"		19.0	"	"	10.3	-	27.5	6.9	7,770	7,400	Agricultural use
W9	"	"		24.8	"	"	14.1	200.0	25.4	7.4	2,160	2,143	Domestic use
W10	"	"		14.4	"	"	6.5	300.0	24.3	7.4	1,648	1,671	Domestic use
W11	"	Well near of Suq		13.3	-	"	7.8		23.4	6.9	5,960	6,157	Domestic use
W12	"	Abandoned				"							
W13	"	Khadsh(Agricult.)		13.2	Bore-hole Pump	"	5.8		24.9	6.9	1,426	1,429	Domestic use
W14	"	Ghelbent		11.8	"	"	6.1		21.6	6.9	1,228	1,318	Domestic use
W15	"			16.5	"	"	7.2		20.6	7.1	1,245	1,365	Agric. & Domest.

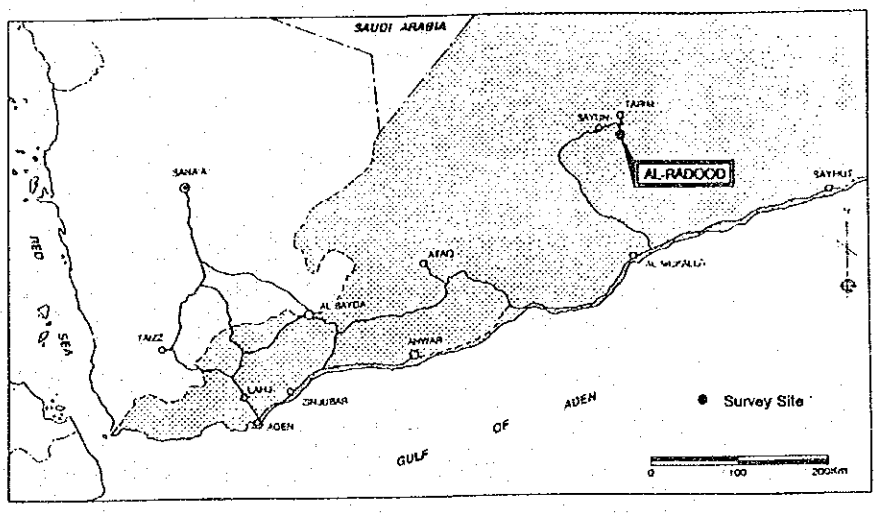
W16	"	Wadi Rhab		14.4		"	8.0		20.7	7.4	11,790	12,719	Agricultural use
W17	"	"	2.5	19.3		"	9.1		21.5	7.1	10,040	10,796	"
W18	"	"		11.8		"	7.9		21.8	7.3	10,260	10,962	"
R19	River water	Durah							22.7	7.8	1,223	1,282	Unuse

(*) Data Source: GAREW-Aden branch

3.3.6 Al-Radood

Site Number	9	Site Name	Al-Radood
Administrative Division	Governorate : Hadramout District : Sayun Sub-district : Tarim		
No. of Villages	12	No. of Houses	1,485
Present Population	8,980		
Planned Area	14 km²	Population Density	641 persons/km²
Income Sources	Rank 1: Agriculture (80%) Rank 2: Remittances (20%)	Monthly Income	YR6,000
Medical Facilities	Hospitals/ Clinics: 1	Educational Facilities	Primary School: 2
	Medical Staff: 2		Intermediate School: 1
	No. of Beds:		Secondary School:
Shops/Restaurants		Mosques	12

Water Purchase Practice	Quantity	lit/ day/ persons: lcd
	Price	YR / lit : YR /m³
	Source	Al-Mafod
Existing Water Facilities	Water Source	At the central village Al-Radood, there is 1 public open well and many private wells
	Reservoir	1 No.(22,000gal) and a lot of small tanks
	Pipeline	3" - 1"
	Water Rate	YR10/100 gal
	Consumption	Al-Radood 40 - 50 lcd Others 30 - 50 lcd
Electric Power Facility	Supplied from Sayun	



