3.3 LAND USE

3.3.1 Land Use

Grasp of the present land use conditions is one of the important factors for the assessment of the existing agriculture and social welfare of the farmers and for the forecast of the future land and water resources development potentials. Low cropping intensity, high percentage of fallow land and low utilization of land resources due to frequent crop failures limit the optimum utilization of agricultural resources.

The present land use of Quetta and Mastung Tehsils including the Quetta Area is summarized as follows:

Total Area:	241,330 ha
a. Cultivated area:	100,950 ha (41.8%)
a-1. Irrigated area:	46,951 ha (46.5%)
a-2. Non-irrigated area:	53,999 ha (53.5%)
b. Other areas	140,380 ha (58.2%)

Of the total cultivated area of 100,950 ha, the fallow land is 64,264 ha (63.7%).

The Quetta Area of 28,000 ha itself includes the cultivated land of 13,705 ha (49%) of which 13,626 ha is ordinary upland field and 79 ha is orchard (FIG 3.3.1).

On the other hand, the present land use of Kalat Tehsil including the Kalat Area is summarized as follows:

Total Area:	98,040 ha
a. Cultivated area:	55,952 ha (57.1%)
a-1. Irrigated area:	2,093 ha (3.7%)
a-2. Non-irrigated area:	53,859 ha (96.3%)
b. Other areas	42,088 ha (42.9%)

The Kalat Area of 12,000 ha itself includes the cultivated area of 2,793 ha (23.3%) of which 2,778 ha is ordinary upland field and 15 ha is orchard (FIG 3.3.2).

3.3.2 Land Tenure

The existing agricultural land is classified under three different land tenure systems as follows:

(1) Owner Occupier

The farmers have their own land and cultivate it themselves. Though some are cultivating their land through casual labour, common ownership with fixed shares is generally observed.

(2) Occupancy Tenant or Lathband Bazgar

This is a local term called "lathband" which means that the tenant has the occupancy right i.e. the tenant has the permanent and hereditary rights. Moreover he has the right to transfer the land to other tenants. But he is bound to pay the fixed share of the produce to the owner of the land.

(3) Tenant at-will or Tenant Tab-e-Marzi

This type of tenant is entirely temporary and can be ejected at any time from the land he cultivates. There is no security involved. This tenancy is generally prevalent in canal command areas. The owner supplies every input and receives fixed produce of winter (rabi) and summer (kharif) crops.

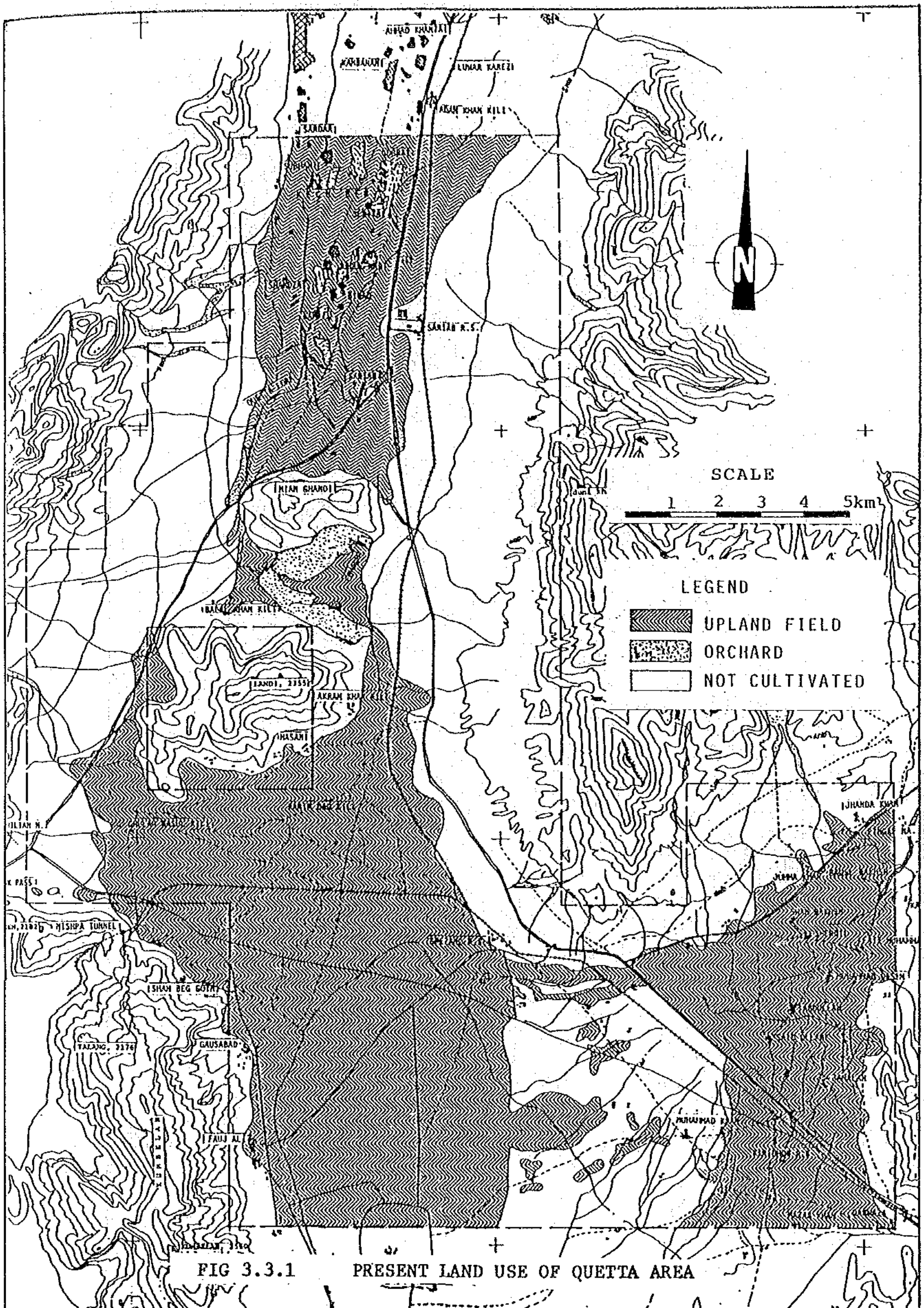


FIG 3.3.1 PRESENT LAND USE OF QUETTA AREA

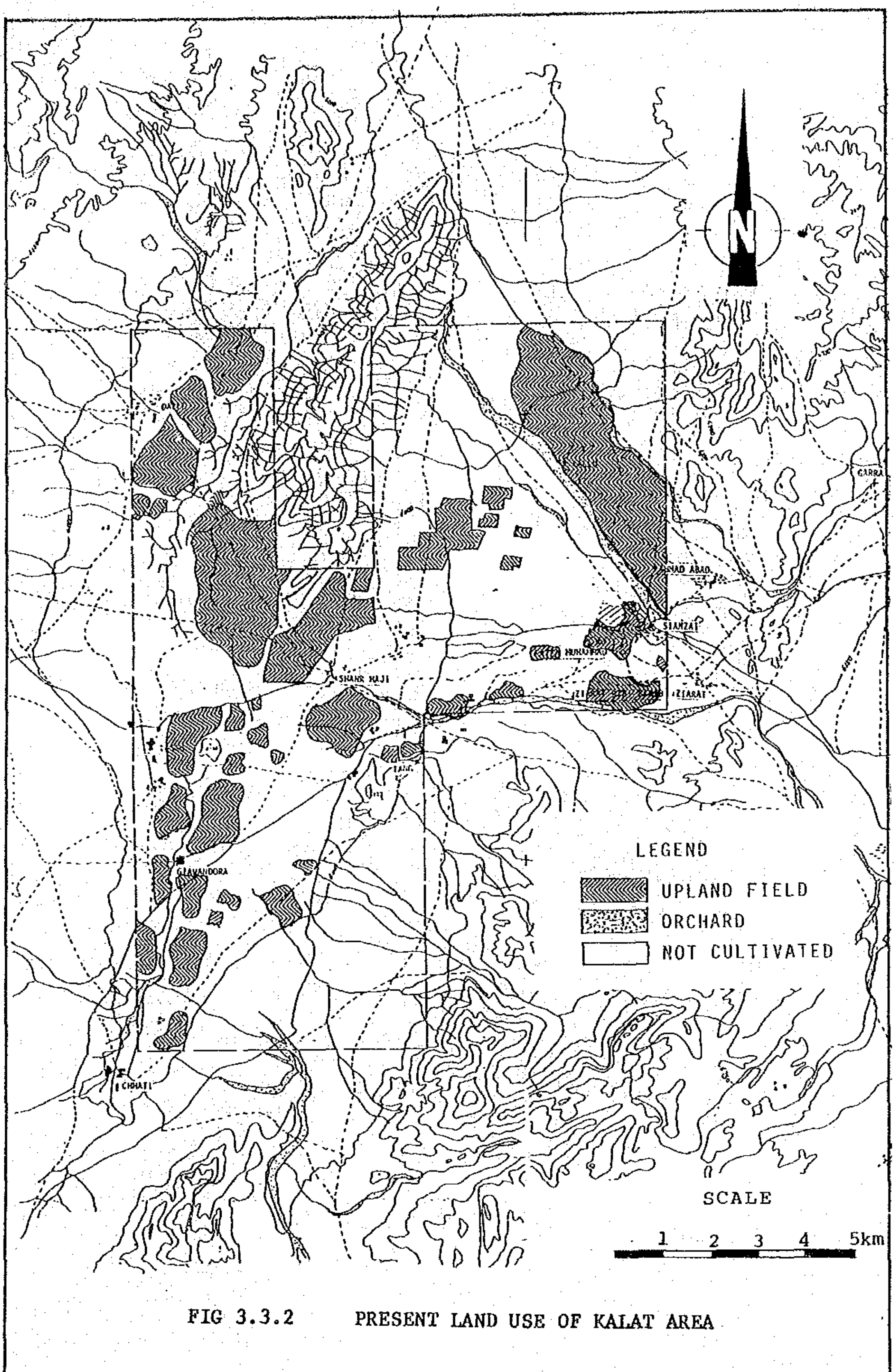


FIG 3.3.2 PRESENT LAND USE OF KALAT AREA

3.4 AGRICULTURE

3.4.1 General

The Quetta Area of 28,000 ha expands over both Quetta and Mastung Tehsils; of which agricultural land is estimated to be approx. 13,700 ha. Irrigated area is estimated to be approx. one (1)% of the agricultural land or 137 ha. In the irrigated area, fruit trees (mainly apple) and vegetables are cultivated.

