6-12 Al-Sheab Al-Aswad (S-3)

6-12-1 Geography

This site is located on the flat terrace of the mountain slope at about 2,400 m A.S.L. This flat surface coincides with the upper bedding of the limestone. Valley walls intersecting with the flat surface are very steep. The mountain mass consists of sandstone and its slopes are relatively steep. In the wadi the valley bed is covered by sand and mud deposits and used as farmland (see Fig. 6-14)

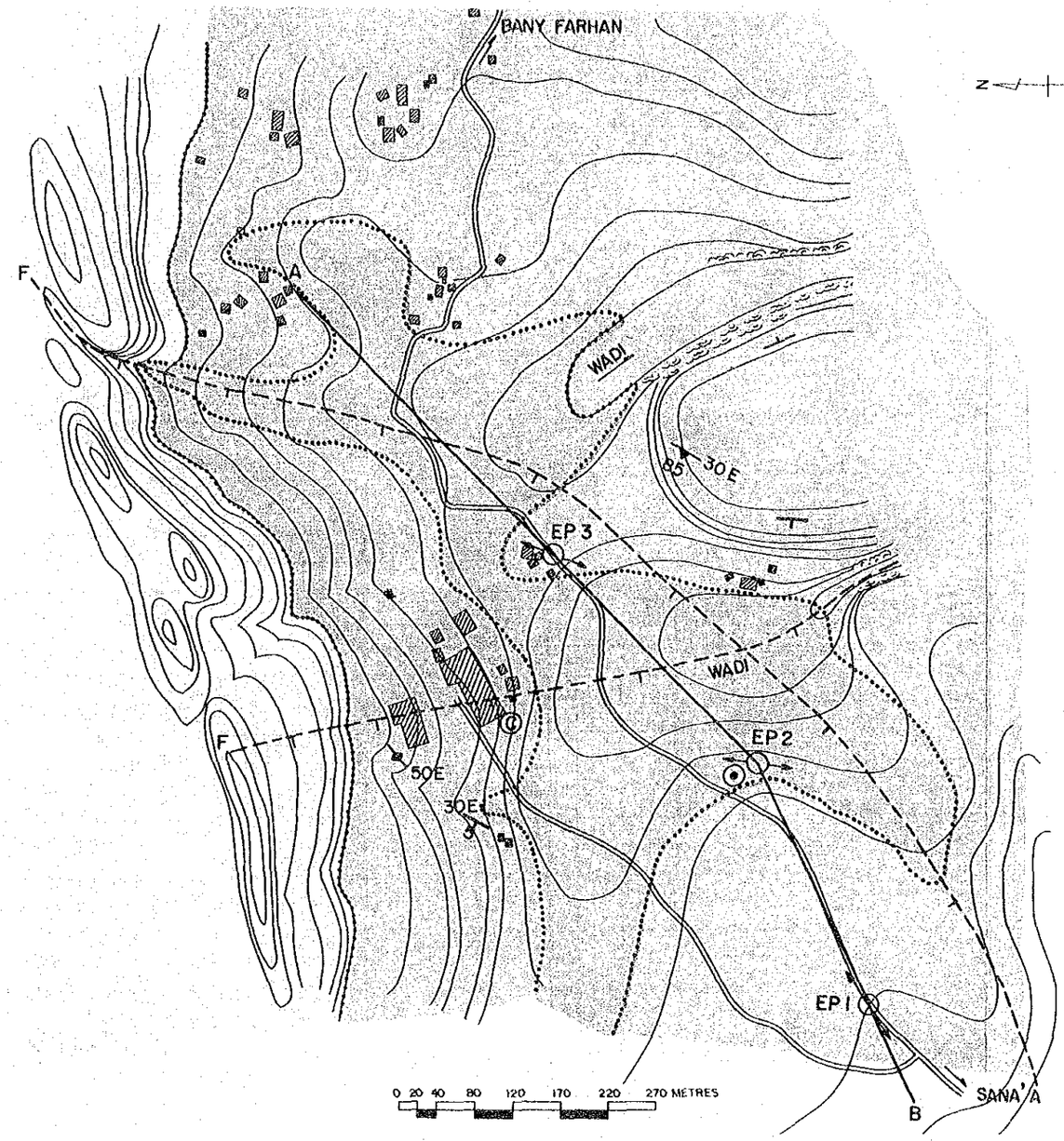
6-12-2 Hydrogeology

The survey area consists of limestone (Amran series) and sandstone. The regional strikes are NE-SW and dips are 5°W, although at the valley walls the formations are inclined to the valley. Thin shale layers of 1 m thickness are interbedded with this formation.

Sandstones are arkosic containing rounded cherty gravel several centimeters in diameter. Generally speaking, the beddings are clearly defined.

Two types of faults are running through the central part of the site long the directions (NE-SW and NW-SE). At 5 Km south of the survey site, Pre-Cambrian granite, the local basement, formation outcrops.

A geological cross section was drawn, based on the electric prospecting and field exploration (see Fig. 6-15). Accordingly the thickness of limestone (i.e. the depth to the basement) is estimated to be 40-80m.

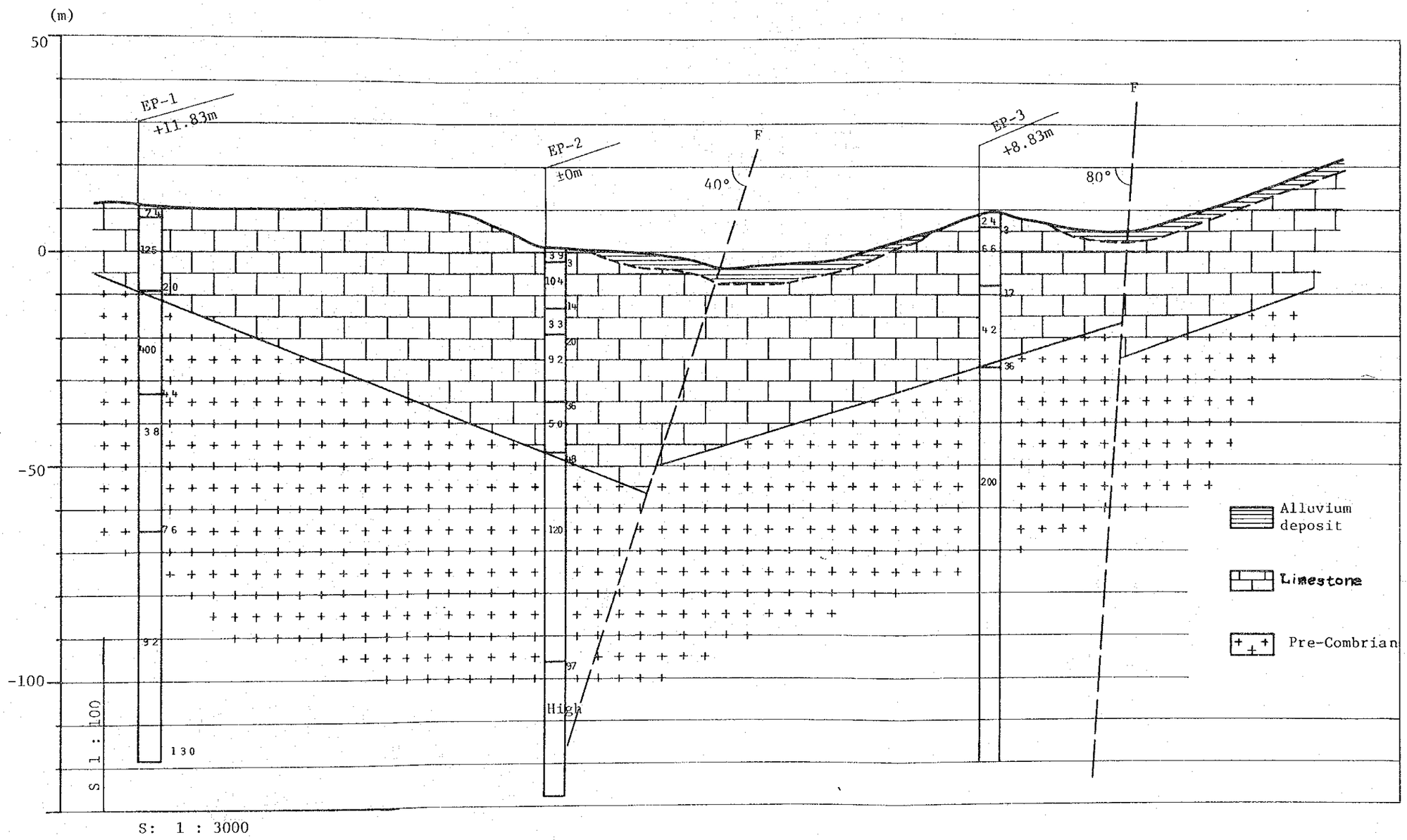


LEGEND	
	ALLUVIUM
	LIMESTONE
	SANDSTONE
T	STRIKE. DIP
	CRACK
E.P	ELECTRICAL PROSPECTING POINT
©	CISTERN
F—T—	FAULT
A——A'	GEOLOGICAL SECTION LINE
⊙	PROPOSED BOREHOLE

Fig. 6-14

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC		
THE RURAL WATER SUPPLY PROJECT PART-II		
GEOLOGICAL MAP OF AL SHEAB AL ASWAD (S-3)		
DESIGNED BY	Pacific Consultants International	
DATE	SCALE 1:	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN		

FIG. 6-15 Geological Cross Section
At Survey Site Al Aswad
(S-3)



S: 1 : 3000

6-12-3 Recommended Water Source

A dam construction at the narrowest part of the valley downstream of the village is recommended for the future water source development. The watershed area is not very large however, the dammed water may become polluted from the village located upstream.

The two faults, the position of which were estimated at the central part where the electric prospecting was applied, indicate the high possibility of deep groundwater development. We were informed of a well drilled at location E.P.2 to a depth of 160 m accomplished by local investment after our survey was completed. They are reported to have acquired a yield of 330 m^3/day.

Type A: Deep Groundwater - proposed for the project water source -

1. The recommended site is west of the intersection point of two faults near E.P. No.2.
2. According to the hydrogeological survey, the electric resistivity at No.2 point becomes extremely high at depths below 90 m. It is assumed therefore that a weathered or faulted zone with concentrated joints in the Pre-Cambrian formation (Gneiss) exists between 60-90m depth.
3. The recommended drilling depth is 90-100 m.
4. Road system is in good condition.
5. Operational water must be carried in from outside.

Type D: Dam - proposed for the future development -

1. Two southward flowing wadis are recommended.
2. The watershed area is small.

3. The limestone basement is extensively jointed.

4. The wadi at the west side is used extensively by the local people, so that dam construction may cause some land use problems.

5. Although the site is ideal for dam construction, the construction risks are rather high and further detailed study is necessary for the construction of the reservoir.

6-13 Bany Farhan and Bany Saria'a (S-4)

6-13-1 Geography

The site is located northeast of Al-Sheab Al-Aswad, and Bany Farhan lies on the small flat plain of the mountain slope at 2,400 m A.S.L. The valleys dissect the flat limestone country and form steep bank walls. Agricultural fields have been constructed behind the supporting wall built with rock blocks along the valley.

Bany Saria'a is located in a basin located 1 Km south of Bany Farhan (Fig. 6-16).