1. Location

The site of Al-Radood is a cluster of villages in the agricultural belt surrounding Sayun city, a central community of the Wadi Hadramout basin in Hadramout governorate. The distance from Aden is about 1,000 km via the national highway. The communities in the Wadi basin mainly engage in agricultural production in the fertile land using rich groundwater resources along the basin. The communities have traditionally been sending a wave of labor force to the Gulf countries, particularly Saudi Arabia. Such a background of the region's communities with relatively stable revenues is reflected in the site of Al-Radood having an appearance of a suburban type of residential area. Although all the villages constituting the site has their own water supply systems with the open wells as water sources, they are now in need of an integrated system having deepwells as its source, as the nearby larger communities such as Sayun and Tarim have launched on an upgraded system with aid from the World Bank/IDA to serve citizens with safe and stable water at lower water rates.

2. Present Water Supply Systems

The site is composed of 12 villages including Al-Radood, with its population totaling 9,000, located in a green belt at the junction of the Wadi Idim and the Wadi Anuel. Since the region is rich in shallow groundwater, each village has a variety of water systems of its own with the open wells as its sources. The current conditions of such various systems are described separately as follows:

a. Al-Radood System

The water service for the community of Al-Radood is separated into two groups: one is a public service covering nearly two thirds of the community managed by the community's water office; the other is groups of privately-owned systems, each of which supply to its own member households of 2 to 10 in number.

The public system consists of an open well 30 m deep and an elevated tank of 22,000 gal. capacity, 11 m high, with distribution network from the tank of 3" to 1" steel pipe totaling 1,206 m in length. The system now serves 170 households. The house connections are 3/4" steel pipe in diamter, each one provided with a water meter on it. Water is served twice a day, for three hours in the morning and for two hours in the afternoon.

Consumption is metered at a rate of YR 10/100 gal. to be paid bimonthly. The water bills of households range from YR 130 to 390 every two months, on average at a level of YR 260/two months. The water office was established in 1980, with the fund entirely collected from the beneficiaries. Its management by three staff members is autonomous. On the other hand, private systems in the community total as many as 26, with its facility consisting of an open well and distribution lines independently managed by the member families. Most of these small facilities were reportedly installed in 1988, costing the owner about YR 300,000. These days the owners had money to pay for their systems, but since the outbreak of the Gulf war they cannot afford to install such a facility, and even the replacement and repair seem to have grown difficult.

b. Other Communities' Systems

The systems owned by other communities than Al-Radood are grouped into three categories, according to their service levels and operational conditions as follows:

i. Regular water supply systems

- Shuriuoof and Rateeh

The two communities jointly use a complete supply system with one open well, one reservoir and pipelines with house connections with meters.

- Sonah

This village has a similar system as the above one.

- Al-Husn

Part of this village is served with private systems.

ii. Privately-owned but publicly-used system

- Al-Gawi (using an irrigation well)
- Pl Muaroof
- Al-Mudaimena

iii. Systems currently having problems

- Al-Sharqa

The well, reservoir and pipeline are all dilapilated. The height of the reservoir is not enough.

- Al-Mhewad

The village has only one privately-owned open well and pipeline. Other three houses fetch water from the well.

- Al-Rabwa

The yield is not enough. The elevated tank got old.

- Al-Dekha

The pump frequently raises a trouble.

The villages in the site currently have the problems in common as follows: (1) The open wells are not always stable, and deep wells are desirable. (2) Most of small systems have difficulty operating and maintaining, putting a heavy economic burden on the owners. The Sayun regional water system recently installed actually offers a very low water rate. Such surrounding changes seems to prompt the villages of Al-Radood to shift to an upgraded regional system.

3. Water Sources

a. Natural Environment

The site of Al-Radood is in the floodplain formed by the Wadi Idim, a major tributary of the Wadi Hadramout, which starts near the site of Al-Raidah/Shamalya and cuts down the vast platform of 800 to 900 m in elevation. The Wadi Hadramout is one of the most significant groundwater basin, where agriculture is thriving, using abundant groundwater resources. The wadis in this region are surrounded by steep cliffs of 50 to 100 m in height on both sides, the top of which forms flat rocky platforms.