The Kalat Area of 12,000 ha is located in Kalat Tehsil; of which agricultural land is estimated to be approx. 2,790 ha. Irrigated area is estimated to be approx. two (2)% of the agricultural land or 56 ha. In the irrigated area, fruit trees and vegetables are cultivated. On the other hand, in the non-irrigated area, wheat, cumin, sorghum, etc. are cultivated.

The cultivated area, number of farm household and cultivated area per farm household for the respective Tehsils (Quetta, Mastung and Kalat) are in TABLE 3.4.1.

TABLE 3.4.1 PRESENT FARM HOUSEHOLD

Name of Tehsil	Cultivated Area (1) (ha)	Farm Household (2) (household)	(1)/(2) (ha/household)
Quetta	69,333	10,057	6.9
Mastung	31,617	18,929	1.6
Kalat	55,952	23,591	2.4

Source: Tehsil statistic data, 1985

The cultivated area is level or slightly uneven which can easily be levelled by minor levelling practices. Slight to moderate erosion problems exist mostly along with small streams which can also be easily reclaimed by farm machinery.

Size of existing farm plots ranges from 0.4 ha to 0.6 ha (1 - 1.5 acres) and their shapes vary according to their land ownership but mainly of rectangle. There are few systematic secondary or tertiary roads in the Study Area. This would be due to the present farming practices and transportation of agricultural inputs and outputs being mostly made with manual labor force and draft animals.

3.4.2 Farming Practice

(1) Cropping Pattern

The following are the outline of cropping pattern of the Study Area:

a. Major summer crops (Kharif crops) are sorghum (grain and green), maize (grain and green), onion, potato, vegetables and melon.

   * Onion, potato and vegetables are cultivated in the field with irrigation.

b. Winter crops (Rabi crops) include wheat, cumin, vegetables and alfalfa (under fruit trees).

   * Vegetables and alfalfa are cultivated in the field with irrigation.

   * Alfalfa is replaced every 3 - 4 years.

c. Rainfed field (barani/sailaba) is dominant in the Study Area and sorghum and melon as summer crops and wheat and cumin as winter crops occupy the maximum hectarage.

d. The farmers having the supply of irrigation water grow cash crops like vegetables and fruits which give good return to them (FIGs 3.4.1 and 3.4.2).

(2) Farming Practice

Most of the cultivated land is not provided with irrigation facilities and the farmers are practicing extensive farming in the farm-land. However, they are realizing intensive farming in the irrigated areas.

The agricultural production in the Study Area has not been stable due to irregular distribution of monthly rainfall, absolute shortage of total annual rainfall, low level of farming technique, etc.

The low agricultural production results from difficulties in successful annual rainfall forecasting and the conservativeness of the farmers in using a lot of agricultural inputs in farming. The manual labor force and draft animals are the main labor force in the Study Area. The average number of laborers and domestic animals used for farming per farm household are 3.5 persons and 1.5 heads, respectively.

On the other hand, the employment of farming machines seems to be little needed due to small cropping hectarage per farm household, high availability of family labor, single cropping per year, etc.

As for agricultural input in the non-irrigated land, most farmers have minimized seeds, fertilizer and pesticide, which have resulted in low production and low income. However, in the irrigated land, the farmers keep in line with the activities recommended by agricultural extension office.

According to the field survey conducted in September to October 1986, farmers use fertilizer and pesticide only for such cash crops as vegetables and fruit trees in the irrigated area. The amount of seed and fertilizer by crops recommended by Agricultural Extension Office are shown in APPENDIX TABLE 3.4.3.

3.4.3 Agricultural Production

The agricultural production in the Study Area is largely influenced by wide variation of annual precipitation. The precipitation during the period of April - September, 1987, for instance, was extremely low and the level of production in the rainfed area was accordingly very low for such winter crops (Rabi) as wheat, barley and cumin and summer crops (Kharif) as fodder crops and water melon.

The Farm Economy Survey undertaken during the field survey indicates that the wheat yield was decreased by more than 25% compared with the average and that the production of fodder crops, water melon, etc. was completely failed. All of these figures will be identified in 1986 - 87 Agricultural Statistics.

TABLE 3.4.2 shows the wide variation of precipitation during the period of April - September since 1974, which has often brought about the drought damages in the Study Area.

TABLE 3.4.2 PRECIPITATION DURING APRIL - SEPTEMBER

(Unit: mm)

Year	Precipitation	Year	Precipitation
1974	3.0	1981	19.0
1975	69.0	1982	123.4
1976	26.0	1983	327.9
1977	107.7	1984	7.1
1978	139.4	1985	88.8
1979	0.4	1986	86.4
1980	7.9		

Source: Quetta Samungli Airport, Meteorology Department, Karach

TABLE 3.4.3 presents the 5-year (1981/82 - 1985/86) average production of major farm products in the Province and the concerned Division and Districts.

TABLE 3.4.3 AVERAGE PRODUCTION OF CROPS (1981/82 - 1985/86)

(Unit: 10^3 ton)

Area	Wheat	Cumin	Onion	Potato
Baluchistan Prov.	376.6	2.0	88.9	68.4
Quetta Div.	61.6	1.1	15.9	24.6
Quetta Dis.	2.4	0.14	3.4	0.45
Kalat Div.	67.2	0.81	62.5	41.5
Kalat Dis.	31.1	0.69	56.4	41.3

Source: Agricultural Statistics Baluchistan (1981/82 - 1985/86)

3.4.4 Livestock

The cropped area of Baluchistan which represents only 5 - 6% of the national total is entirely dependent on some forms of irrigation or soil moisture retention. Eighty (80)% of population in the Province is thus engaged in livestock raising in view of the climatic conditions and low rainfall making farming practice difficult and costly.

According to the estimation by Livestock Department based on 1976 Livestock Census, there were 6.8 million sheep, 6.0 million goats, 0.7 million cattle, 4.0 million poultry and 0.7 million other livestock in 1986. Among sheep, Harnai, Bibrik, Rakhshani and Baluchi sheep breeds are best known for mutton and carpet wool. Bhagnari cattle of Baluchistan are famous and popular in the country for pulling heavy loads and tilling hardest soils. Red sindhi cattle, one of the best milch breeds in Pakistan is capable of thriving well in hot and arid climatic conditions and possesses export potentials which are found in Lasbela District. The Province produces a surplus of sheep and goats exceeding about 2 million annually which are sold outside the Province.

The Livestock Department of GOB has been implementing a number of projects and programs to protect the livestock selective breeding and introduction of exotic strains of cattle and poultry. Improvement of the ranges by providing better grazing and expanding extension services has also been kept in view.

The number of livestock is shown in TABLE 3.4.4.

TABLE 3.4.4 LIVESTOCK STATISTICS

(Unit: 10^3 heads)

Area	Sheep & Goats	Camel	Cattle	Horse	Chicken	Others
National	26,501.9	603.4	4,865.5	293.0	29,811.0	23,311.2
Baluchistan	6,877.9	144.6	219.6	13.7	1,645.9	665.8
Quetta Div.	2,405.5	31.7	148.1	2.7	484.9	146.9
Quetta Dis.	86.2	1.4	7.7	0.09	8.3	
Kalat Div.	2,695.3	79.1	183.5	2.3	666.9	200.5
Kalat Dis.	801.2	23.1	30.8	0.7	160.9	4.3

Source: Agriculture Census, 1980

3.4.5 Production Cost and Production Value

Present crop budget for representative crops in the Study Area (unirrigated land only) is estimated using the data of sample households in the first phase survey. Unit cost of plowing by tractor and that of seeding by camel includes cost of labor as well. Fertilizer and pesticide are seldom used in the unirrigated area. Production cost is estimated on condition that labor, draft animal and tractor are all hired.

The results of estimated net production value(NPV) of crops are comparatively high except sorghum as shown in TABLE 3.4.5.

TABLE 3.4.5 PRESENT CROP BUDGET

Crop	Farmgate Price (Rs/kg)	Yield (kg/ha)	GPV (Rs/ha)	Production Cost (Rs/ha)	NPV (Rs/ha)	NPV Ratio (%)
Wheat	2.0	1,050	2,100	1,049	1,051	50
Cumin	19.6	284	5,566	3,804	1,762	32
Sorghum	1.5	472	708	666	42	6
Barley	2.0	632	1,264	860	404	32

3.4.6 Agricultural Supporting Services

(1) Agricultural Extension

Agricultural Extension Office is engaged in many duties such as:

- to guide farmers for agricultural new technique;
- to distribute seeds of high yield varieties, fertilizer and pesticide; and
- to prevent and exterminate plant pests.

Three Tehsils covering the Study Area have respective Tehsil Agricultural Extension Offices. However, owing to the shortage of staff, various facilities and equipment, the extension services to the farmers may not be functioning well (refer to VOLUME II APENDICES).