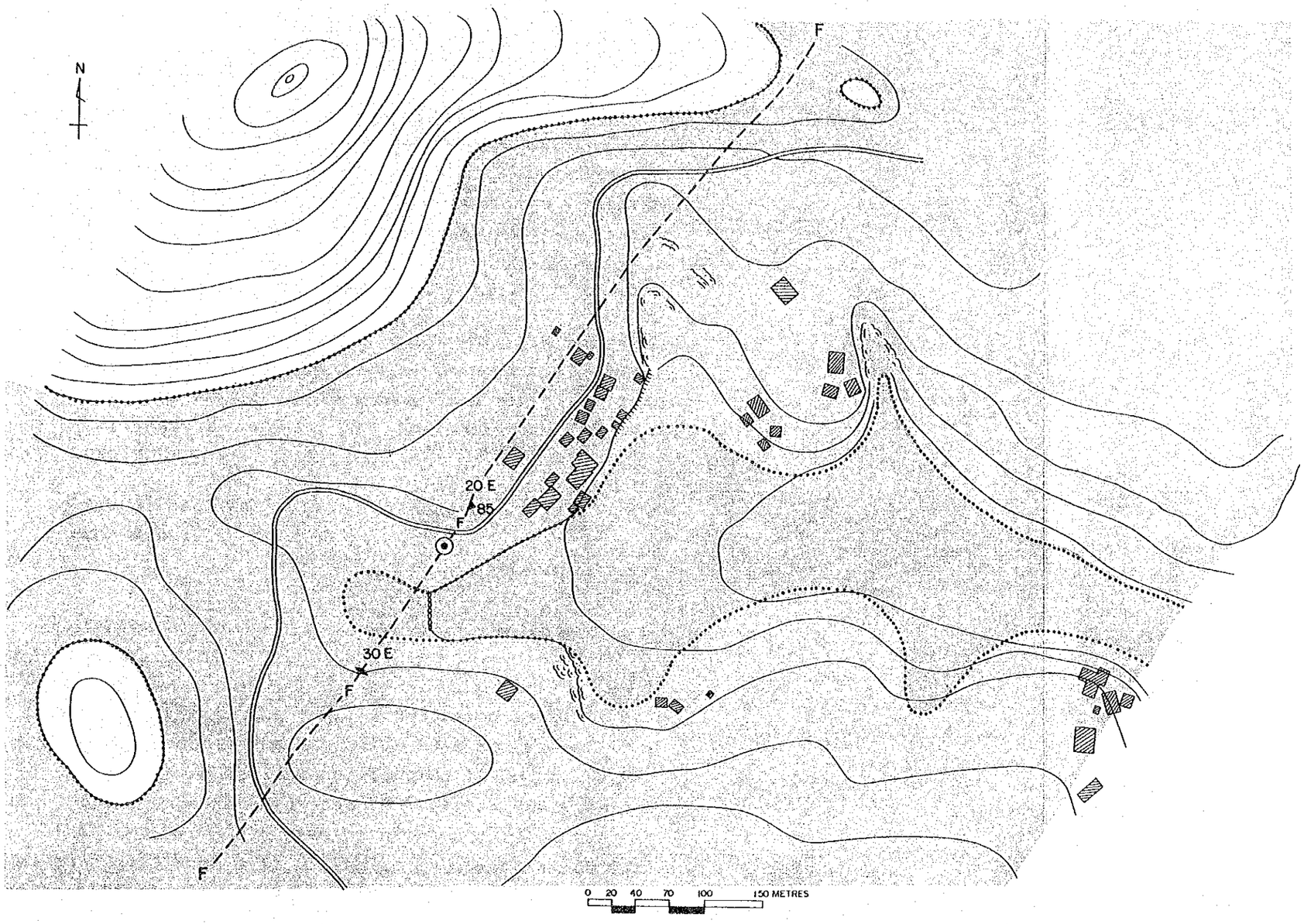
6-13-2 Hydrogeology

The flat plain spreads out on the limestone (Amran Series) formation where joints are prominently developed along N20°W direction and are extensively stratified almost horizontally. In the mountain part, however, sandstone is the main element which is arkosic and contains round cherty gravels.

There is a fault along a N30°-40°E direction west of the village. This fault runs obliquely cross the valley. The valley itself can be regarded as a fault valley. The N30°-40°E fault is coincident with the NE-SW fault of Al-Sheab al-Aswad.

6-13-3 Recommended Water Source

Deep groundwater through the fault is the only a feasible water source at this site.



LEGEND	
	ALLUVIUM
	ANDESITE DYKE
	SANDSTONE
	LIMESTONE
	CRACK
F	FAULT
	PROPOSED BOREHOLE

Fig. 6-16

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC	
THE RURAL WATER SUPPLY PROJECT PART-II	
GEOLOGICAL MAP OF BANY FARHAN & BANY SARIA'A (S-4)	
DESIGNED BY	Pacific Consultants International
DATE	SCALE 1: DRAWING No.
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Type A: Deep Groundwater

1. The upstream location along the fault is recommended.

2. Electric prospecting was not accomplished due to geographic restrictions. The depth to the Pre-Cambrian rock basement, however, was estimated, based on the Spatial relationship with S3 of Al-Aswad and the distribution of the Pre-Cambrian rock. The estimated depth is 50 m.

3. There is a 300 m road section, which is not wide enough and walled by rock block work, through the Al-Aswad area before reaching the site. This rock wall must be removed for the implementation of the project.

4. Operational water is to be carried in from out side the site.

6-14 Ghulayfagah (H-1)

6-14-1 Geography

The site is located in the coastal dune area within 2-3 Km range from the coast. The elevation does not exceed 10 m A.S.L. A wadi named Wadi Kuway, located 12 Km south of village, flows into the Red Sea. Palm trees are planted around the village. Salt precipitation occurs on the ground surface. Rock salt mining is in operation at some coast localities.

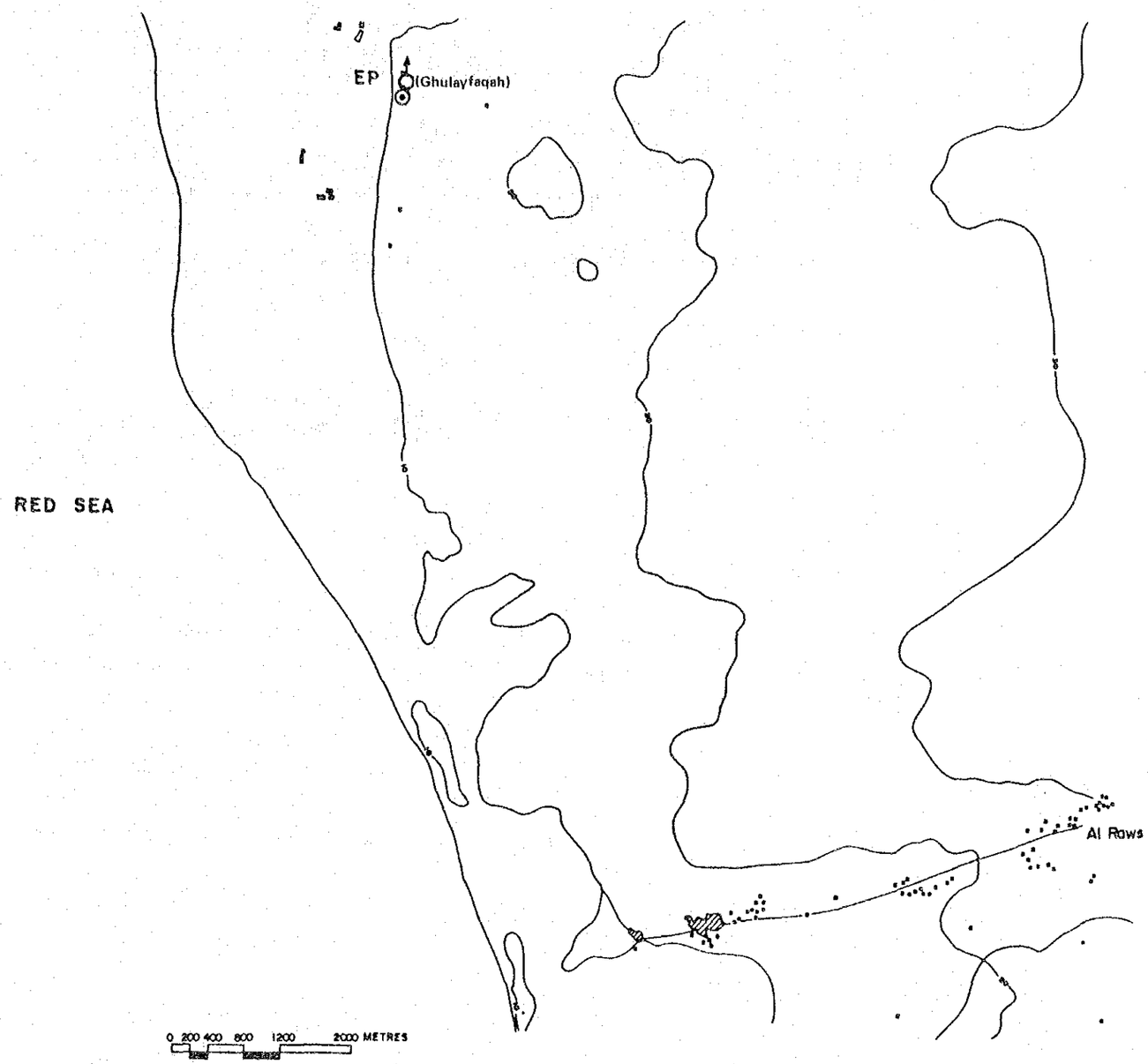
On the way to Ghulayfagah from the Taiz highway desert sands must be traversed. During the present exploration our four wheel drive vehicle study in the sand several times.

6-14-2 Hydrogeology

There are 2 dug wells in the village. The water qualities are relatively acceptable. Sea water intrusion was not detected within a 78 m depth by the electric prospecting method.

6-14-3 Recommended Water Source

The water table is higher and the quality is better within the village area, so the well drilling should be located there with supply facilities.



LEGEND	
⊸○⊸	ELECTRICAL PROSPECTING POINT
◉	PROPOSED BOREHOLE

Fig. 6-17

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC			
THE RURAL WATER SUPPLY PROJECT PART-II			
LOCATION MAP OF GHULAYFAGAH (H-1)			
DESIGNED BY	Pacific Consultants International		
DATE	SCALE 1:	DRAWING No.	
JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN			

6-15 Al-Dahi (H-2)

6-15-1 Geography

The site is located 30 Km inland from the coast at 75 m A.S.L. The village is built on a hill, elevated 1-2 m above the surrounding area. The Hodeidah-Harad highway is under construction 2 Km west of the village. A large cultivated area of land exists between wadi and the village (see Fig. 6-18).

6-15-2 Hydrogeology

At the present time the water supply comes from a deep well. A resident told us that seventeen dug wells are all dry, we measured a low electric resistivity of 8.4 Ω·m below the level of 40 m.

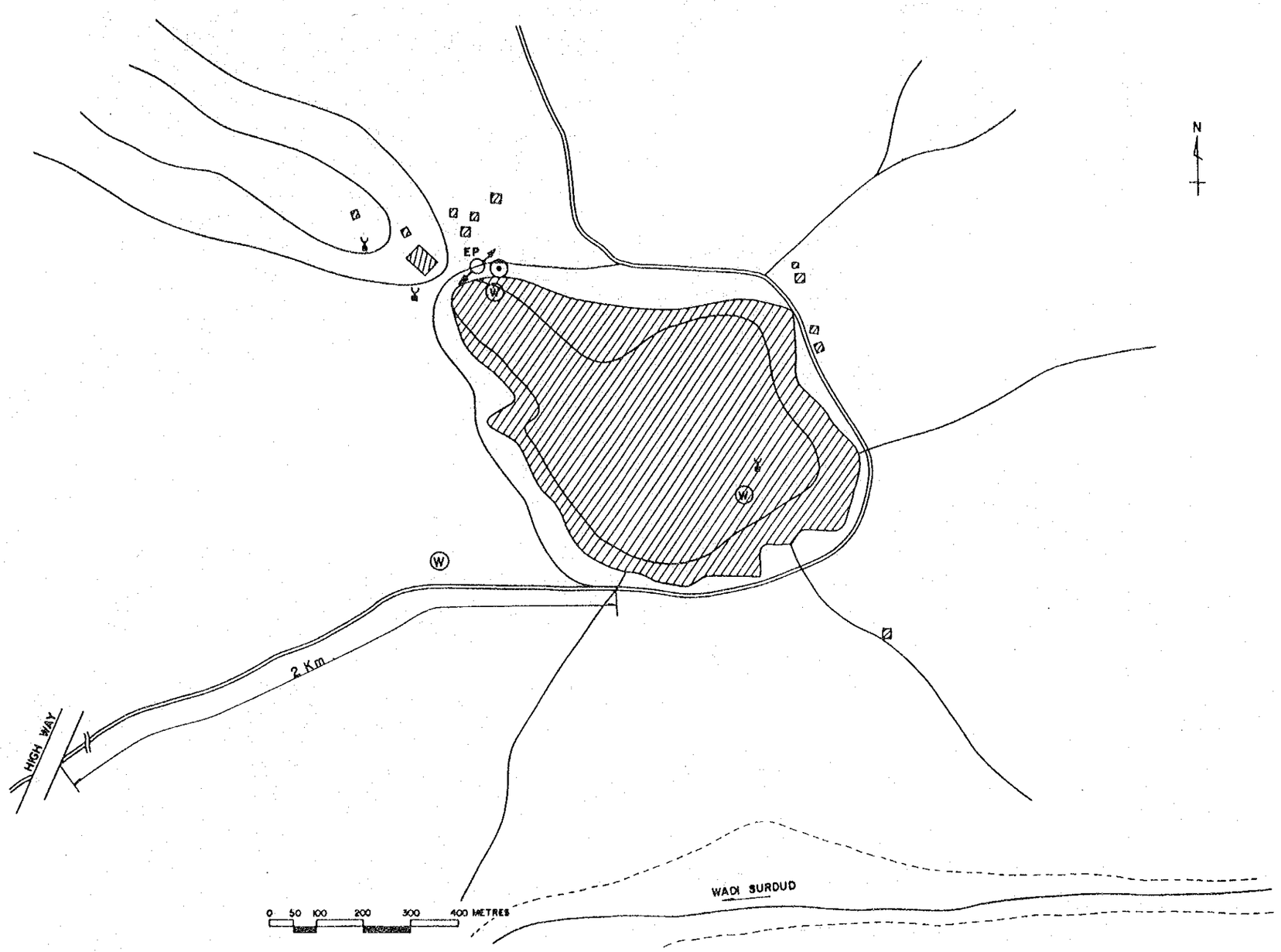
6-15-3 Recommended Water Source

The local community has already been using storage tanks and the water is being distributed through pipe network. Besides this they are considering obtaining a new water source for the increasing demand in the future. The new project for deep groundwater development must be designed so as not to interfere with the existing wells, i.e. the new wells should be drilled, maintaining a 500 m distance from the existing ones.