The region is constituted of Umm Er-Rudhuma Formation of the Palaeogene Paleocene period, floodplain sediment formed by the Wadi Hadramout and its tributaries and alluvial belts on the wadi beds. Umm Er-Rudhuma Formation distributed in this region is largely divided into two groups in terms of their phases: the

upper section consisting mainly of tightly compacted limestone and the lower section of limestone breccia. The lower section now having breccia-like appearance is considered to have been formed through a process of re-cementation of limestone breccia, which had probably been forcefully autobreccuated. It is observed that since this lower section of the cliff has grown fragile due to widespread networks of cracks, it is apt to collapse, and has already accumulated talus-like sediments on its bottom. Such networks of cracks underground can form good passages of groundwater. This structure of brecciated limestone is the main reason that shallow groundwater abounds in this region. Most of the open wells get water from this formation.

b. Hydrogeological Features

The region has 3 deepwells for irrigation purpose (one of them unused) as well as lots of open wells. The deepwells are installed with 8" casing to depths of 50 to 60 m, while the open wells are 2 to 3 m in diameter with their depths ranging from 30 to 38 m. Since the water level is deeper than 20 m, most wells have diesel-driven vertical-shaft pumps or submersible motor pumps. The aquifers for them are mostly brecciated limestone of Paleocene Umm Er-Rudhuma Formation, with their yields ranging from 200 to 300 lit/min. The conditions of the excising wells surveyed by the team are listed in Table-3.16. The results of the study are summarized as follows:

(1) The temperature of groundwater is 24.7°C to 33°C, and its pH, from 7.3 to 8.0.

(2) The electrical conductivity varies from 770 μS/cm to 2,394 μS/cm after correction at 25°C.

(3) Fig.-3.18 includes the isoline map of electrical conductivity in the region. The upper to middle stream of the Wadi Idim has a zone of lower electrical conductivity of less than 700 μS/cm, while its downstream develops a degenerated quality zone of 2,394 μS/cm in Al-Husn village and 2,013 μS/cm in Al-Mhewad.

(4) The communities in this site have developed congested residential areas with surrounding cultivated farmlands. Under such circumstances, the wells in the midst of the communities are feared to be exposed to artificial contamination in the future.

In view of the current site situation, the public water source is recommended to be deepwell(s) of 50 to 60 m in depth, tapping deeper groundwater. Although the yields from open wells are mostly 300 lit/min, those from deepwells are expected to be 400 lit/min or over at a drawdown of 10 m.