The present status of the services is as follows:

Tehsil	Number of Staff Member	Duty
Quetta	70	990 ha/member
Mastung	64	870
Kalat	17	3,291

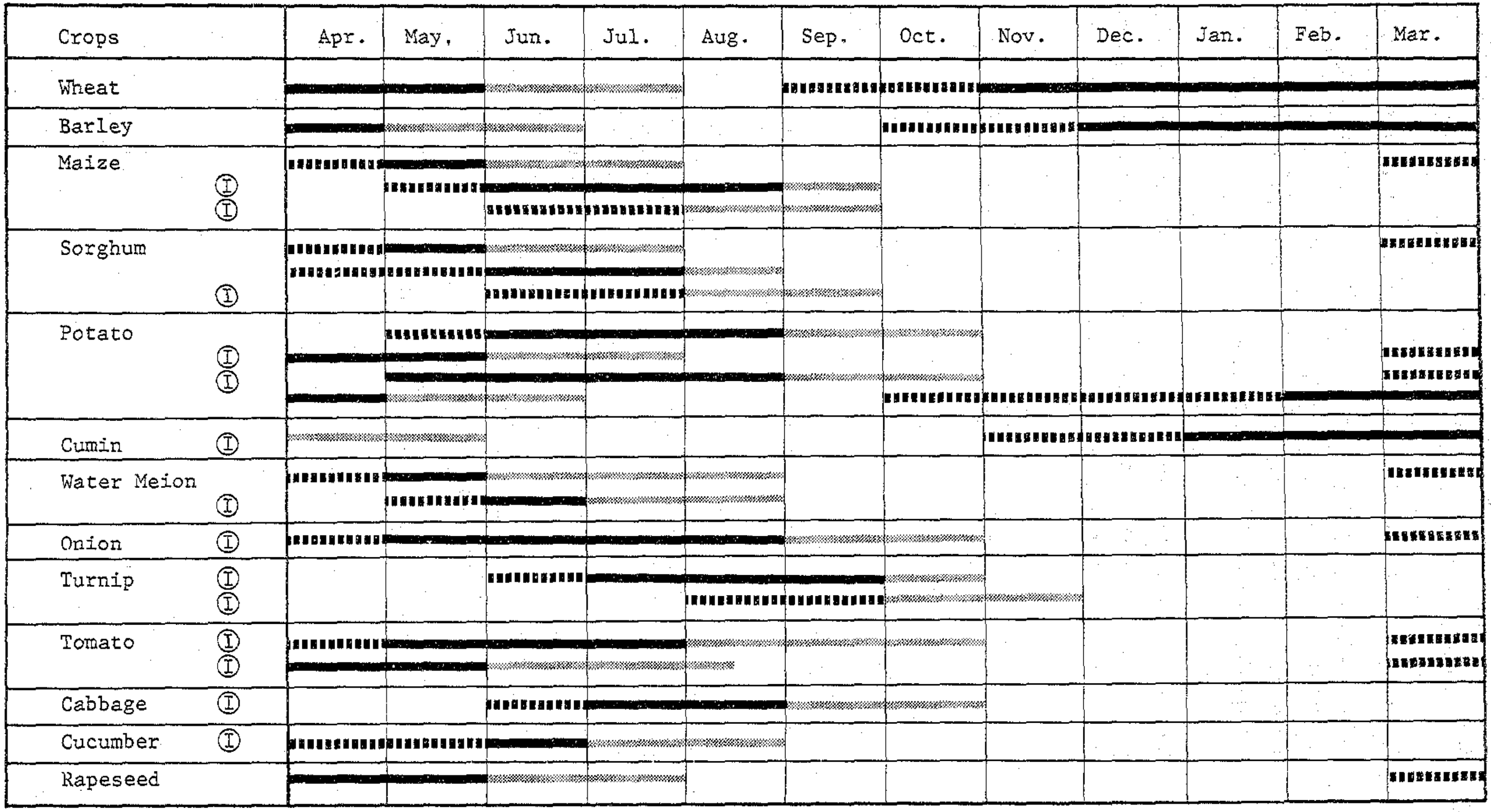
The cropping calendar recommended by the Agriculture Department of Kalat Tehsil is as follows:

Crops	Sowing Time	Harvesting Time
Orchards	Feb - Mar	Sep - Nov
Wheat	15 Oct - 30 Jan	15 Jun - 15 Jul
Cumin	Dec - Feb	15 May - 15 Jun
Barley	Dec - Jan	15 May - 15 Jun
Potato	15 Apr - 15 May	Aug - Oct
Onion	15 Mar - 15 Apr	Sep - Oct
Turnips	15 Jul - 30 Jul	15 Jul - 30 Sep
Peas	15 Feb - 15 Mar	1 May - 15 May
Carrot	15 Mar - 15 Apr	15 Sep - 30 Oct
Pulses	15 Mar - 15 Apr	15 Jun - 15 Jul

(2) Research

There are agricultural research institutes and seed farms and training centres in Quetta and Kalat Districts, numbering 29 in total. They hold the crop field of 2,386 ha in total. These institutes are responsible for studies on cereal crops, vegetables, fruit trees and flowers.

However, remarkable results have not been attained due to the short time since the establishment of these institutes (refer to VOLUME II APPENDICES).



Source: Field Survey Results.

Sowing Period — Growing Period — Harvesting Period

(I) With Irrigation

FIG 3.4.1 PRESENT CROPPING CALENDAR IN QUETTA AREA

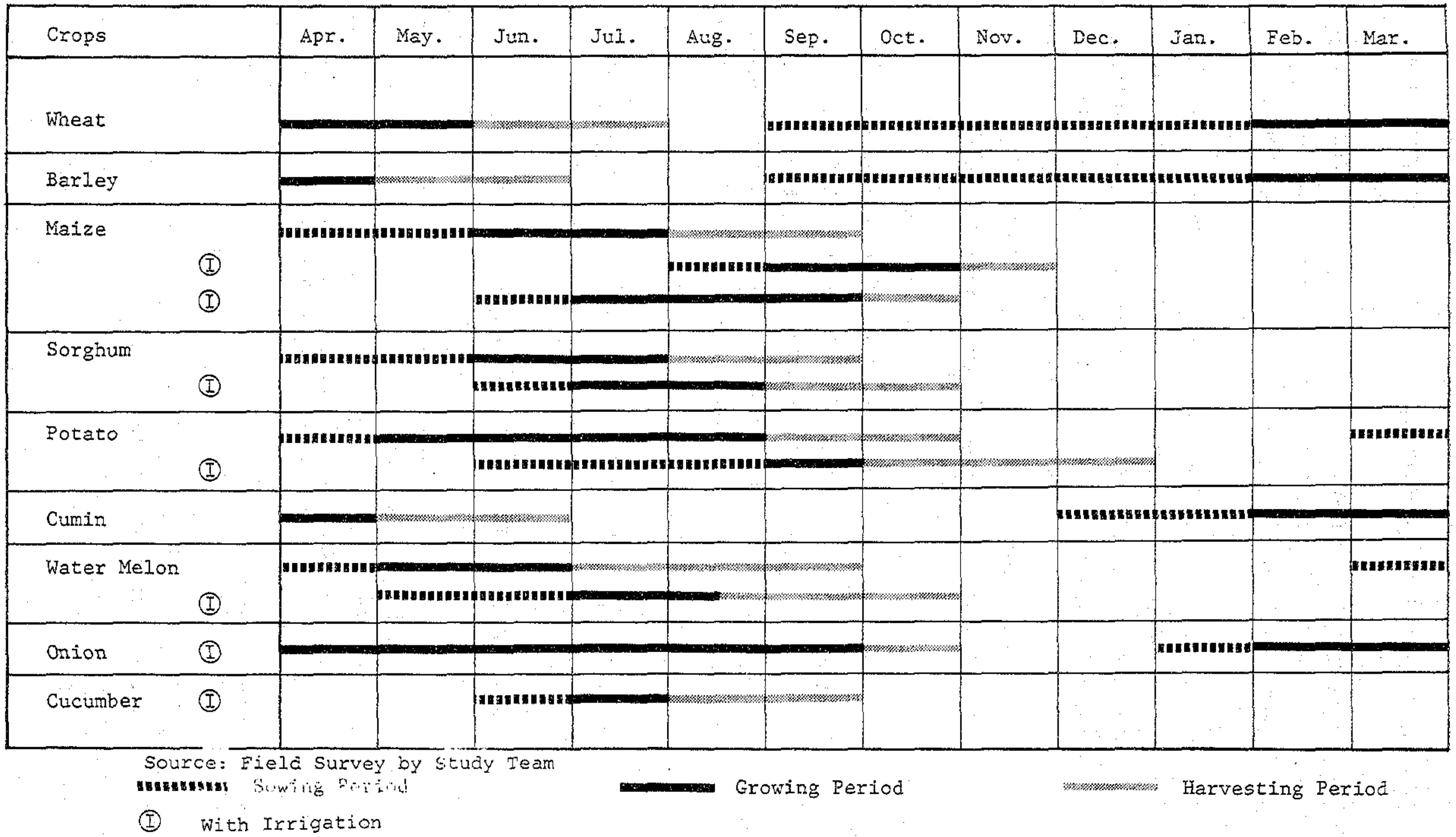


FIG 3.4.2 PRESENT CROPPING CALENDAR IN KALAT AREA

3.5 EXISTING INFRASTRUCTURE FACILITIES

3.5.1 Irrigation Facilities

(1) General

In some parts of the Quetta Area, groundwater is pumped up to the irrigated field through open wells or tube wells with electric motors. In the northern part of the Area, a small area is irrigated with the groundwater through Karezes. In the southwestern edge of the Area, there are a few wells for irrigation purpose. Most fruits and vegetables are cultivated in the irrigated fields. Wheat is cultivated in most of the rainfed fields.

In the Kalat Area, there are no tube wells either for irrigation or for domestic use. There are only a few orchards and vegetable fields which are irrigated by the spring water originating at Dudran and being carried to the field for about 12 km distance through an earth canal. Wheat is grown in most of the rainfed fields.

The irrigation areas of Quetta and Kalat Districts are shown in TABLE 3.5.1

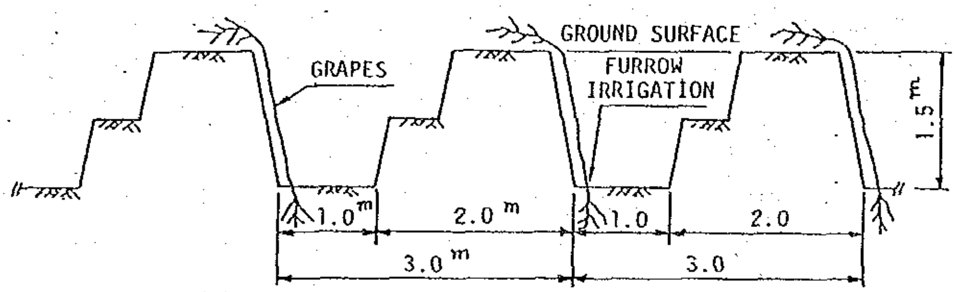
TABLE 3.5.1 SYSTEMWISE IRRIGATED AREA IN 1985/86

Province/ District	Cultivated Area (ha)	Total Irrigated Area (ha)	Irri. Ratio (%)	Canal			Open Wells (ha)	Tube wells (ha)	Karezes Springs etc.
				Govt.	Private	Total			
Baluchistan	1,468,160	510,900	34.8	314,750	25,860	340,610	15,830	95,660	58,800
Quetta Dis.	32,158	16,400	51.0	100	-	100	-	12,800	3,500
Kalat Dis.	117,282	42,500	36.2	-	-	-	1,900	38,600	2,000

Source: Agricultural Statistics, Baluchistan, 1985 - 86
Directorate of Agriculture, GOB

(2) Irrigation Method

Vegetables and fruit trees are mostly irrigated with a basin method. The average size of a basin is 8 m x 8 m. Furrow irrigation with 30 cm high and 1 m interval is widely adopted for vegetable cultivation. Trench irrigation method, a type of the furrow irrigation, is widely adopted for the grape cultivation. The furrow depth is about 1.5 m and the ridge and side slope of the furrow are used as an ivy trellis. This furrow has also a function that the irrigation water flowing in the furrow accelerates vapour in the air to become dewdrop due to the difference of temperatures in the day time and at night.