6-16 Al-Mounirah (H-3)

6-16-1 Geography

The site is located in the desert about 15 Km inland from the coast at an elevation of 40 m A.S.L. A wadi flows westward 2 Km north. The village is built on an elevated place 1-2 m higher than the surrounding area (see Fig. 6-19).



W	EXISTING WELL
-○-	ELECTRICAL PROSPECTING POINT
◉	PROPOSED BOREHOLE

Fig. 6-18

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC		
THE RURAL WATER SUPPLY PROJECT PART-II		
LOCATION MAP OF AL DAHI (H-2)		
DESIGNED BY	Pacific Consultants International	
DATE	SCALE 1:	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN		

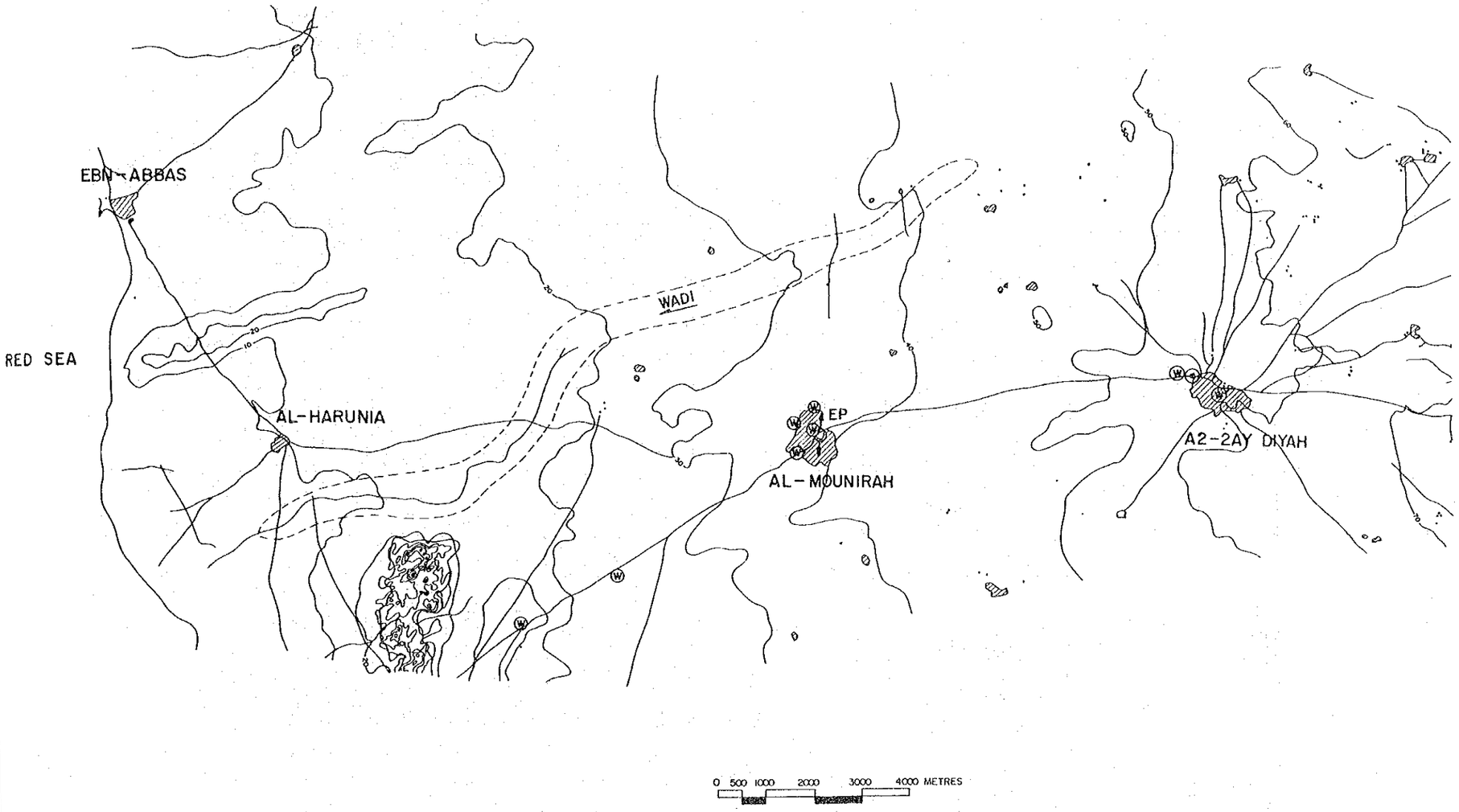


Fig. 6-19

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC	
THE RURAL WATER SUPPLY PROJECT PART-II	
LOCATION MAP OF AL-MOUNIRAH (H-3)	
DESIGNED BY	Pacific Consultants International
DATE	SCALE 1: DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN	

6-16-2 Hydrogeology

Waters from the existing deep and shallow wells are not good in quality, so even if the water demand is met with adequate quantity, the quality problem may still remain.

6-16-3 Recommended Water Source

Deep groundwater will be the target at this site. The drilling site can be in a wadi 2 Km north of the village or somewhere inland. Since there is no available data concerning the wadi basin, the inland site may diminish the risk in spite of the greater distance to the service area.

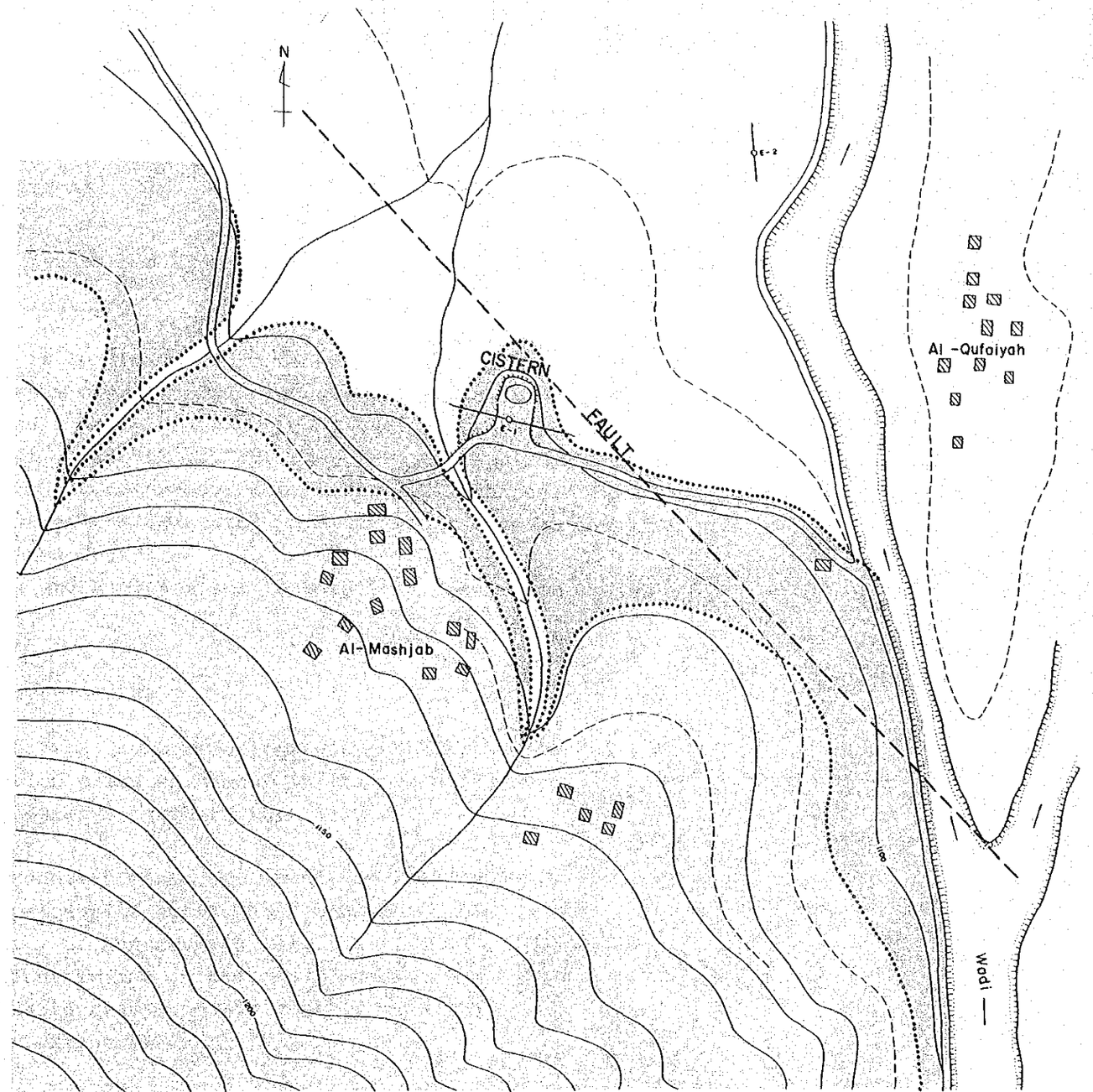
6-17 Al-Mashjab (T-1)

6-17-1 Geography

The site is located on the left bank of the Wadi Mashjab at elevation 1,200 m A.S.L., where the wadi flows out from the mountain to the wadi plain (Fig. 6-20).

6-17-2 Hydrogeology

The villages are built on the piedmont slope, consisting of Pre-Cambrian rocks. In the lower plain, however, bordered by the trunk road connecting the villages, Quarternary deposite predominate. The boundary line between the Pre-Cambrian mountain mass and Quarternary plain runs directly in a SE-NW direction, forming a fault escarpment. Since the right bank of the wadi consists of Trap Series. The Trap Series may underlie along the Wadi Mashgab in the plain, bounded with Pre-Cambrian rocks by the fault.
At the present time dug wells are supplying groundwater by Wadi Mashgab 2.5 Km away from the village.



LEGEND	
	ALLUVIAL DEPOSIT
	TALUS
	PRE - CAMBRIAN

0 20 40 80 120 160 200 240 METRES

Fig. 6-20

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC			
THE RURAL WATER SUPPLY PROJECT PART-II			
GEOLOGICAL MAP OF AL-MASHJAB (T-1)			
DESIGNED BY	Pacific Consultants International		
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6-17-3 Recommended Water Source

Deep wells can be drilled into the underlying fault plane in the wadi. Electric prospecting suggests the depth of the basement complex to be about 110 m or more around point No. 2.