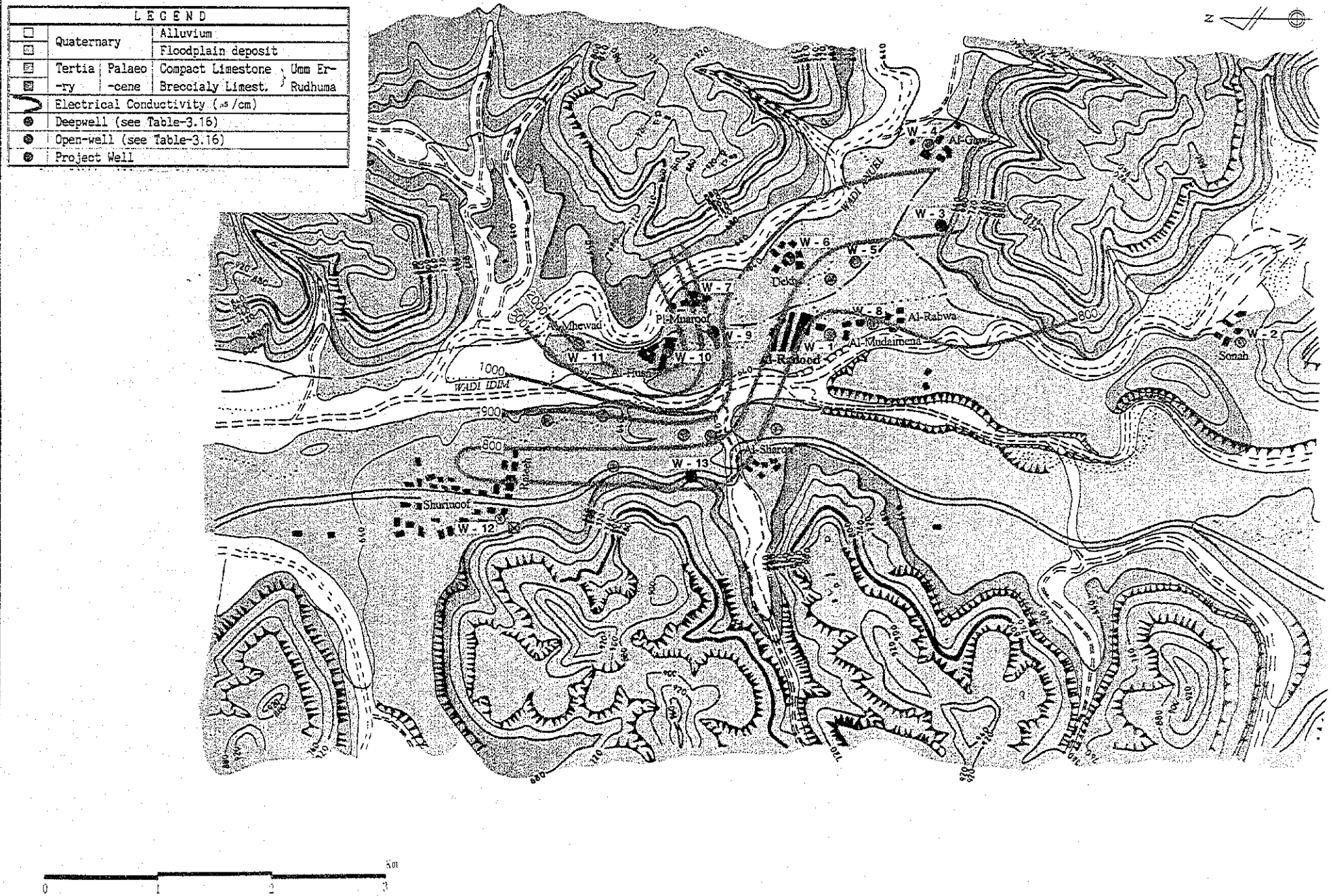


Fig.-3.18 Hydrogeological Map of Al-Radood Area

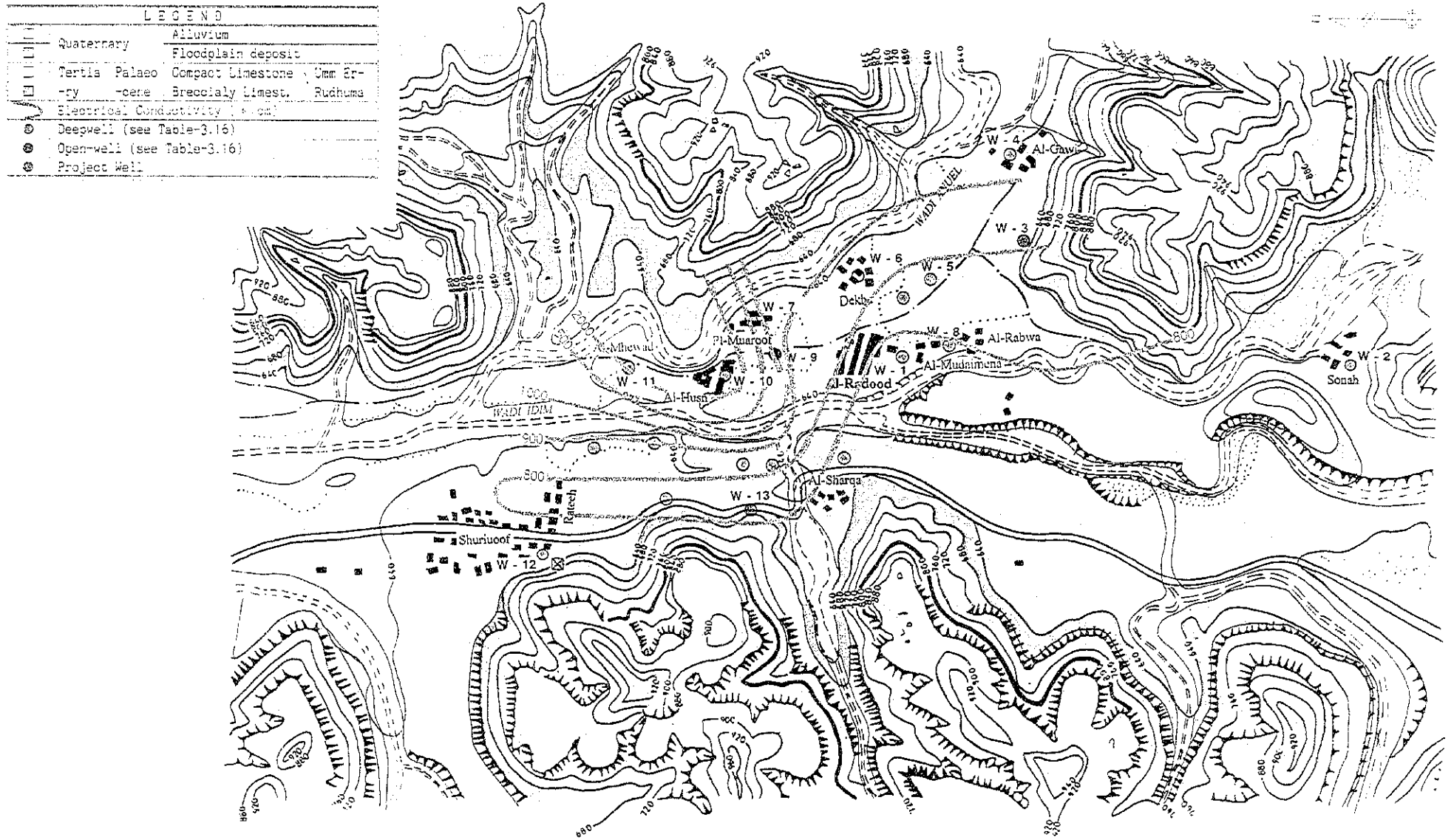


Fig.-3.18 Hydrogeological Map of Al-Radood Area

Table-3.16 List of Existing Wells (Al-Radood)

No.	Type	Source	Dia. (m)	Depth (m)	Pump	Aquifer	SWL (m)	Q (l/min)	T (°C)	pH	EC(μS/cm)		Remark
											Measured	Corrected at 25°C	
W1	Openwell	Al-Radood	3.0	30.0	Submersible & Borehole Pump	Brecciated Limestone	26.00	350	33.0	7.4	1,002	864	General use
W2	"	Sonah	3.0	38.4	Borehole Pump	"	36.10	300	30.2	7.5	861	780	"
W3	Deep Well	Al-Rabwa	0.2	50.0	"	"	?	300	31.9	7.3	936	822	Agriculture
W4	Openwell	Al-Gawi	3.0	?	"	"	33.32		31.4	7.3	1,092	968	General use
W5	"	Private well	3.0	30.0	"	"	26.70		24.7	8.2	765	770	Agriculture
W6	"	Dekha	3.0	?	Submersible Pump	"	27.40		31.5	7.8	952	842	General use
W7	"	Pl- Muaroof			Borehole Pump	"	26.10		29.1	7.9	1,002	926	"
W8	"	Al-rabwa			"		28.10		38.6	8.0	946	744	"
W9	Deep Well	Private well			"		?						Agriculture
W10	Openwell	Al-Husn			"		20.83		31.8	7.4	2,720	2,394	General use
W11	"	Al-Mhewad	2.2		"		20.83		26.5	7.8	2,073	2,013	"
W12	"	Shuriuoof			"		?		30.3	7.5	919	831	"
W13	"	Al-Aharqa	0.2		-		?						Not operating