In order to prevent the surface runoff of rain water and to store the surface runoff and also to prevent the top soil and gully erosion, a kind of flood irrigation method 'Bundats' is widely adopted for wheat cultivation during winter by making a bund at the downstream edge of the field.

The irrigation fields are expanding year by year. However, they are receiving insufficient irrigation water due to the limited water resources, causing low agricultural productivity. Less than one half of the optimum amount of irrigation water may be applied in the existing irrigation fields in the Study Area.

The irrigation interval is usually determined based on the available irrigation water. The average irrigation intervals for the vegetable cultivation and fruit trees are reportedly 7 to 10 days and 2 to 4 weeks, respectively.

(3) Irrigation Facilities

Most of the existing irrigation facilities except Kareze are constructed and owned by the respective farmers. Most of the Karezes in the Study Area are abandoned because of drawdown of the groundwater level or have collapsed due to the intrusion of flood water, etc. Main irrigation facilities in the Study Area are open/tube wells, pumps and their operation rooms, farm ponds, irrigation canals and pipe lines.

Recently in the northern part of the Quetta Area, most of the pumped irrigation open wells are encountering shortage of water, because penetration to aquifer is limited and the seasonal fluctuation of drawdown of water level is big, causing the installation and operation of pumps impracticable. Tube wells are commonly used for the irrigation or rural water supply. Based on the farmer's request/Provision of Annual Development Programs (ADP), the Provincial Government agencies, i.e. Irrigation and Power Department, Baluchistan Development Authority and WAPDA Hydrogeology Project, Quetta, drill the tube well, in the case that the drilling of tube well is found technically feasible and that farmers have made financial deposit and funds have been made available in the ADP by the Government of Baluchistan.

Normally, the turbine or submersible pumps for tubewells and centrifugal pumps for open wells are operated by electricity. In the Quetta Area, electric power is common, because electricity supply lines are provided widely. However, diesel engines are also used where electricity supply does not exist, but its operation and maintenance is costly and troublesome for the farmers. The operation hours are not controlled by any local agencies or organizations. These are operated as long as possible at farmers' will. Therefore, the groundwater level significantly draws down during irrigation season of summer in the northern part of the Quetta Area. Usually, 2 to 5" dia. pump is installed and its discharge is 2-15 l/sec (30 - 240 gpm) and irrigates 2 - 12 ha (5 - -30 acres) of vegetable field or orchard.

TABLE 3.5.2 NUMBER OF TUBE WELLS AND COMMAND AREA

Province/ District	Area Irrigated by Tube Wells	Number of Tube Wells									Average Tubewell Command Area (ha)
		W/Electricity			W/Diesel			Total			
		Govt.	Pvt.	Sub-Total	Govt.	Pvt.	Sub-Total	Govt.	Pvt.	Sub-Total	
Baluchistan	95,660	121	4,629	4,750	94	3,323	3,417	215	7,952	8,167	11.7
Quetta Dis.	12,800	19	1,060	1,079	0	0	0	19	1,060	1,079	11.9
Kalat Dis.	38,600	7	2,480	2,487	16	740	756	23	3,220	3,243	11.9

Source: Agricultural Statistics, Baluchistan, 1985 - 86
Directorate of Agriculture, GOB

Pumped water is usually once stored in a farm pond through the leading pipe from the well. Most of the farm ponds do not have any lining or any proper facilities. Their storage capacity is about 100 m^3. Distribution of water from the farm pond is controlled by earth plugging on the earth canal. Some farm ponds located in the gravelly area are mortor-lined with thickness of about 1 to 2 cm.

In order to make the water level as high as possible, the feeder pipe or canal as well as farm pond itself is installed or constructed on the embankment. Leakage of water from feeder canal and farm pond seems to be large. Most of the irrigation canals are unlined, having bottom width 30 cm, height 30 cm and side lope 1:1.0. Some diversion boxes to control the distribution of water near Mian Ghundi are made of concrete.

3.5.2 Flood Control and Drainage Facilities

Most of the Study Area is located in the centre of alluvial valley with slope of 1 to 2% except alluvial gravelly conic foot of hilly or mountainous area. Natural channels appear at the mountainous areas. Most of them disappear in the alluvial conic foot and come up again at the lowest part of the plain, forming the main drains. All of the natural channels carry the gravel from mountain ranges and deposit the washed small particles in flat area. The channel bed is eroded and gravel and cobble are deposited, making it highly permeable. No artificial drainage facilities are found in the Study Area.

Irrigation and Power Department of Baluchistan has constructed near the Study Area some delay action dams aiming at the recharge of groundwater and to minimize the flood peak discharge and debris runoff (FIGS 3.5.1 and 3.5.2). They are a kind of penetration dam of earth-fill type with a spillway but without any intake facilities. Three (3) delay action dams were constructed at the end of gorge near the Quetta Area and one (1) near the east entrance of the Kalat Area. They are designed against the previous maximum flood discharge. Due to the heavy rain in August 1987, Wali Dad delay action dam in the Quetta Area was flushed out.

Dasht-i-Khuni area located in the southern part of the Quetta Area is a closed drainage area, causing the thick deposit of fine sand in the central plain. The rain fallen in the area can not be drained and makes a seasonal natural lake.

In the Study Area, no artificial drainage system of farm level exists. Surplus irrigation water is used again for irrigation of the downstream field until it disappears. No leaching of salinity is practiced because of no significant damages having occurred until now.

3.5.3 Road Systems and Transportation Facilities

(1) Road Systems

There is total 350 km length of roads in Quetta District out of which 38% are asphalt-paved. In Kalat District, there is a total of 450 km length of roads out of which 27% are asphalt-paved. National/Inter-provincial Highway, the minimum 3.65 m width metalled and 7.3 m width surface-treated, connects the main cities of the Province.

National Highway No. 25 runs through the Province from north to south connecting Karachi, Khuzdar, Kalat, Quetta, Chaman and Afghanistan. National Highway No. 50 runs through northern part of the Province connecting NWF Province, Dera Ismail Khan, Zhob and Quetta. National Highway No. 65 connects Sind Province, Sibi and Quetta. Inter-provincial Highway connects Quetta, Nushki, Koh-i-Taftan and Iran. This Highway together with National Highway No. 25 is called RCD (Regional Community Development) Highway.

In the Quetta Area, National Highway No. 25 and 50 bifurcate at Sariab. There are also some provincial roads with asphalt pavement and/or gravel-paved connecting villages in the Area. Unpaved roads are also trafficable except during rainy time (FIG 3.5.1).

A provincial road in the Kalat Area starting from Neemurgh connects the National Highway No. 25 at Mighuzar, running from each to west. There is another road from north to south connecting Chhatti and Karchhap. These roads are partially gravel-paved (FIG 3.5.2).

(2) Transportation Facilities

1) Air Services

Quetta Samungli Airport is located about 10 km northwest from Quetta City. There are daily and weekly air services operated by Pakistan International Airlines. Its flight network connects Quetta to Karachi, Lahore and Islamabad daily and Zhob, Turbat, Sibi, Sukkur, Panjgur and Dera Ismail Khan weekly. An air strip with heli-pads for emergency use in located beside National Highway No. 25, 4 km north from Kalat Town.

2) Railway

Within the Quetta Area, two National Railway lines which bifurcate at Spezand run through. One of them has daily service from Rohri to Quetta which connects Quetta to Lahore or Karachi. The other is Quetta-Zahidan line which connects Quetta twice a week to Zahidan in Iran. Also Quetta-Chaman line originating from Quetta connects Quetta daily to Chaman and Afghanistan.
Freight-ton-kilometer in 1984 - 85 was 254 million ton-km and number of passengers was 11 million in Baluchistan with total railway distance of 1,474 km.

3) Bus Services

Bus services are the main transportation for the people in the Study Area. The long distance buses and mini-buses are plying daily between Quetta City and main cities and towns in the Province. Irregular bus services are operated by private sector between Kalat Town and the Kalat Area through Provincial road.

3.5.4 Electricity Supply and Domestic Water

(1) Electricity Supply

Electricity supply is operated by WAPDA all over Pakistan. According to the master plan for rural electrification prepared by WAPDA, all villages with a population of more than 300 in the Province will be electrified by the middle of 1990. However, due to lack of funds, shortage of generating capacity and other technical problems, only 20% of the villages have been electrified.

The electricity in the Study Area is supplied by 220 kV line from Guddu and 94.35 MVA Thermal Power Station in Quetta through national grid system. Almost all the Quetta Area is covered by the supply line from Sariab Road Grid Station with 2 x 20/26 MVA capacity. In the northern part of the Quetta Area, high-densed feeder line networks have been completed and many well pumps are operated with electricity. On the other hand, in the southern part of the Area, there are three (3) pumping stations for rural water supply scheme and the areas around the stations are only supplied with electricity (FIG 3.5.1.).

The Kalat Area is covered by Kalat Grid Station with 15 MVA capacity. In and around the Area, only two (2) supply lines are running. One is from Kalat Town to Ahmad Abad (Sianzai) and the other from Sianzai to Chhatti. The latter line, however, has not yet been supplied with electricity. In the northern part of the Area, the feeder line from Mangochar Sub-grid Station with 1 x 6 MVA capacity has reached Yusafzai, and one of the branch lines has been extended upto a place 4 km northeast of Dallo village.

Main transmission lines running through the Quetta Area and the secondary transmission line to Kalat Grid Station are supplied with 220 KVA and 132 KVA, respectively. The feeder lines are usually supplied with 11 KVA. Power supply tariff varies with purposes. The lowest unit rate is for irrigation purpose.

(2) Domestic Water

About 30% of population in rural areas are supplied with potable water of 19 to 51 l/day/head. They are mainly supplied by tube wells constructed by I&P Dept. or recently Public Health Engineering Dept. of GOB.