6-18 Al-Manara and Al-Dukum (T-2)

6-18-1 Geography

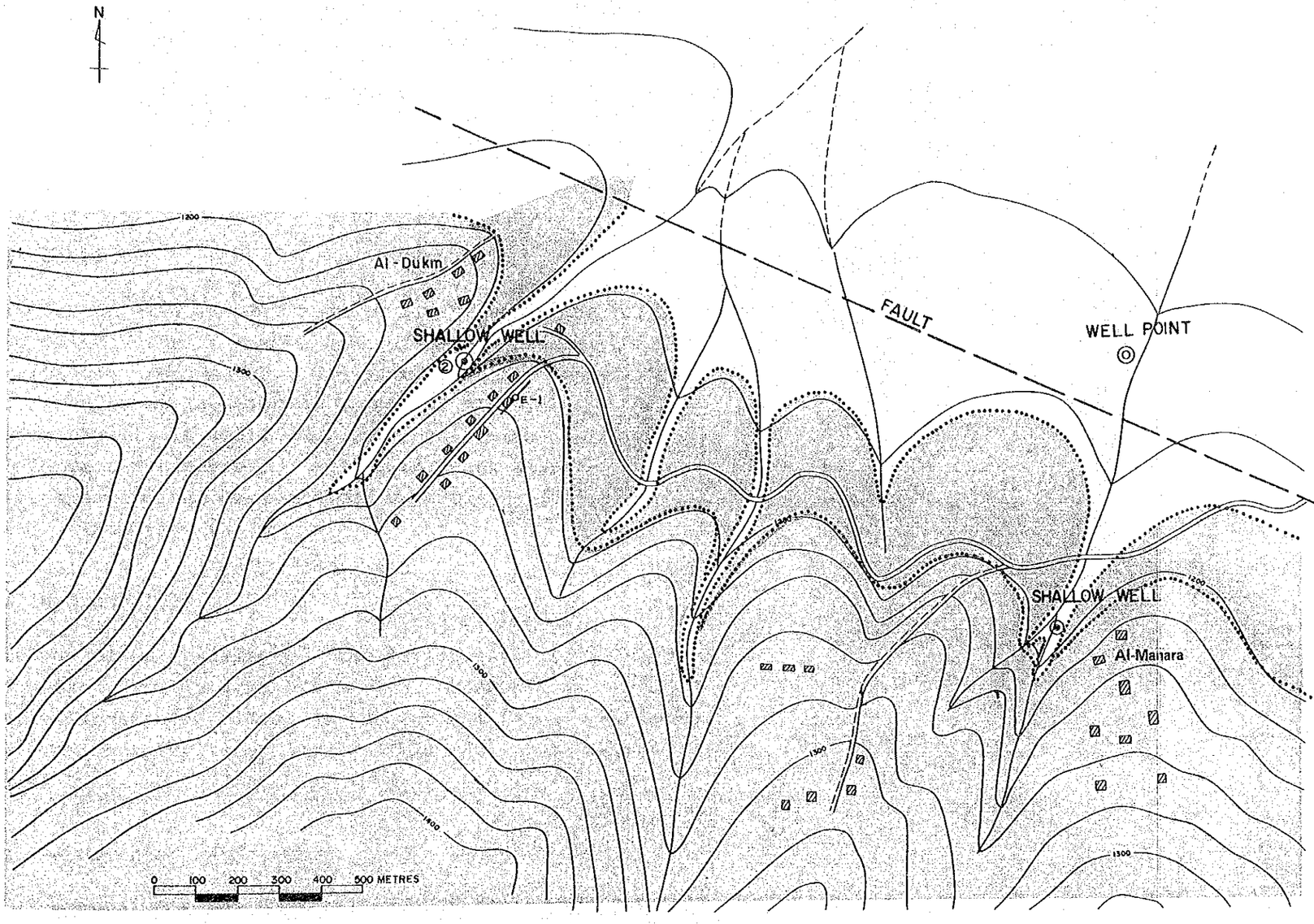
The site is located west of Al-Mashjab at about 1,200 m A.S.L. and consists of a Pre-Cambrian mountain mass (of a mature stage) and a low plain along Wadi Mashgab which borders on the former. Several valleys flow into the Wadi Mashgab plain from the mountain. Each valley is V-shaped. The villages are located on the piedmont slope between the valleys. (See Fig. 6-21)
Al-Manara and Al-Dukum are located 2 Km apart from each other.

6-18-2 Hydrogeology

The subsurface fault line, bounding the Trap Series on the Pre-Cambrian plain as stated in the preceding section, supposedly extends north of the village.

The Pre-Cambrian rocks are mainly gneiss and Schist (quartz schist, phlogopite schist and amphibole schist). The schistosity of the rock is parallel to the wadi direction in the mountain and joints also develop in the same direction. Quarternary deposits (mainly sand and gravel) cover the plain extensively.

A spring discharges from a small fracture in the Pre-Cambrian rock up-stream from the small wadi near Al-Dukum (3ℓ/min or so). People draw water from this spring. In addition, a dug



LEGEND	
	ALLUVIAL DEPOSIT
	TALUS
	PRE - CAMBRIAN

Fig. 6-21

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC			
THE RURAL WATER SUPPLY PROJECT PART-II			
GEOLOGICAL MAP OF AL MANARA, AL DUKUM (T-2)			
DESIGNED BY	Pacific Consultants International		
DATE		SCALE 1:	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN			

well has been constructed downstream from the same wadi, presumably exploiting the shallow groundwater in the weathered zone over the Pre-Cambrian basement complex.

6-18-3 Recommended Water Source

Deep groundwater from the fault, assumed to be located in the wadi north of the village, should be developed.

6-19 Al-Maydan, Al-Jubail, Sheibd Hamud (T-3)

6-19-1 Geography

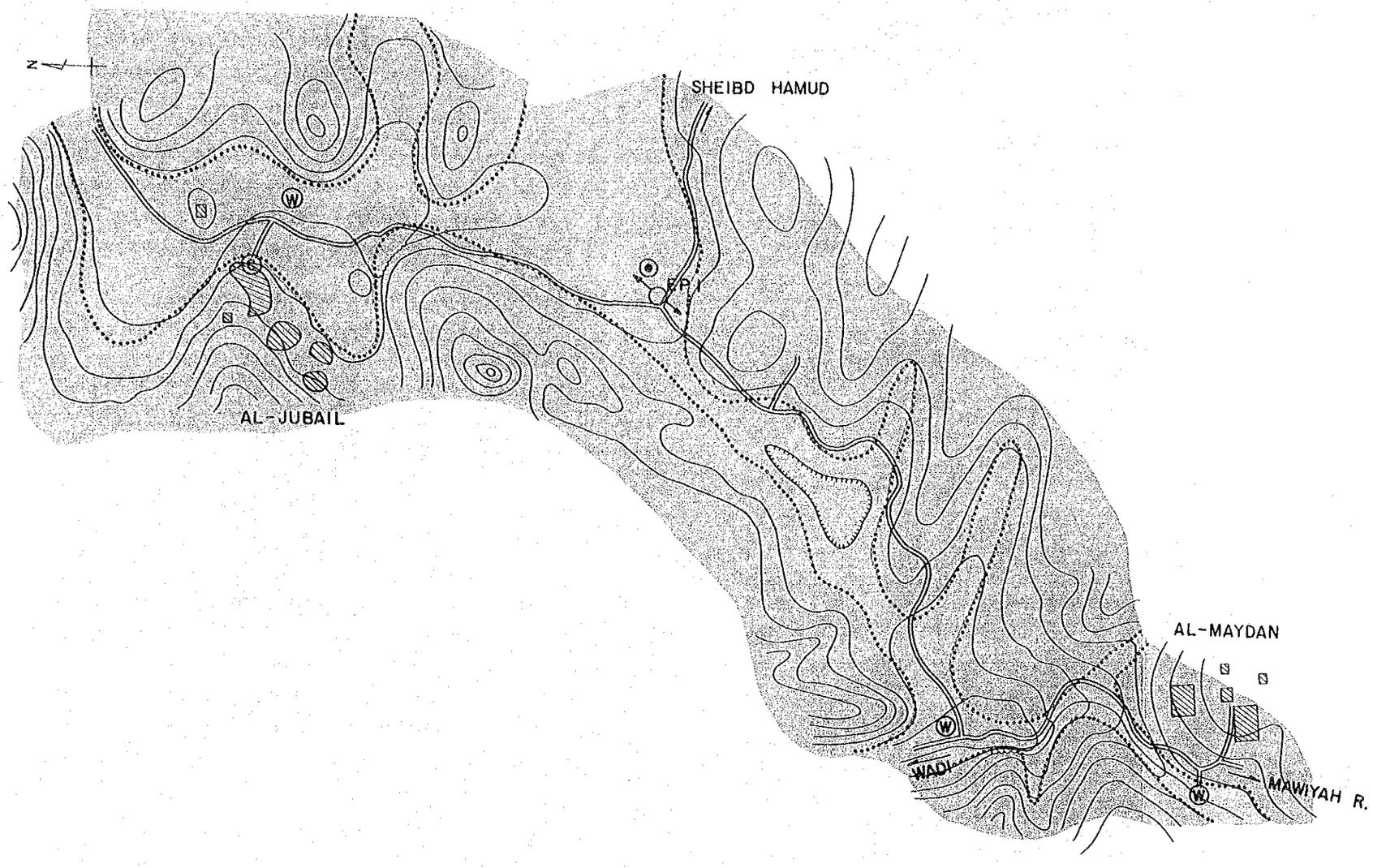
The site is located 1,400 - 1,500 m A.S.L. where the topographic relief undulates with tens of meters' relative height. Three villages are located 2.5 - 3 Km apart from each other. Sheibd Hamud is at the highest level and Al-Maydan is at the next lower level. A small wadi intersects with a minor mountain. There are trees of 30 - 50 m in trunk diameter in some localities around the wadi and the wadi plain is used as farmland. (See Fig. 6-22)

6-19-2 Hydrogeology

The site consists entirely of Trap Series, i.e. tuff, rhyolite, andesite etc. The Tuff is predominant among all of them. The stratification is almost horizontal and is not accompanied by any prominent faults or joints. The wadi deposits are estimated to be no thicker than 10 m.

6-19-3 Recommended Water Source

Since structural discontinuities, such as faults and joints, are not found in the exploration site, there will not be much difference in the yield of the deep groundwater from Trap Series caused by a difference in the well location.



LEGEND	
	ALLUVIUM
	YEMEN VOLCANICS
E.P.	ELECTRICAL PROSPECTING POINT
W	EXISTING WELL
C	CISTERN
⊕	PROPOSED BOREHOLE

Fig. 6-22

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC	
THE RURAL WATER SUPPLY PROJECT PART-II	
GEOLOGICAL MAP OF AL-MAYDAN, AL-JUBAIL AND SHEIBD HAMUD (1/3)	
DESIGNED BY	Pacific Consultants International
DATE	SCALE 1: DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN	

Type A: Deep Groundwater

1. The site consists entirely of the Trap Series with horizontal stratification and without any prominent faults and joints.

2. The recommended drilling site is located in the flatland halfway between Al-Maydan and Al-Jubail. This site is the most convenient site for the three villages and for a transportation network.