The Quetta Water Supply Project is now in the construction stage with the financial assistance from the Kuwait Fund. This project is to collect groundwater from the Chiltan piedmont and northern part of Quetta City by drilling 24 tube wells and to supply the people of 425,000 in Quetta City with safe water of max. 46,500 m^3/day.

In the northern part of the Quetta Area, most of domestic water is supplied by pumping up the groundwater from open wells or tube wells. Some domestic water is collected from open wells using bucket by manual labor or camel. In the southern part of the Area, basically domestic water is supplied from the open wells. Groundwater is lifted manualy or by camel. Recently, I & P Dept. of the GOB has constructed tube wells at Hassani, Spezand, Kumbela and Pingov villages for the rural water supply. Operation and maintenance of these wells is carried out by I & P Dept. with its own expense. No private in-house tap is installed and village people transport water from communal distribution tanks. Baluchistan Integrated Rural Development Project (financed by UNICEF) and Self Help Project (financed by West Germany) and other agencies are assisting to develop safe water supply for the rural areas.

In the Kalat Area, people use groundwater from open wells lifted by manual labor or irrigation canal water from Dudran spring.

3.5.5 Communication

(1) Postage

There are 37 post offices in Quetta District and 20 in Kalat District. Post offices are sometimes combined with telegraph offices. In the Study Area, there is no post office.

(2) Telephone

National Wide Dialling (NWD) has been established for long distance calls to connect main cities including Quetta and Kalat in addition to Subscribers Trunk Dialling (STD). In the northern part of the Quetta Area, there are a few telephone connections, but there is no telephone connection in the Kalat Area.

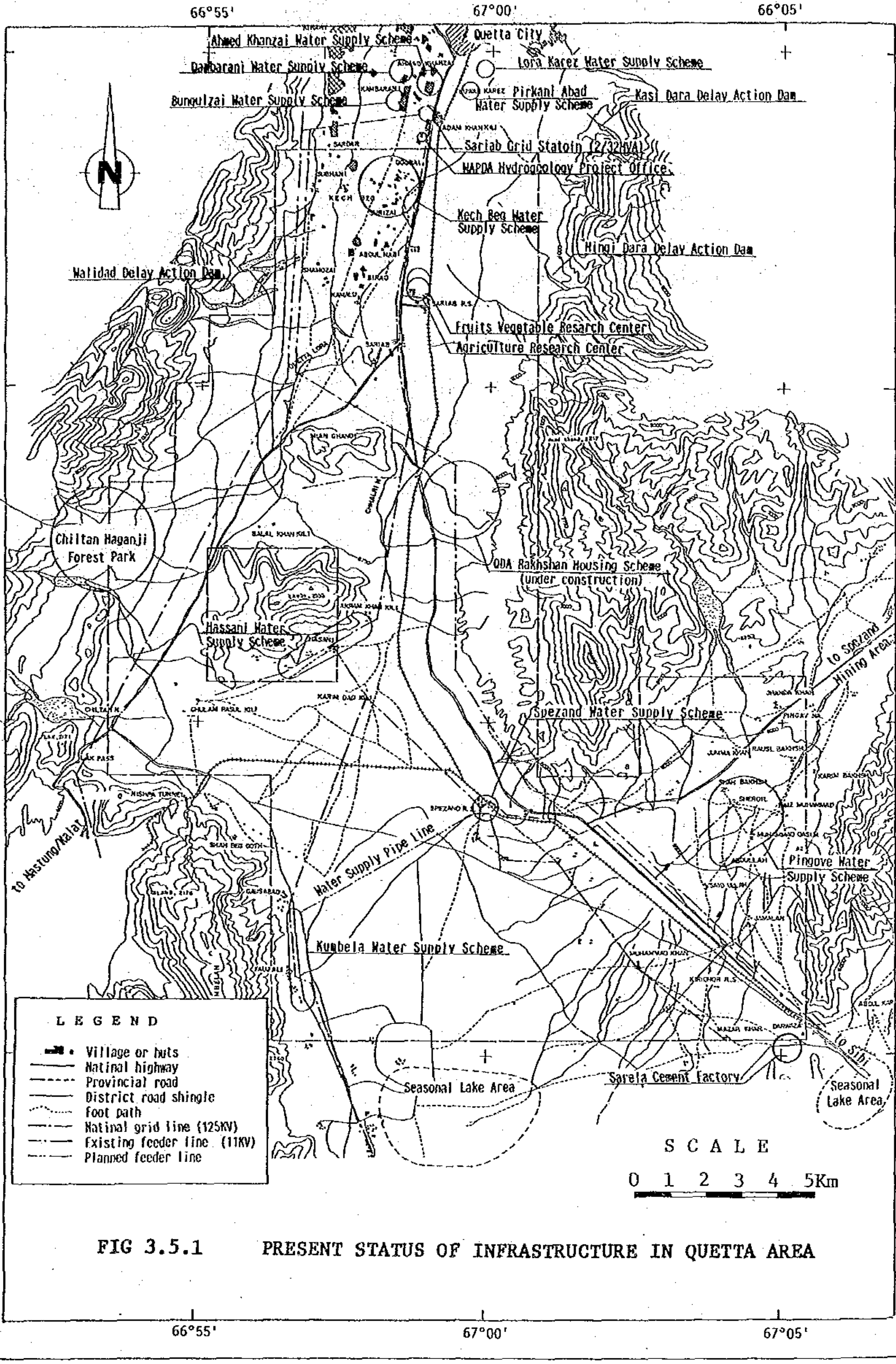


FIG 3.5.1 PRESENT STATUS OF INFRASTRUCTURE IN QUETTA AREA

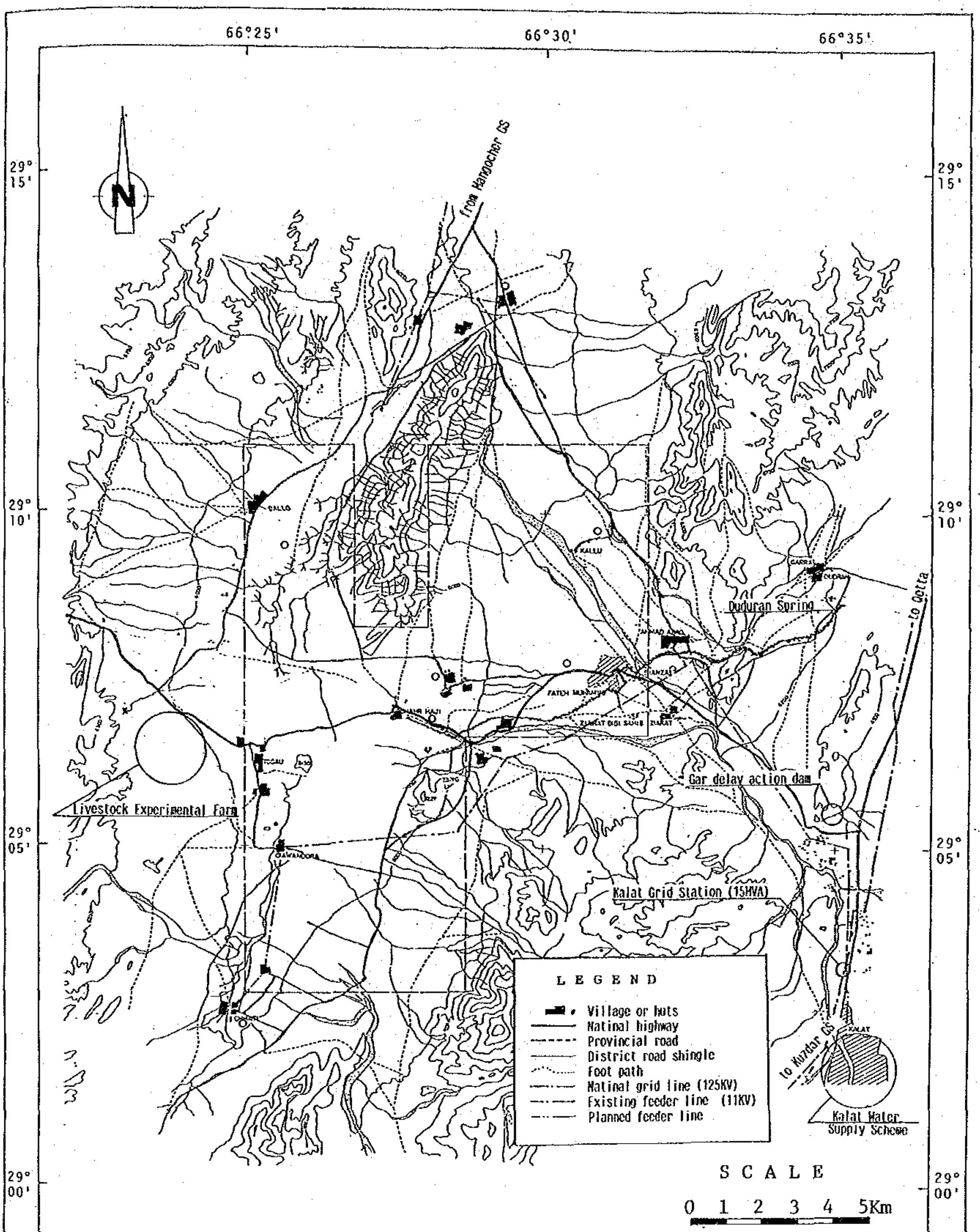


FIG 3.5.2 PRESENT STATUS OF INFRASTRUCTURE IN KALAT AREA

CHAPTER-4 GROUNDWATER RESOURCES

CHAPTER 4 GROUNDWATER RESOURCES

4.1 HYDROGEOLOGY

4.1.1 Previous Surveys and Investigations

There are many survey reports regarding the hydrogeology of the Study Area. The summary of the main reports among them are as follows:

(1) Quetta Area

a. Water Supply of Quette Basin - A.H. Kazmi & S. Qamar Raza, 1970

Domestic and irrigation water has been collected mainly from the groundwater in the Quaternary Formation spread in the lowlands. The spring water from the conglomerate and limestone of the Tertiary Formation in the highlands is also the important water resources. The resports further mention the water balance as follows:

"Around the Quetta City area, the utilization of groundwater may exceed its supply. The future development of groundwater in the area should be made in the areas far from Quetta City and should aim at the fissured veins of the Quaternary Formation."

b. Geophysical Surveys in North Baluchistan - UNDP & WAPDA, 1979

The report mentions that on the basis of electric prospective surveys conducted in and around the Study Area, further development of groundwater will be expected in the areas especially at the foot of mountains excluding the central part of Dasht area where the saline water has been observed.

c. Geohydrology of Quetta Valley - S.A.T. Kazmi, 1973

The detailed survey including 26 test holes (120-360m deep) was conducted. According to the survey, the basement is deep (600m or more) in the northern part of Quetta City. The groundwater is mainly stored in the Quaternary Formation and the groundwater from the basement rock will not be expected. The distribution of groundwater in the Dasht area is complicated and not clear. The groundwater in the southern part of Quetta City is not developed fully. Approx. 95,000 m^3/d of groundwater is not yet used and flowing out of the area.

d. Groundwater Studies in Selected Area of Baluchistan - UNDP, 1982

The groundwater is stored mainly in the Quaternary Formation. The spring water from the conglomerate and limestone of the Tertiary Formation is important even though its content seems to be a few.

e. Quetta Water Supply - Quetta Development Authority, 1983

Eight (8) test holes (183-305m deep) were dug and detailed pumping tests were conducted for five (5) holes out of them. According to water balance study, the recharge of groundwater in the northern part of Quetta City is 136,000 m^3/d and the groundwater being used at present is 86,000 m^3/d. Therefore, there will be surplus groundwater even though the groundwater use through karazes and springs is deducted. Based on the results of the study, the construction of 18 wells in the areas far from Quetta City is planned aiming at the pumping-up of groundwater of 29,000 m^3/d for water supply to Quetta City.

f. Monitoring Studies on Groundwater Levels in Quetta Valley, Baluchistan - WAPDA Hydrogeology, Quetta, Nov. 1986

In order to size the degree of decline of groundwater tables in Quetta Valley, previous observation data and newly observed data are compared. Also the groundwater use for domestic and irrigation are studied. Futhermore, the plan to monitor the groundwater in the valley is proposed. In the groundwater balance study, the recharge and discharge amounts are estimated to be 76 cusec and 91 cusec, respectively.

(2) Kalat Area

a. Internal Hydrogeologic Report No. 3 Kalat Area - WAPDA, 1978

Most of groundwater in the area is collected from the sand/gravel layer of the Quaternary Formation through open wells and limestone layer of the Tertiary Formation through springs.

b. Preliminary Hydrogeological Report No. 4 Kalat Area - UNDP/WAPDA, 1978

Five (5) test holes were dug and they found out the comparatively shallow basement. Two (2) test holes out of five (5) did not get good results of the pumping test.

c. Geophysical Surveys in North Baluchistan - UNDP and WAPDA, 1979

The comprehensive electric prospecting survey conducted in the area shows that the Quaternary Formation is thin in general and that its thickness increases gradually from south to north.

d. Groundwater Studies in Selected Area of Baluchistan - UNDP, 1982

The water balance study shows that there will be surplus groundwater of 13,000-23,000 m^3/d in the area.

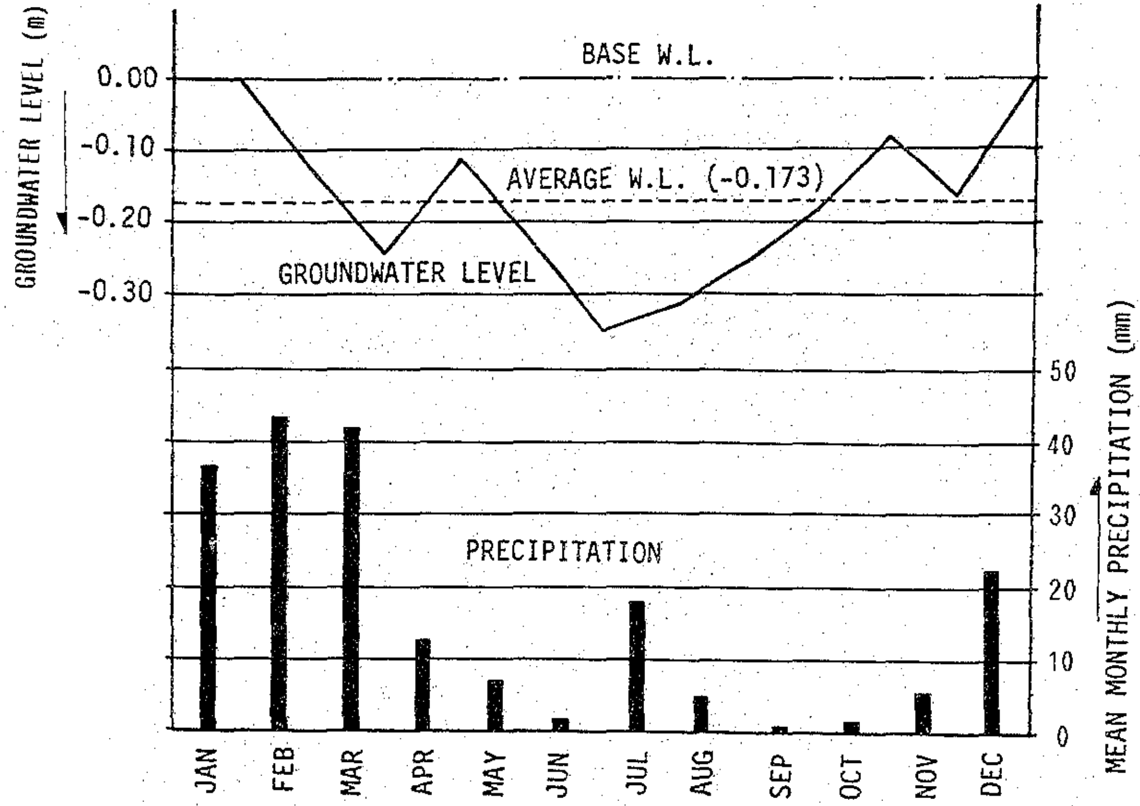
4.1.2 Hydrogeology

The Mesozoic Formation of the Study Area is composed of compacted fine limestone and shale, and is not permeable due to no big openings in the Formation. However, the storage of groundwater in the fissured veins in the fault zones is expected.

The same prospect can be applied for the Tertiary Formation. The limestone layers (Spintangi Nodular limestone for instance) have many fissured veins in some portions and may store much groundwater in them (fissure water).

The Quaternary Formation usually has aquifers because it is not consolidated and porous due to its young age. Especially, gravel zone is permeable and apt to form good aquifers (stratum water). Until now, the groundwater in and around the Study Area has been obtained mainly from the stratum water of the Quaternary Formation.

The observation of the groundwater level is made by the WAPDA Hydrogeology Project. However, no periodical and continuous observation for respective gauging stations is reported in recent years. According to the monthly observation records for two years by UNDP, the groundwater level is high in winter and it goes down by 35 cm in summer (June and July) as shown in FIG 4.1.1.



PERIOD	FLUCTUATION (m)
JAN - FEB	0.00
FEB - MAR	-0.128
MAR - APR	-0.244
APR - MAY	-0.110
MAY - JUN	-0.226
JUN - JUL	-0.348
JUL - AUG	-0.317
AUG - SEP	-0.259
SEP - OCT	-0.189
OCT - NOV	-0.082
NOV - DEC	-0.168
DEC - JAN	0.00
AVERAGE	-0.173

Sources; UNDP Technical Report No.4,1982

FIG 4.1.1 MONTHLY GROUNDWATER FLUCTUATION IN QUETTA BASIN

4.2 PRESENT GROUNDWATER USE

4.2.1 General

The Study Area belongs to the arid zone with annual rainfall of approx. 200 mm. The groundwater is the important water resource due to unavailability of surface water.

The main methods of collection of groundwater are classified into the following three (3) types:

a. Kareze : To collect the underflow water at the foot of the mountains by leading it through tunnel

b. Open Well : To collect the groundwater of 20 - 30 m deep (100 m in some cases) in Quaternary Formation by constructing a well of 2 - 3 m dia. at the lowlands.

c. Tube Well : To collect the deep groundwater (100 - 150 m)

The collection of open well groundwater is made mainly by manual labor or camel. In some cases, it is made with pumps. The spring water is important water resources like Dudran spring in the Kalat Area.

Usually, wells are owned by individuals or firms and operation/maintenance as well as construction is controlled with the expenses from them. Organizations which manage the overall groundwater use are almost none or under poor administrative conditions.

The locations, ownership, purpose and groundwater level for respective wells (excl. Kareze) in the Study Area are shown in APPENDIX 4.2.1.

(1) Quetta Area

Approx. 25 tube wells and approx. 170 open wells exist in the Quetta Area and almost all these wells concentrate in the northern part of the Area which belongs to Quetta Tehsil (FIG 4.2.2).

The northern part of the Area has been rapidly organized due to its advantageous locations adjacent to Quetta City. In the Area, the development of groundwater for irrigation and domestic uses has been progressed by means of open wells or karezes from the ancient times. Recently, many tube wells have been constructed to cope with the increase of population in Quetta City. However, the decrease of groundwater is reported. In the eastern part of the Area, many of karezes constructed around the foot of the Murdar Mountains have been abandoned due to the decrease of groundwater level and poor operation and maintenance of them. The destruction of public roads due to the intrusion of flood water into these abandoned karezes has become a social problem. Three (3) delay action dams were constructed by the Irrigation and Power Department, Government of Baluchistan, in order to recharge the groundwater.

The development of groundwater in the southern part of the Area is delayed. The groundwater which is collected from open wells by manual labor or camel is used only for domestic purpose except at Fauj Ali area in the western part. The following eight (8) tube wells have been constructed recently: three (3) for rural water supply by the Irrigation and Power Dept., GOB, at Hasani, Pingov and Kumbela, three (3) for supplying water to the cement factory which is under construction at the south edge part of the Area and two (2) for irrigation water supply at Fauj Ali. The karezes constructed at Fauj Ali are not used for the same reason as the northern part of the Area.

(2) Kalat Area

The population is small in the Kalat Area and development of groundwater is delayed. A few open wells in respective villages are supplying domestic water to the villagers, totalling 22 wells (FIG 4.2.4). The Dudran spring (ave. discharge: 100 l/sec) located approx. 5 km east of the Area is supplying irrigation water to the field of approx. 200 ha in the eastern part of the Area and also domestic water to the villagers living nearby. There is no kareze in the Area.

Three (3) test wells dug in the Area by UNDP/WAPDA are now filled up with sand and gravel and can not be used. Most of the open wells are 30 - 70 m deep and the excavation into the aquifer is not enough, causing some of them to become dry wells. The lifting of groundwater is made by manual labor or camel. The water quality of wells which are not used often has become worse.