3. On the approach to the site two or three road sections must be widened and improved.

4. Operational water can be obtained from dug wells within the site.

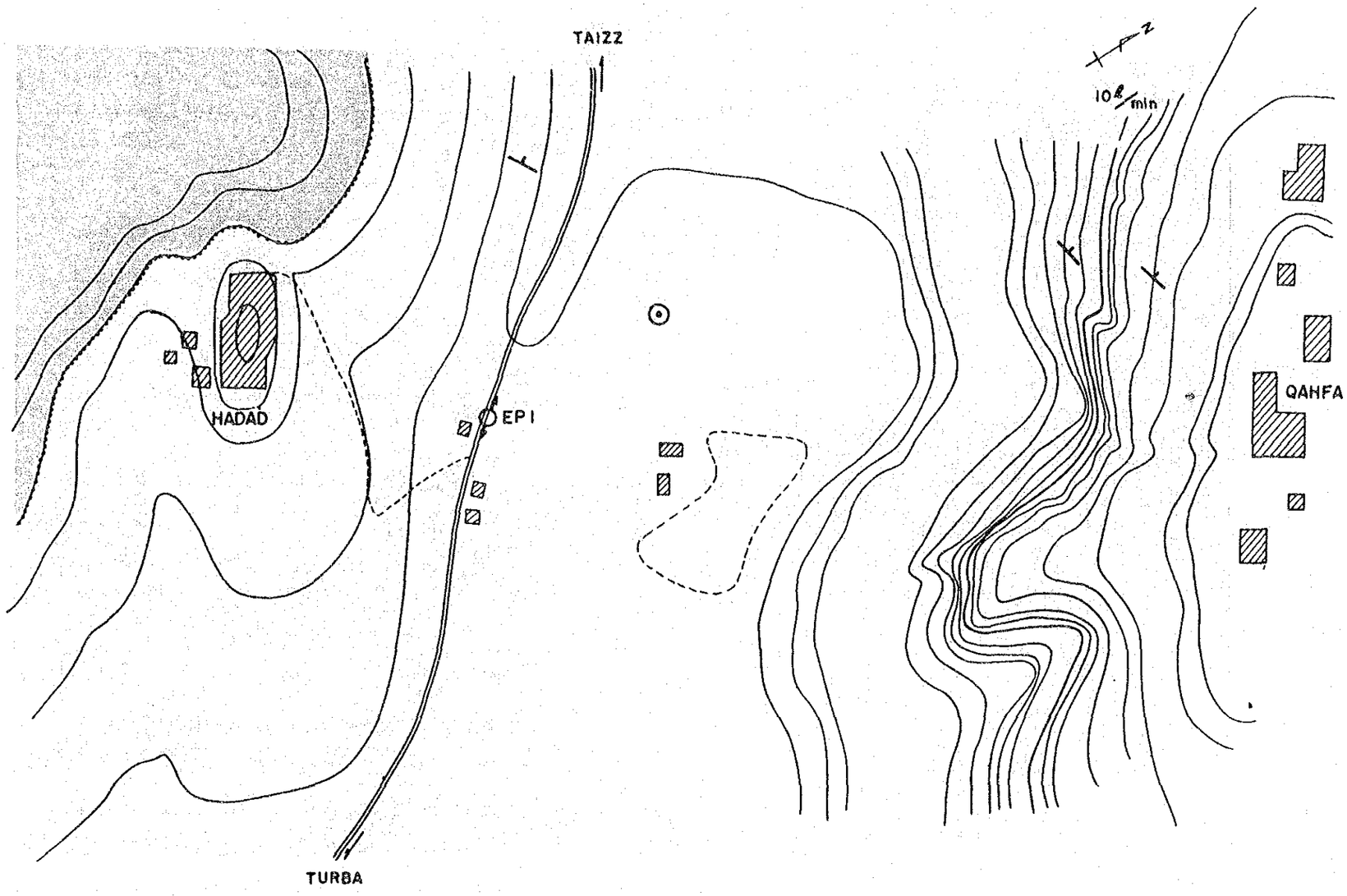
6-20 Hadad, Qahfa (T-4A)

6-20-1 Geography

The site is located 15 Km from Turba forward Taizz along the Turba highway at 1,200 m A.S.L. It extends on both sides of the road and is bordered by the Wadi Mahjar (flowing westward with stream water) 2 Km north of the site. There is also a V-shaped valley meandering between the Turba highway and Qahfa. The flow rate is approximately 10 ℓ/min. (See Fig. 6-23)

6-20-2 Hydrogeology

The mountain mass, at the location of Hadad, consists of Trap Series, i.e. andesite and tuff, extensively underlain by sandstone. The regional strikes are NE-SW and slight dips are in a northerly direction. The sandstone is arkosic and contains cherty pebbles several centimeters in diameter. There are two large scale faults: one runs NE-SW located 1-2 Km west of the site and another runs E-W 2 Km north of the site along Wadi Mahjar.



LEGEND	
	SANDSTONE
	YEMEN VOLCANICS
EP	ELECTRICAL PROSPECTING POINT
	PROPOSED BOREHOLE
	STRIKE . DIP

0 20 40 70 100 150 METRES

Fig. 6-23

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC	
THE RURAL WATER SUPPLY PROJECT PART-II	
GEOLOGICAL MAP OF HADAD, QAHFA (1-4A)	
DESIGNED BY	Pacific Consultants International
DATE	SCALE 1: DRAWING No.
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6-20-3 Recommended Water Source

Deep groundwater in the sandstone formation is feasible for development for the project water source. Dam construction in a V-shaped valley is also feasible for the future water source development. According to the present topographical survey, a 15 m high dam can store 25,000 m^3 of water.

Type A: Deep Groundwater

1. The Trap Series in mountain mass, and sandstone in piedmont and lower region.
2. The recommended site is located halfway between two villages, and 2 faults are located 1 - 2 Km north of the site.
3. The road is sufficiently maintained for transportation.
4. Operational water can be obtained within the site.

Type D: Dam

1. Sandstone base outcrops at the riverbed and banks.
2. The riverbed gradient is less than 3° (5%) as determined by visual observation measurement.
3. A 150 m section of the road to the dam site must be constructed.
4. A dam 15 m high dam can store 25,000 m^3 of water. Detailed study on hydrology is necessary.

6-21 Al-Kudha, Al-Hagl (T-4B)

6-21-1 Geography

The site is located in the hilly region, where the mountain mass is 50-100 m elevated over the city area of Turba and the wadis are dissecting the slope. The villages are built

on the summit and on the ridge. There is a steep cliff east of the site, the relative height of which is about 500 m. This cliff runs long distance, i.e. tens of kilometers, as if it encircles the site. The wadi at the foot of the cliff foot flows down to the south Yemen. (See Fig. 6-24)

6-21-2 Hydrogeology

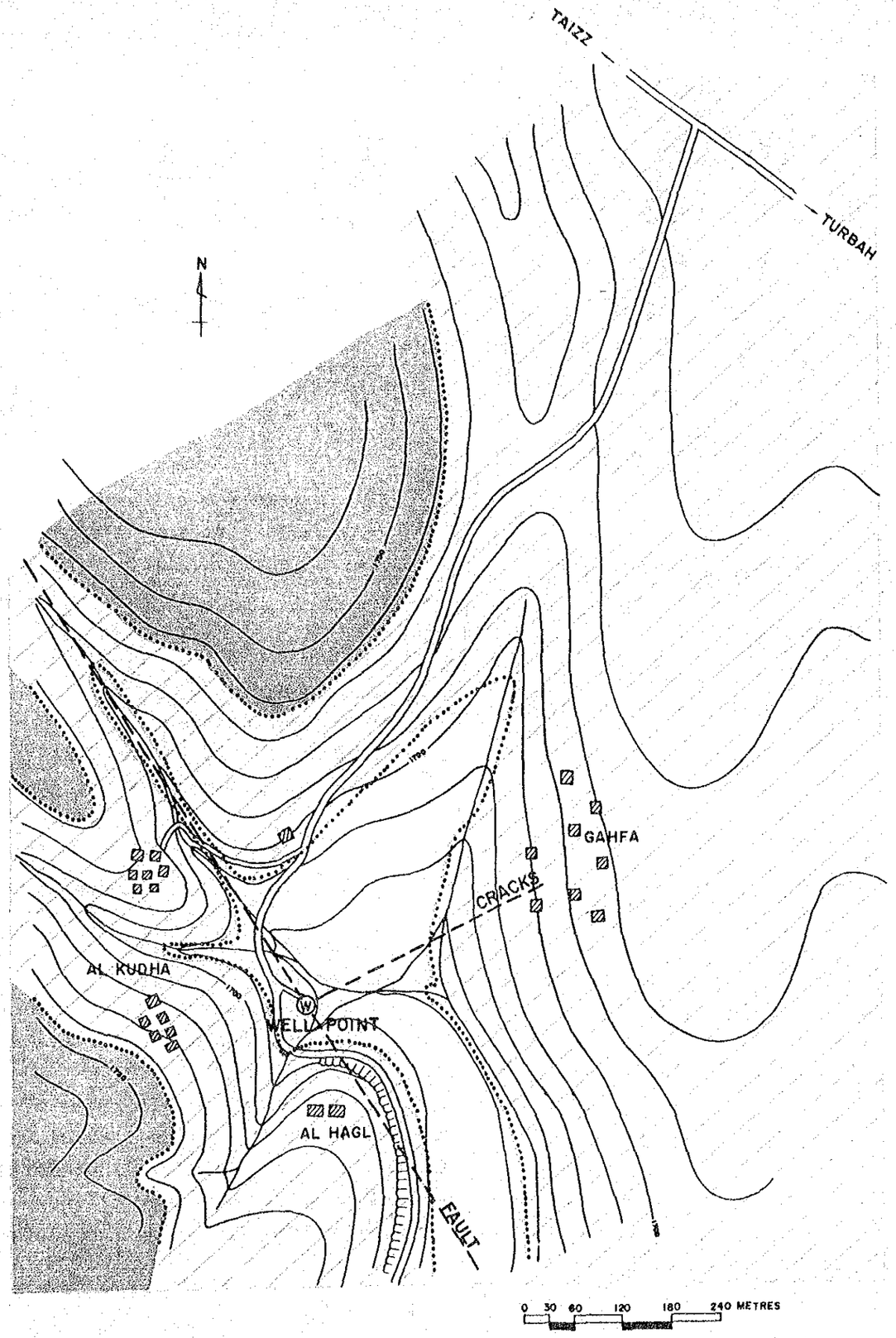
The site geology consists of sandstone, which covers the ground surface extensively, and Trap Series, which unconformably overlies sandstone at the summit. Sandstone is mainly arkosic, with thin reddish shale and conglomerate layers interbedded at some locations. At the lower part of the Trap Series shale and sandstone become major formations.

Although some small scale joints and faults, aligned N50°W and N40°E, can be recognized, the structural discontinuity is generally quite subtle. The stratification is almost horizontal or dipping slightly to SW.

6-21-3 Recommended Water Source

Due to the long steep cliff of elevation 500 m, encircling Turba region, it seems rather difficult to obtain a stable water source. It would not be efficient to design water sources for every village. Designing on a regional basis is much more suitable.

The water source under the present restriction, will be developed from the deep groundwater in the sandstone and shallow groundwater in wadi alluvium and weathered layer of sandstone. However, both sources are not reliable with regard to their stability.



LEGEND	
	ALLUVIAL DEPOSIT
	YEMEN VOLCANICS
	TAWILAH GROUP

Fig. 6-24

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC			
THE RURAL WATER SUPPLY PROJECT PART-II			
GEOLOGICAL MAP AL KUDHA, AL HAGL (T-4B)			
DESIGNED BY	Pacific Consultants International		
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JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN			

6-22 Shohat, Al-Kadash (T-5)

6-22-1 Geography

This site is located on the relatively flat geomorphic surface south of Al-Kudha and Al-Hagl at about 1,600 m A.S.L. Except for some steep wadi bank, the region generally lies on a flat geomorphic surface. The flat surface consists of bare rock and is not used for agriculture, but the narrow wadi beds are used as farmland. (See Fig. 6-25)

6-22-2 Hydrogeology

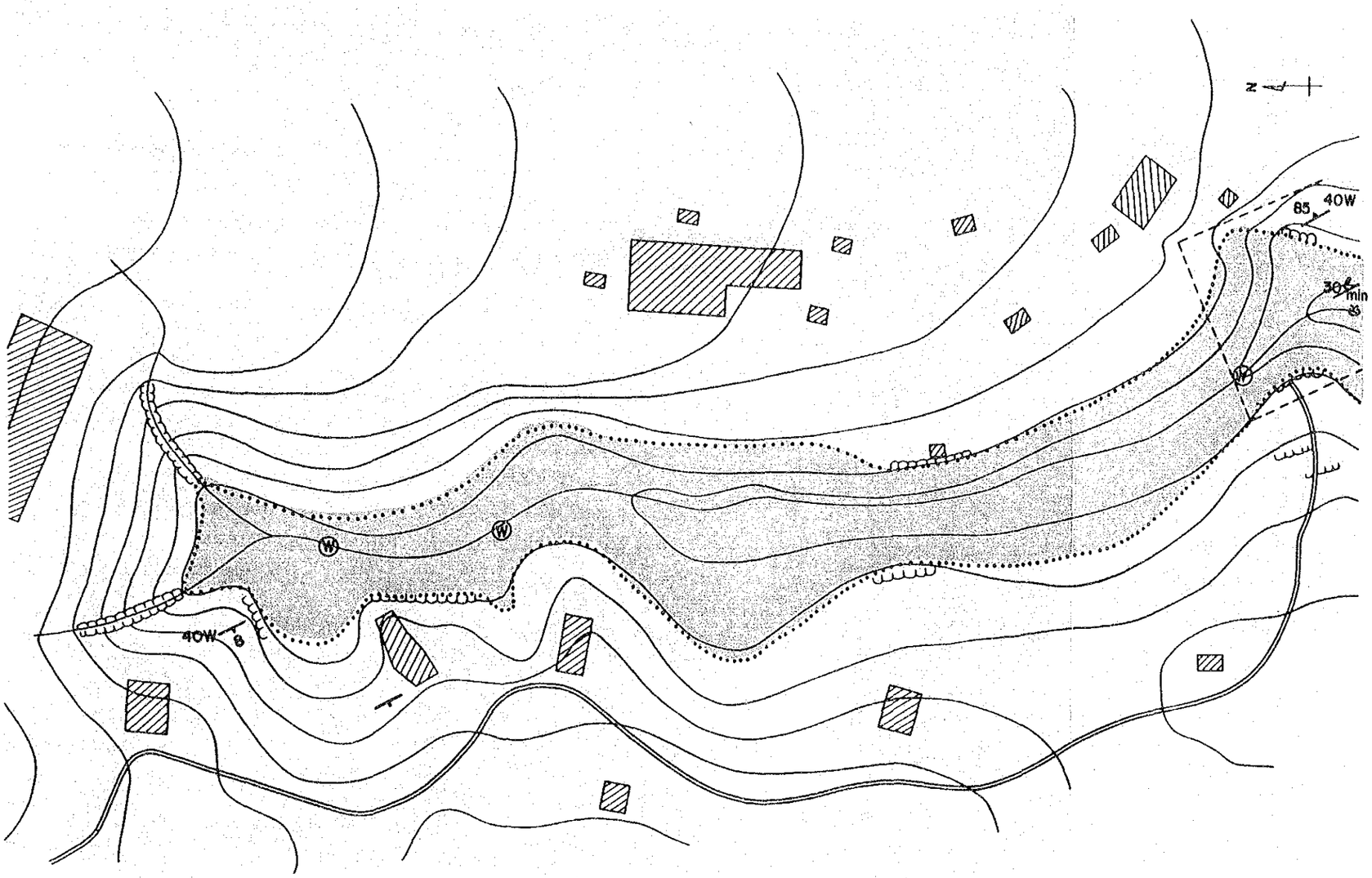
The site consists of sandstone, and regional strikes are NW-SE and slight dips are in a southerly direction. The surrounding small hills consist of the Trap Series. There are no prominent joints and faults.