At Gar, east of the Kalat Area, a delay action dam for groundwater recharge has been constructed by the I & P Dept., GOB.

4.2.2 Water Right

At present, there is no argument regarding the groundwater right within the Study Area except northern part of the Quetta Area, because of the scattered hand-dug wells with small amount extraction by manual labor.

Water is principal arbitor of land division and distribution among tribal groups. In such situations, typically a subsection of tribe has its own right to claim the flow or a share of the flow for certain variable period of time. Within the tribal subsection, an individual land owner has claim to a share of the subsection's right with which to irrigate or utilize water in his own land.

If formerly uncultivated land is brought under production in an area where traditional water right exists, tribal sanctions normally dictate the land be divided and distributed to tribal members in proportion to each individual's water share.

If new land is brought under cultivation in an area where no surface water rights exist, there are two patterns of tribally-sanctioned land division;

a. Equally among all nuclear families (parents and children) termed "orbal".

b. Equally among all living males in the tribal subsection regardless of age. Land which is so divided is usually the tribal group's "shamilat", or jointly held undivided land.

Rights governing groundwater that is provided to land with no traditional water rights are of at least two variations:

a. The well principle, i.e., water that is under a land belongs to the land owner.

b. The share principle, i.e., one's water share is in direct proportion to his land holding.

Baluchistan Ordinance No. IX of 1978 entitled "The Baluchistan Ground Water Rights Administration Ordinance, 1978" provides the means for administration in tube well projects except in tribal area. Therefore, this ordinance can not be applied for the tribal area. Though this ordinance has been in force since 1978, there is little evidence that it has been enforced.

4.2.3 Water Balance

(1) Extraction Amount

Within the Study Area, no organization to manage the overall groundwater use at the Village or District level has been established. There is no official well registration. Non-periodical surveys of groundwater use only have been made by WAPDA Hydrogeology Project Office, GSP, etc. independently.

From the viewpoint of the purpose, the groundwater extraction in the Area can be divided into following two categories;

a) domestic water usually extracted from open wells by bucket, and

b) irrigation water usually extracted by pumped open wells or tube wells.

The amount of domestic water is estimated based on the population and number of animals in the Area. Their annual consumption per capita is assumed as follows:

Human	:	7.4 m3/year (= 20 lit./day)
Sheep and goats	:	2.5 m3/year (= 7 lit./day)

The amount of irrigation water is estimated based on the inventories of the existing wells. It is assumed that duration of extraction is 10 hours and that operation days a year are 250 days. Therefore, 28.5% of pump capacity becomes annual extraction amount. No return flow through the feeder canal, farm pond nor other irrigation facilities is considered.

Based on above assumptions, the extraction amount of groundwater in the Area is estimated 7 million and 8 million m3 per year in the Quetta and Kalat Areas as shown in TABLE 4.2.1, respectively.

(2) Water Balance

The source of groundwater is rainfall which infiltrates into ground, flows through it and is stored in its coarse sections. Therefore, the capacity of groundwater in an area is almost in proportion to the acreage of the catchment of the area. Even in the case that the groundwater in the fissured veins is included in the capacity, the above theory practically can also be applied, even though there is a little difference between the actual catchment and the topographical catchment areas.

Most of rainfall infiltrates into the ground through the coarse sediments in the piedmont sections. However, the infiltration of rainfall in the highlands may also be considerable due to the progressed weathering and existence of a number of fissures in those sections. No infiltration of rainfall occurs in the plain sections due to the progressed clay sediment in those sections.

The water balance in respective basins is analysed with the assumed ratio of infiltration of thirty (30)% for piedmont sections and five (5)% for highland sections as shown in TABLE 4.2.2.[1/] The above assumed ratio of infiltration may be reasonable judging from the existing data available.

1/ The previous report in 4.1.1 (1) a. of Chapter 4 describes that the rechange in the Quetta Valley may be about 34% of the total rainfall. If the above assumed ratios are applied in the area, its average ratio becomes 14%.

TABLE 4.2.1 ESTIMATION OF WATER BALANCE

	Topo-graphy	Catch-ment Area (km^2)	Ave. Rain-fall (mm)	Rate of Infiltra-tion (%)	Possible Recharge (m^3/d)	Estimated Discharge (m^3/d)	Balance (m^3/d)
Quetta Area							
Veins A,B,C	Piedmont Highland	77 68	162 1/ 162	30 5	11,762	18,753	-6,991
Vein D	Piedmont Highland	33 55	135 2/ 135	30 5	4,679	47	4,632
Vein E	Piedmont Highland	107 202	148 3/ 148	30 5	17,111	258	16,853
Kalat Area							
Veins A,C (Western part)	Piedmont Highland	348 404	193 3/ 193	30 5	65,884	1,233	64,651
Veins A,B (Eastern part)	Piedmont Highland	400 587	193 4/ 193	30 5	78,971	21,142	57,829

1/ Sariab Station
2/ Spezand Station
3/ Average of 1/ and 2/
4/ Kalat Station

The result of the analysis shows the following:

a. The balance in the northern part of the Quetta Area is minus and there will be no more allowance for future groundwater development;

b. There will be still big allowance in Vein D of the Quetta Area (1% is used);

c. Big allowance will also exist in Vein E of the Quetta Area (1.5% is used); and

d. There will be still big allowance in the Kalat Area (2% and 27% are used in western and eastern part, respectively).

4.2.4 Groundwater Quality

Sixty five (65) groundwater samples in total from the existing wells in the Quetta Area and twenty seven (27) in the Kalat Area were analysed by WAPDA and JICA Study Team during the period of 1976 to 1987.

The average values of EC (electric conductivity), pH and SAR (sodium adsorption ratio) in each area are summarized in TABLE 4.2.2.

TABLE 4.2.2 WATER QUALITY OF STUDY AREA

Area	EC (S/cm)	pH	SAR
Quetta, Northern Part	905	8.2	2.2
Quetta, Southern Part	1,280 (895)1/	7.9	6.6 (2.0)1/
Kalat	1,175	7.5	3.0

1/ Show the values in the case that the values of HS-3,4 & 5 which show extremely high EC are excluded.

The groundwater quality varies seasonally and annually, in general. The deterioration of its quality in the northern part of the Quetta Area is reported in the report "Monitoring Studies on Groundwater Levels in Quetta Valley, 1986". It may be caused by the over-extraction of groundwater which accelerates the intrusion of highly mineralized surface water into the ground.

In Spezand, the southern part of the Quetta Area, where thick fine alluvial layer is developed, the existence of high-saline groundwater is confirmed. A tube well in Spezand drilled by I & P Department of GOB aiming to supply safe water to the area was abandoned because of its high salinity. Also high-saline water appears in the Murdar piedmont slope near Hassani village. These two areas are located near the bottom of the closed drainage area of Dasht-i-Khuni.

The quality of the groundwater in the Kalat Area is moderate but comparatively high saline than that of the Quetta Area. High saline water exists reportedly at the upper stream of the Dasht-i-Goran.

The highly mineralized water is of sodium chloride or sodium sulphate. While medium to low mineralized water is of sodium bicarbonate or magnesium bicarbonate.

According to the Department of Agriculture, Baluchistan, the water quality for irrigation is classified into three (3) classes (TABLE 4.2.3), and the groundwater in the Study Area can be defined as Class II water. On the other hand, according to the USDA Salinity Laboratory's Grouping, these groundwaters are defined as C3-S1, which states as follows: "These water cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected. However, the water can be used on almost all soils with little danger. Sodium-sensitive crops such as stone-fruit trees and avocados may accumulate injurious concentrations of sodium" (FIG 4.2.3).

TABLE 4.2.3 CLASSIFICATION OF IRRIGATION WATER BY DEPARTMENT OF AGRICULTURE BALUCHISTAN

Ingredient	Class I	Class II	Class III
TSS (ppm)	Less than 700	700 to 1,200	More than 1,200
pH	Upto 7.8	7.8 to 8.2	Above 8.2
CO_3 (ppm)	Upto 100	100 to 130	Above 130
HCO_3 (ppm)	Upto 120	120 to 150	Above 150
SO_4 (ppm)	Upto 200	200 to 500	Above 500
Cl (ppm)	Upto 20	20 to 40	Above 40
Na (%)	Less than 20	20 to 60	Above 60
Boron (ppm)	Upto 0.5	0.5 to 2.5	Above 2.5