At present two dug-wells in wadi are in use and one of the two, located up-stream, is installed with a pumping facility. There is a spring (30ℓ/min approximately) down-stream and this indicates the existance of shallow groundwater along the wadi. This shallow groundwater may be discharged in a large quantity as waste.

6-22-3 Recommended Water Source

The shallow groundwater along the wadi is feasible for development. In this case a "sub-surface dam" where groundwater is stored by blockage down-stream is recommended. The overall water table is elevated in this long and narrow wadi bed.

Approximately 100,000 m^3 water can be stored by shielding up to 2 m below the ground surface at the dam site, assuming the effective porosity of the aquifer to be 20%. The maximum thickness of alluvial deposits was determined to be about 10 m by electric prospecting. (See Fig. 6-26 and 6-27)



LEGEND	
	ALLUVIUM
	SANDSTONE
(W)	EXISTING WELL
	STRIKE, DIP
	CRACK

0 20 40 70 100 150 METRES

Fig. 6-25

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC			
THE RURAL WATER SUPPLY PROJECT PART-II			
GEOLOGICAL MAP OF SHOHAT, AL-KADASH (T-5)			
DESIGNED BY	Pacific Consultants International		
DATE		SCALE 1:	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN			

Further surveying is necessary before executing the project at this site.

Type B3: Sub-surface Dam

1. A shielding site is located at the Stream with the lowest elevation near the village in order to secure the maximum storage capacity.

2. There must be some influence from the springs of other villages 100 m down-stream from the site.

3. At the dam site the maximum depth to the basement rock (sandstone) is 13 m.

4. 100,000 m^3 water can be stored, when the wadi bed is shielded up to 2 m depth below the ground surface, assuming the effective porosity of the aquifer to be 20%.

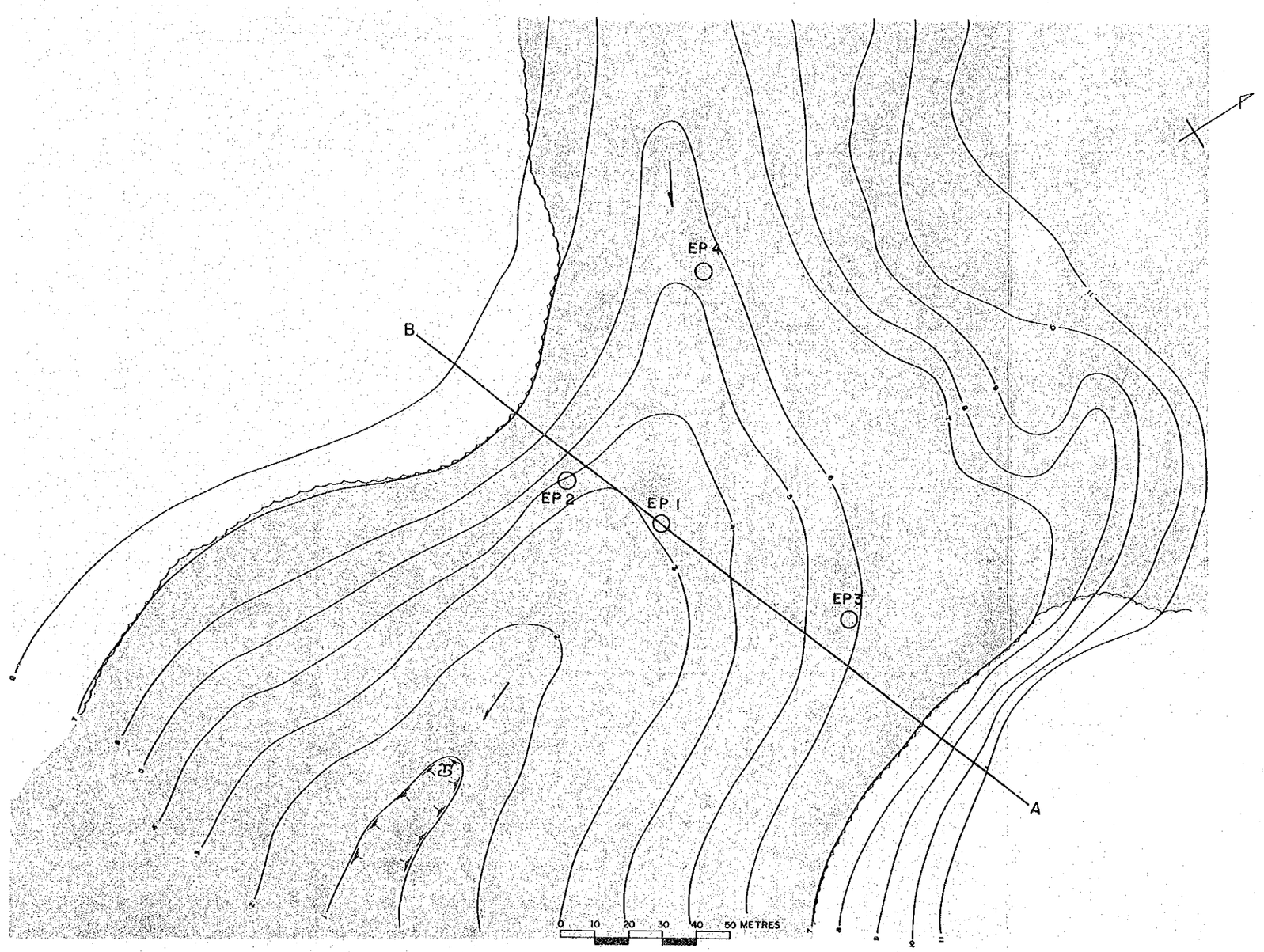
5. Since a 300 m road section along the route is narrow and steep, therefore either road improvement or new road construction is necessary.

Type B1: Shallow Well

1. Another shielding 70 m up-stream (around E.P. No.4) for the dam site is to be built.

2. Depth is 15 m.

3. Operational water is available within the site.

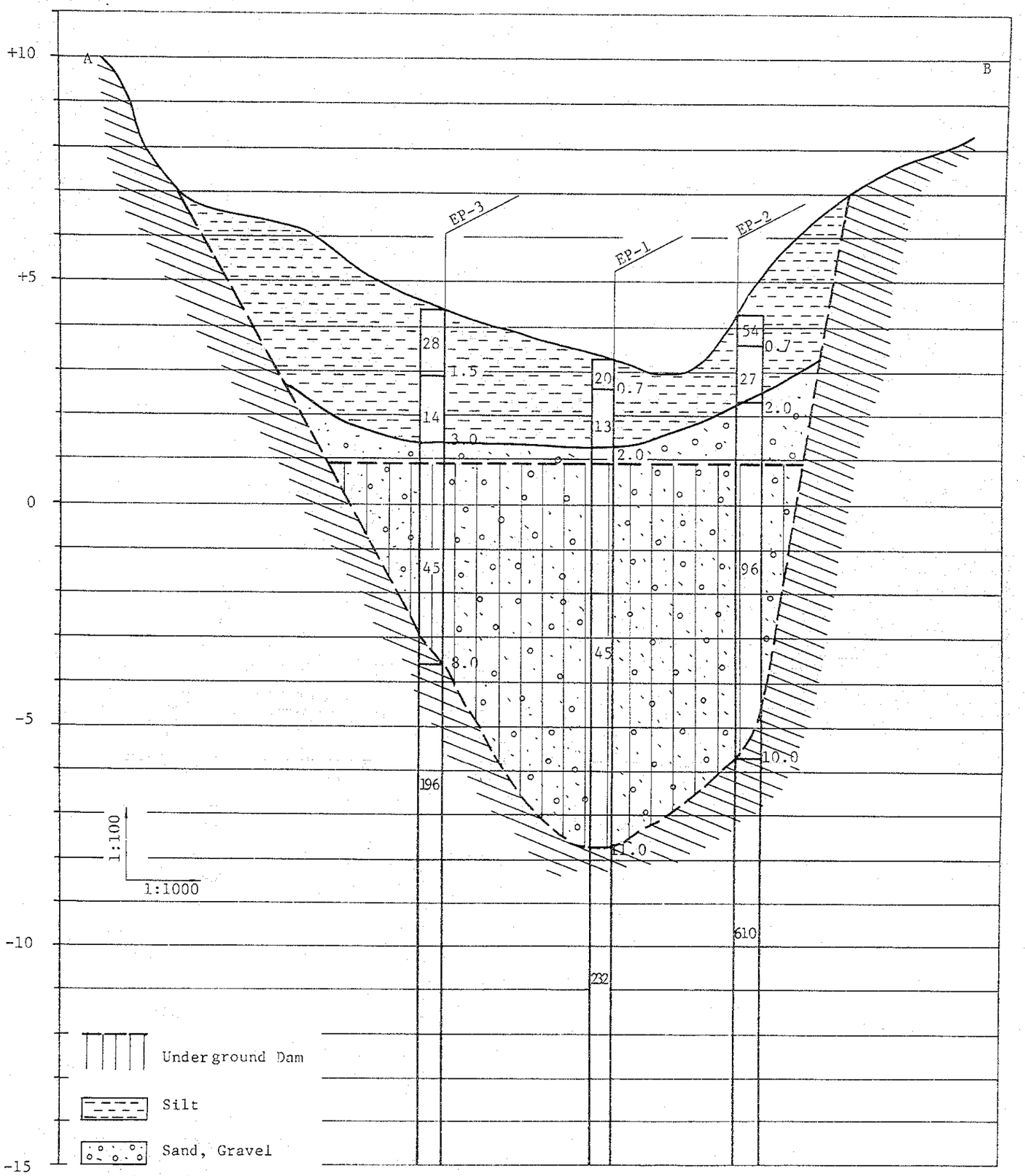


LEGEND	
	ALLUVIUM
	SANDSTONE
	SPRING
B — A	AXIS OF DAM
EP1 ○	ELECTRICAL PROSPECTING POINT

Fig. 6-26

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC			
THE RURAL WATER SUPPLY PROJECT PART-II			
DETAILED MAP OF UNDERGROUND RESERVOIR DAM OF SHOHAT, AL-KADASH (T-5)			
DESIGNED BY	Pacific Consultants International		
DATE	SCALE 1:	DRAWING No.	
JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN			

Fig. 6-27 Geological Cross Section
At Survey Site Shohat, Al Kadash



6-23 Al-Zakira (T-6)

6-23-1 Geography

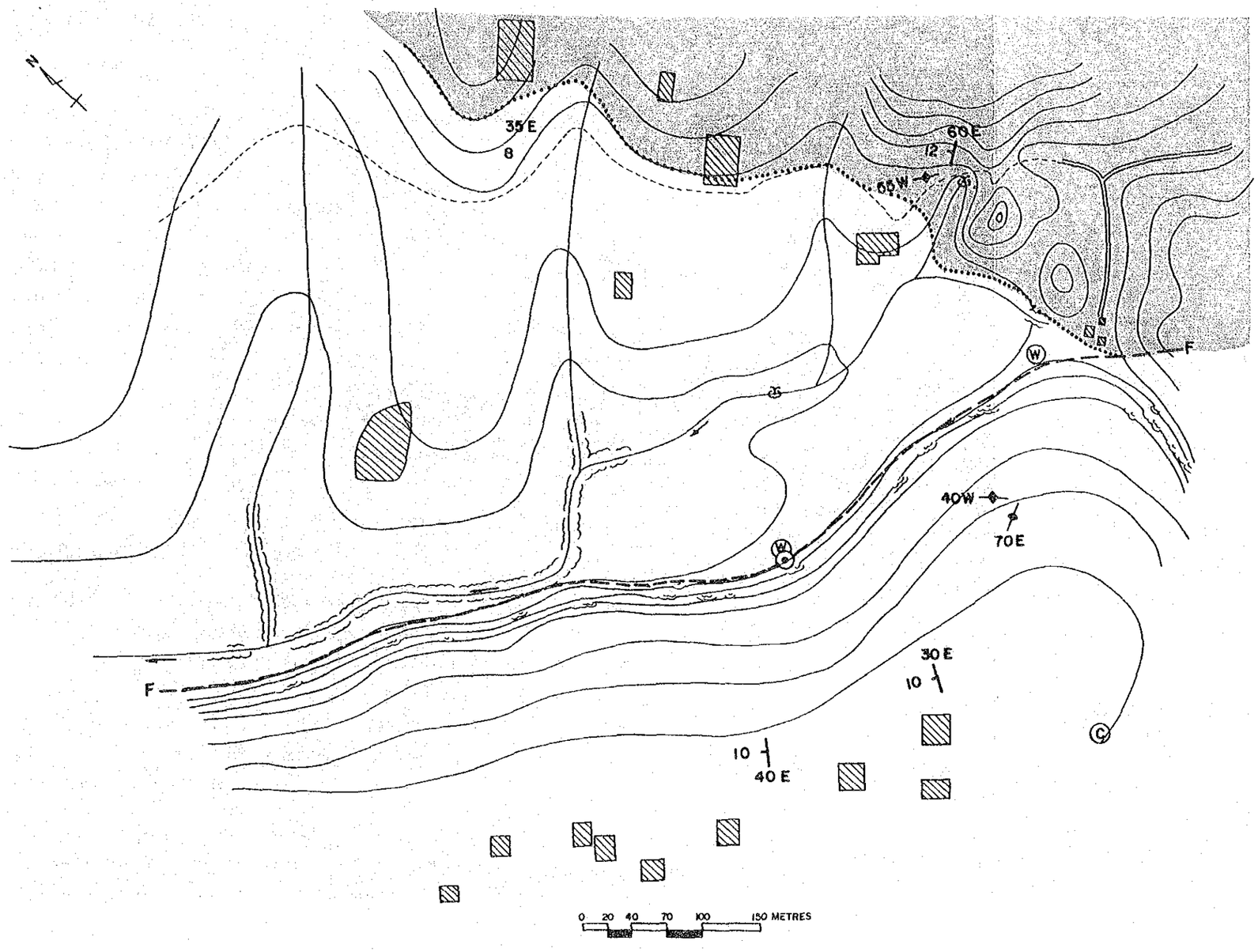
The site is located on the flat surface of the single slope at 1,800 m A.S.L. Steep cliffs exceeding 200 m in relative height are bordering the site in the north and east of the village. At the eastern side the cliff height exceeds 500 m. At the foot of the northern cliff, a flat plain extends and small wadis dissect it into a V-shape. The alignment of the northern valley is N70°W and on a straight line. (See Fig. 6-28)

6-23-2 Hydrogeology

The site consists of arkosic sandstone. On the small hills, however, Trap Series are unconformably overlying it. Regional strikes are NW-SE and slight dips are in a SW direction. The straight cliff of N70°W direction suggests block movement and a resulting fault, based on the continuity of the stratigraphy. Two types of joints prevail: joints of N40°W and N70°W directions. Up-stream from the northern low plain springs are issuing from the layer boundaries in the Trap Series. This discharge seems to be restricted only after the rain falls. We could not find any discharge at the spring site one week after the last rain.

6-23-3 Recommended Water Source

Effective utilization of the spring water can be planned, but there is doubt of the discharge stability. Another plan would be to tap deep groundwater in the sandstone along the fault located in the N70°W direction. However, a steep cliff exceeding 500 m in relative height is adjacent to the site, and since the water shed basin is small, this plan is not feasible from a water quantity standpoint. Therefore, further data collection is urgently required for the water source planning for the area.



LEGEND	
	YEMEN VOLCANICS
	SANDSTONE
	DIP STRIKE
	CRACK
F---	FAULT
C	CISTERN
S	SPRING
O	PROPOSED BOREHOLE

Fig. 6-28

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC		
THE RURAL WATER SUPPLY PROJECT PART-II		
GEOLOGICAL MAP OF ZAKIRA (T - 6)		
DESIGNED BY	Pacific Consultants International	
DATE	SCALE 1:	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN		

6-24 Bab Al-Mandab (T-7)

6-24-1 Geography

Bab Al-Mandab is a traditional water supply port at the southern most tip of Y.A.R. It is located on the coast protruding into the Red Sea and the Indian Ocean. This cape is composed of small hills of several tens of meter above sea level. It is difficult however to secure a water source, since these surface reliefs are made of Quarternary volcanics. The site is located near the territorial border, and therefore, the water source was located near the Umari, military base.

Umari is situated in a flood plain 8 Km inland from the coast at 100 m A.S.L. Small mountains of 200 m height are scattered around Umari. (See Fig. 6-24)

6-24-2 Hydrogeology

The deposits in the flood plain are gravel and sand, and poorly sorted. Small mountains are made of Quarternary volcanics; mainly of compact basalt. Since there is a dug well in Umari, we used this well for a pumping test. The resulting permeability was 5×10^{-2} cm/sec indicating a good aquifer. The stratification estimated by electric prospecting is as follows,

0 - 25 m depth	:	Alluvium
25 - 55	:	Quarternary volcanics
55 -	:	Trap Series

6-24-3 Recommended Water Source

Alluvium was found to be a good aquifer with a high permiability. Since we do not know how much the water table is depressed during the dry season, the well must be drilled as deep as possible.

BAB - AL - MANDAB

GEOLOGICAL MAP (T-7)

	GRAVEL SAND
	QUATERNARY VOLCANICS
(W)	WELL
	ELECTRICAL PROSPECTING POINT
	NEW WATER SOURCE

DUBAB

UMARI

EP

N

0 100 200 300m

FIG. 6 - 29
BAB - AL - MANDAB
GEOLOGICAL MAP
(T - 7)

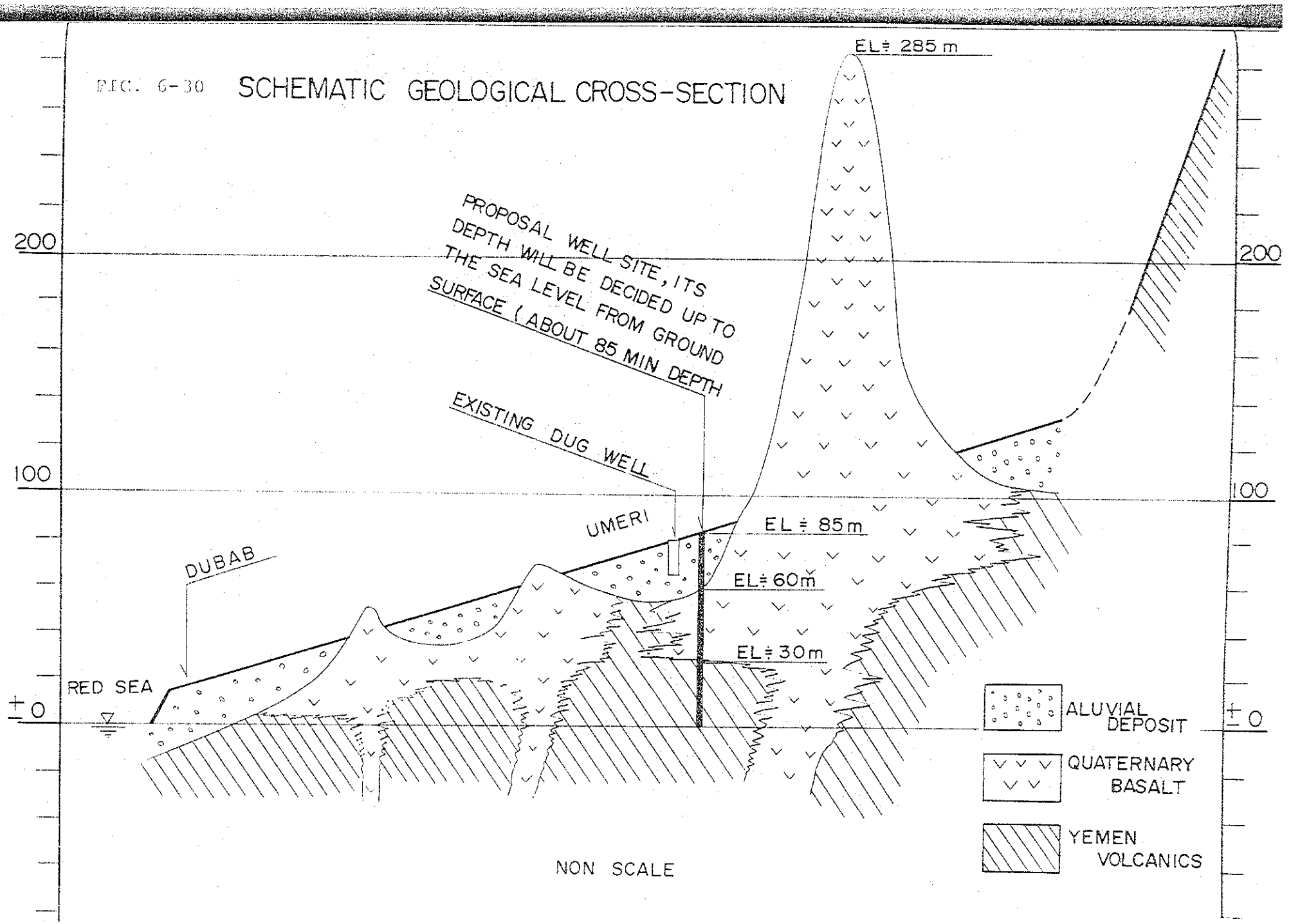


FIG. 6-30 SCHEMATIC GEOLOGICAL CROSS-SECTION
EL÷ 285 m
PROPOSAL WELL SITE, ITS DEPTH WILL BE DECIDED UP TO THE SEA LEVEL FROM GROUND SURFACE (ABOUT 85 MIN DEPTH
EXISTING DUG WELL
UMERI
DUBAB
RED SEA
EL ÷ 85m
EL÷ 60m
EL÷ 30m
200
100
±0
ALUVIAL DEPOSIT
QUATERNARY BASALT
YEMEN VOLCANICS
NON SCALE

Type A: Deep Groundwater - proposed for the project water source.

1. Water source is sought at Umari, because of the military base location there and since it has the highest elevation in the Tihama coastal belt except for the mountains near the border.

2. The geological stratification was estimated by electric prospecting. The details are as follows,

0-25m depth	:	Alluvial deposits
25-55	:	Quarternary basalt
55-	:	Yemen volcanics

3. In order to avoid sea water intrusion the well depth should be restricted to a range between the ground surface and sea level (i.e. 85 m in depth). (See Fig.6-30)

4. Well drilling will penetrate two stratification boundaries (at 25 m and 55 m depth), and discharge may be more stabilized by an additional increment from the shallow aquifer in the Alluvial deposit. It seems better than Type B4.

5. Road problems do not exist.

6. Operational water can be drawn from a dug-well 300 m away.

Type B4: Sub-surface Dam - proposed for the future water source development.-

1. The site is same the as Type A

2. The depth is down to the rock base (≒25m), and the diameter of the hole must be large enough for the inside operation of dull tools (3m or more).

3. The water collecting pipe will be around 30 m long.

4. Discharge stability is not yet known, because no data is available concerning the level of the groundwater during the dry months.

Type E: Others - proposed for the future development.-

1. Constructing three dams in wadi (with 500 m intervals) 1.5-2.5 Km up-stream of the site.
2. The length is 400 m and the depth is 3 m.
3. Gravels could be obtained by sieving dug debris.
4. Probability frequency and flood flow volumes are not clear, therefore, the effect can not be known.

6-25 Yahkhtol (T-8)

6-25-1 Geography

This village is located 1-2 Km inland from the coast at 1-2 m A.S.L. There are sand dunes of 5 m in relative height 3 Km north of the village. Sand and gravel are extensively distributed in the inland. These are thought to be from the flood plain deposit. (See Fig. 6-31)

6-25-2 Hydrogeology

The coastal sand dune area prevails around the village but in the inland area sand and gravel extensively cover the ground surface. A dug well is found 2 Km inland from the coast, although the quality of the well water is very much deteriorated. There is no well in the village, and people carry in the shallow well water from a distance of 20 Km.

6-25-3 Recommended Water Source

It may be difficult to develop water source around the village because of the unsatisfactory water quality. However, somewhere between Mokha and Taizz at 100 m A.S.L. may provide good water owing to the Quarternary volcanics in the small hills.

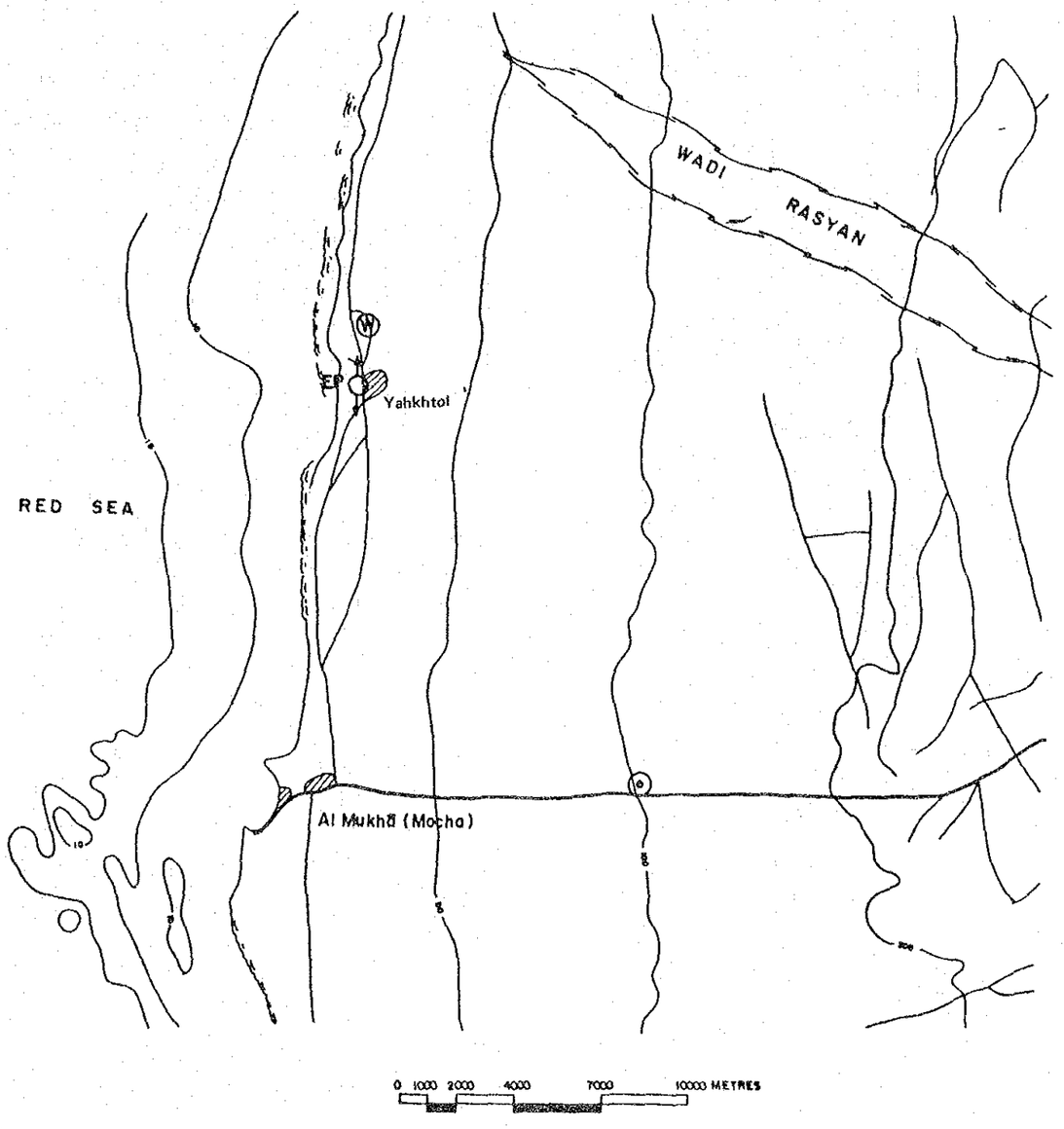


Fig. 6-31

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC	
THE RURAL WATER SUPPLY PROJECT PART-II	
LOCATION MAP OF YAHKHTOL (T-8)	
DESIGNED BY	Pacific Consultants International
DATE	SCALE 1: DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN	

6-26 Makbana (T-9)

6-26-1 Geography

Villages are located in the mountain at 900 m A.S.L. The major direction of the valley is N30° - 45°W which coincides with the alignment found in the aerial photograph of the same region. There are abundant stream flows in the wadi south of the survey site. Many shallow wells are also in use in this wadi to provide water for irrigation. Makbana covers very large area and its center is close to the water divide. (See Fig. 6-32)

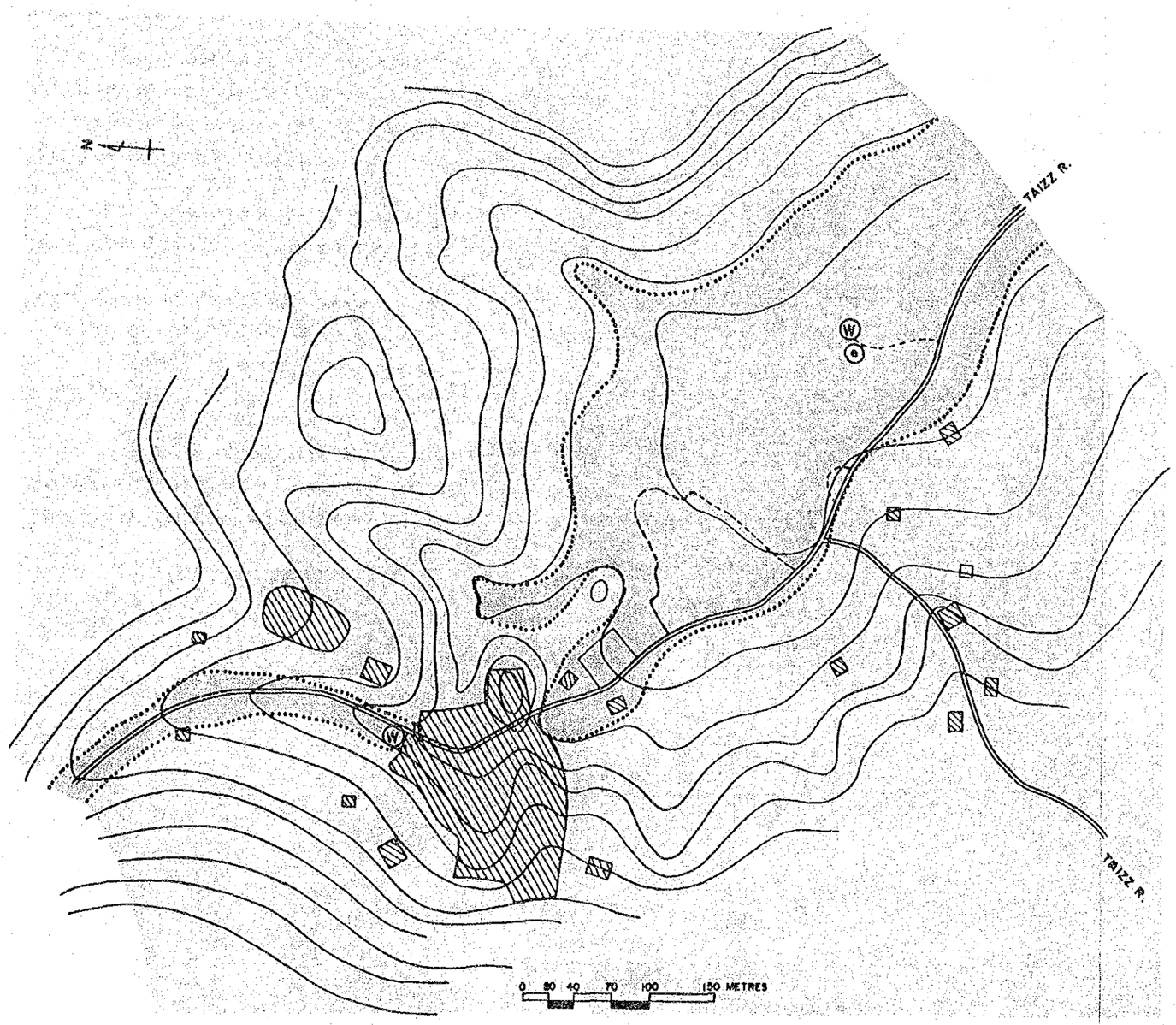
6-26-2 Hydrogeology

The survey site consists entirely of Trap Series, i.e. mainly andesite and basalt. Small cracks are heavily contained in the rock, but any large scale faults and clearly oriented joints are not observed. However, the valleys are aligned along NW-SE direction rationally since they have probably been formed along the weak line of the same direction. Faults and alignments parallel to the valleys can be recognized on a 1/500,000 scale geological map.

Dug wells are used in wadi course, although, these wells are out of use and covered for conservation purposes during the dry season because of lowering of water level in them at that time.

6-26-3 Recommended Water Source

Deep groundwater development through the weak lines in wadi may be feasible.



	LEGEND
	ALLUVIUM
	YEMEN VOLCANICS
Ⓦ	EXISTING WELL
⊙	PROPOSED BORHOLE

Fig. 6-32

MINISTRY OF PUBLIC WORKS YEMEN ARAB REPUBLIC			
THE RURAL WATER SUPPLY PROJECT PART-Ⅱ			
GEOLOGICAL MAP OF MAKBANA (T - 9)			
DESIGNED BY	Pacific Consultants International		
DATE		SCALE 1:	DRAWING No.
JAPAN INTERNATIONAL COOPERATION AGENCY, TOKYO, JAPAN			

Type A: Deep Groundwater

1. The site is consists entirely of Trap Series and almost horizontal stratification. Small cracks are prominent however, faults and large-scale joints are not observed.

2. Valleys are formed along the weak lines, which control the direction of faults and alignments.

3. The recommended drilling site is near the existing wells the south of Makbana Center, considering the convenient access to the consuming communities.

4. The well depth is from 200 m to 250 m, determined by the difference in elevation between the site and the wadi to the south.

5. Operational water can be obtained from outside the site.

CHAPTER VII

RECOMMENDATIONS

1. At most sites the development of deep groundwater is recommended for immediate use. Special emphasis has been placed (in Section 6-24), on the development of water source in Turba region, however, further study is necessary.

2. In the Turba region, the wide area is suffering from the dry conditions; however, villages are concentrated and the population density is relatively high. Therefore it seems necessary to provide a water source development project covering such a problematic area. In the case of the Turba region, the applicability of dams should be examined considering the relatively high precipitation. Concerning the groundwater development, the potential effectiveness of wells placed sufficiently far from the steep cliff line running through south to southwest of Turba should be examined.

   In the Tihama region, there is no problem with the quantity of water; however, the quality varies significantly from place to place. Various replenishment and sub-surface flows of groundwater have fluctuated since alluvial deposits were formed there, and the variation of water quality seems to be caused by evapotranspiration.

3. In recent years, the number of deep groundwater developments is increasing, and the water table in Sana'a is being lowered. A comprehensive water development project, which includes every local water balance, must be launched as early as possible. Such a project should minimize the undersirable effect caused by previous projects.

This policy is essential in such a country like Y.A.R. where precipitation is very limited and an arid environment prevails.

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