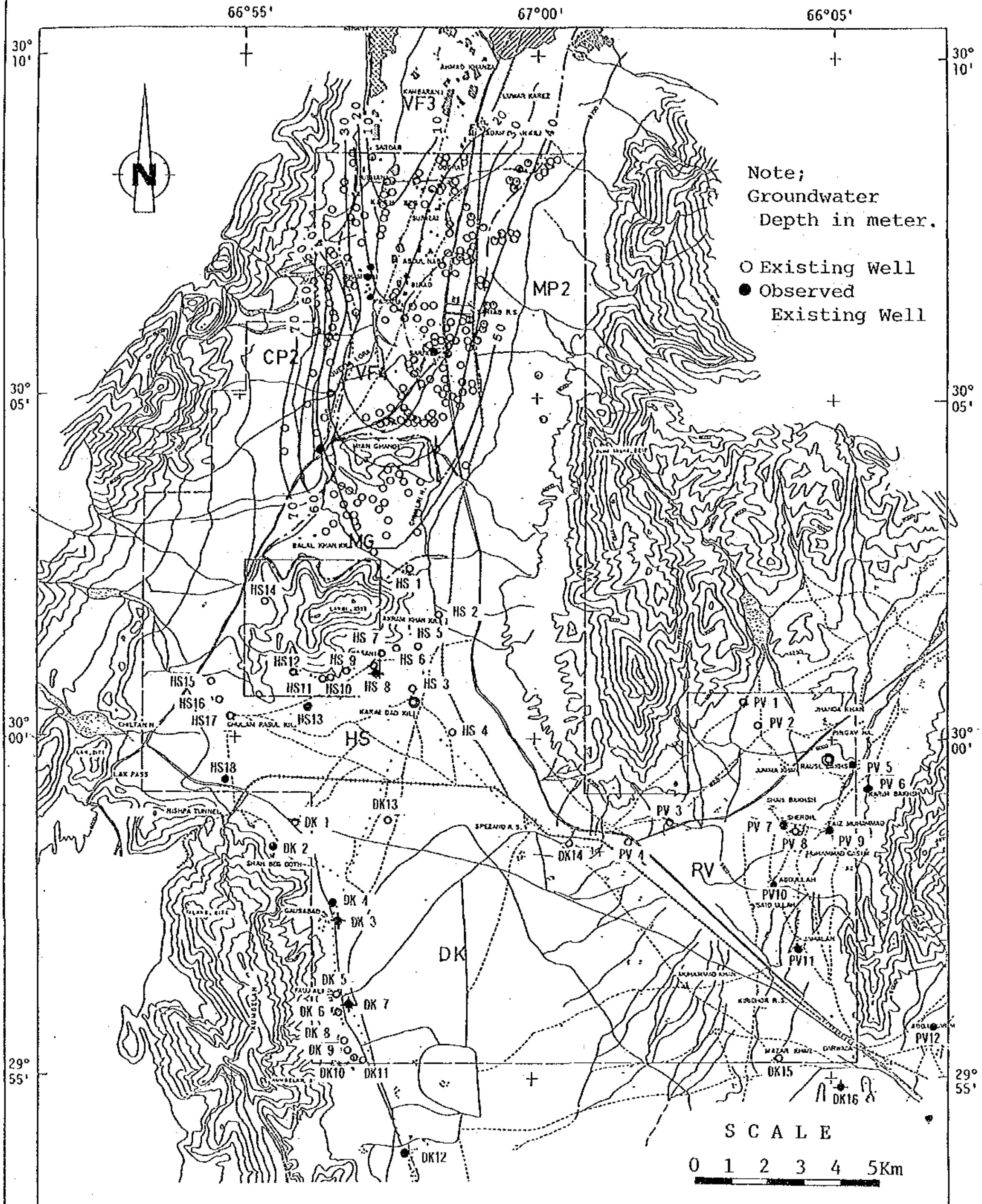
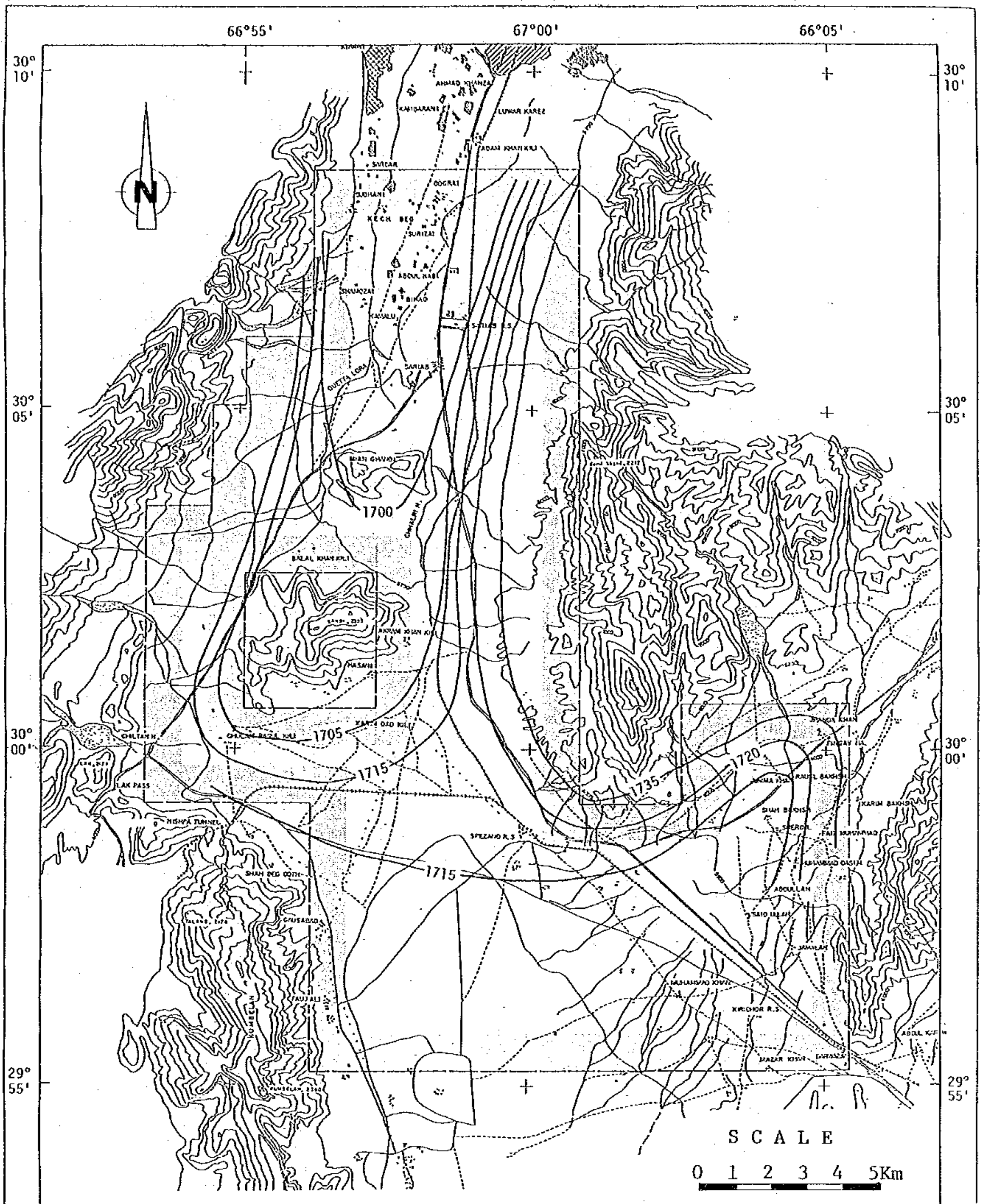


FIG 4.2.1 EXISTING WELLS AND GROUNDWATER DEPTH IN QUETTA AREA

Sources: WAPDA, Monitoring Studies on Groundwater in Quetta Valley, 1986.
WAPDA, Geohydrology of Quetta Valley, 1973.



Altitude in meter

FIG 4.2.2 **ALTITUDE OF GROUNDWATER SURFACE IN QUETTA AREA**

Sources: WAPDA, Monitoring Studies on Groundwater in Quetta Vally, 1986.
WAPDA, Geohydrology of Quetta Valley, 1973.

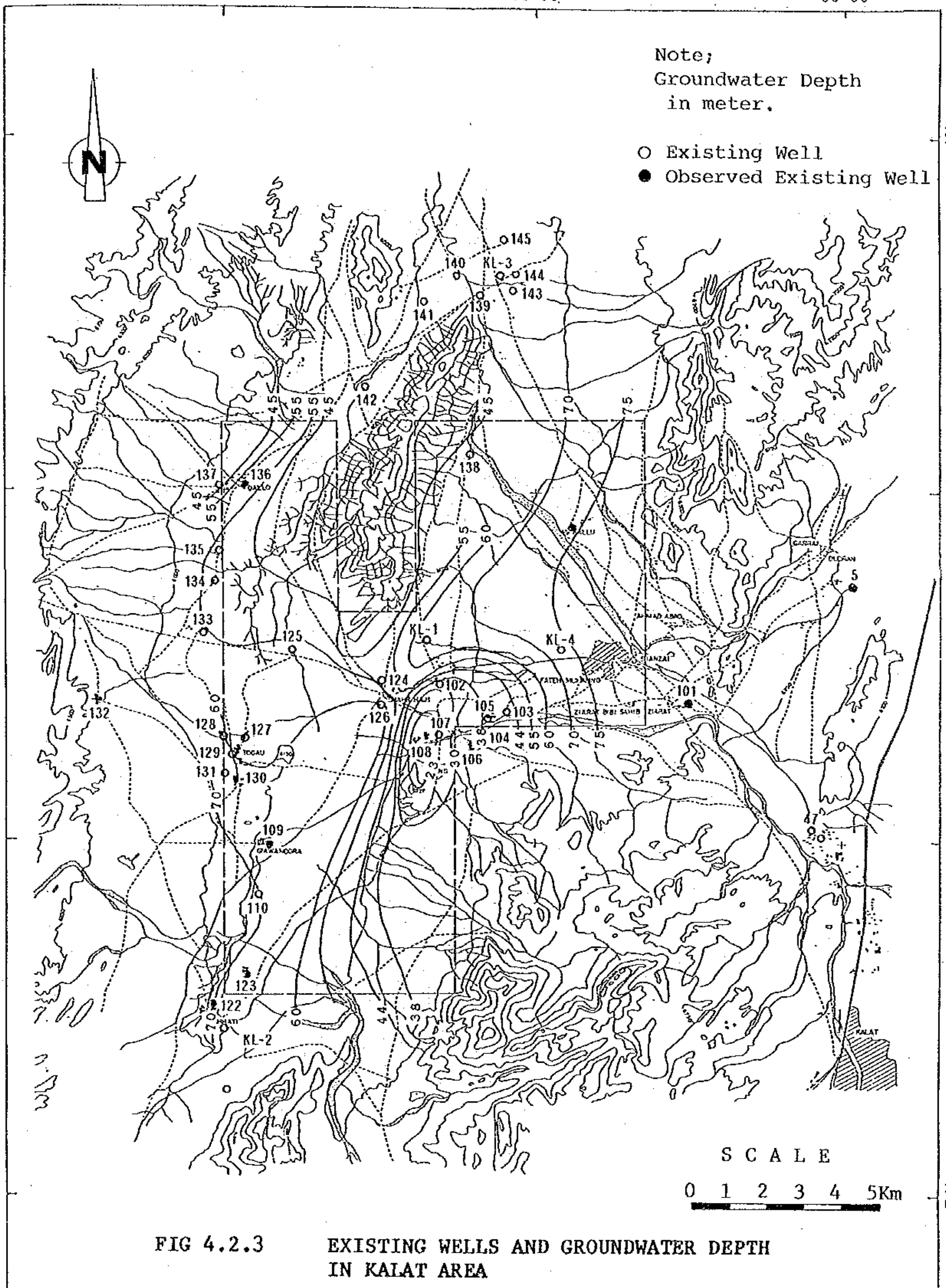


FIG 4.2.3 EXISTING WELLS AND GROUNDWATER DEPTH IN KALAT AREA

Sources: WAPDA, Internal Hydrogeologic Report No.3 Reconnaissance Survey-Kalat Area, Shirinab-Pishin, 1978.

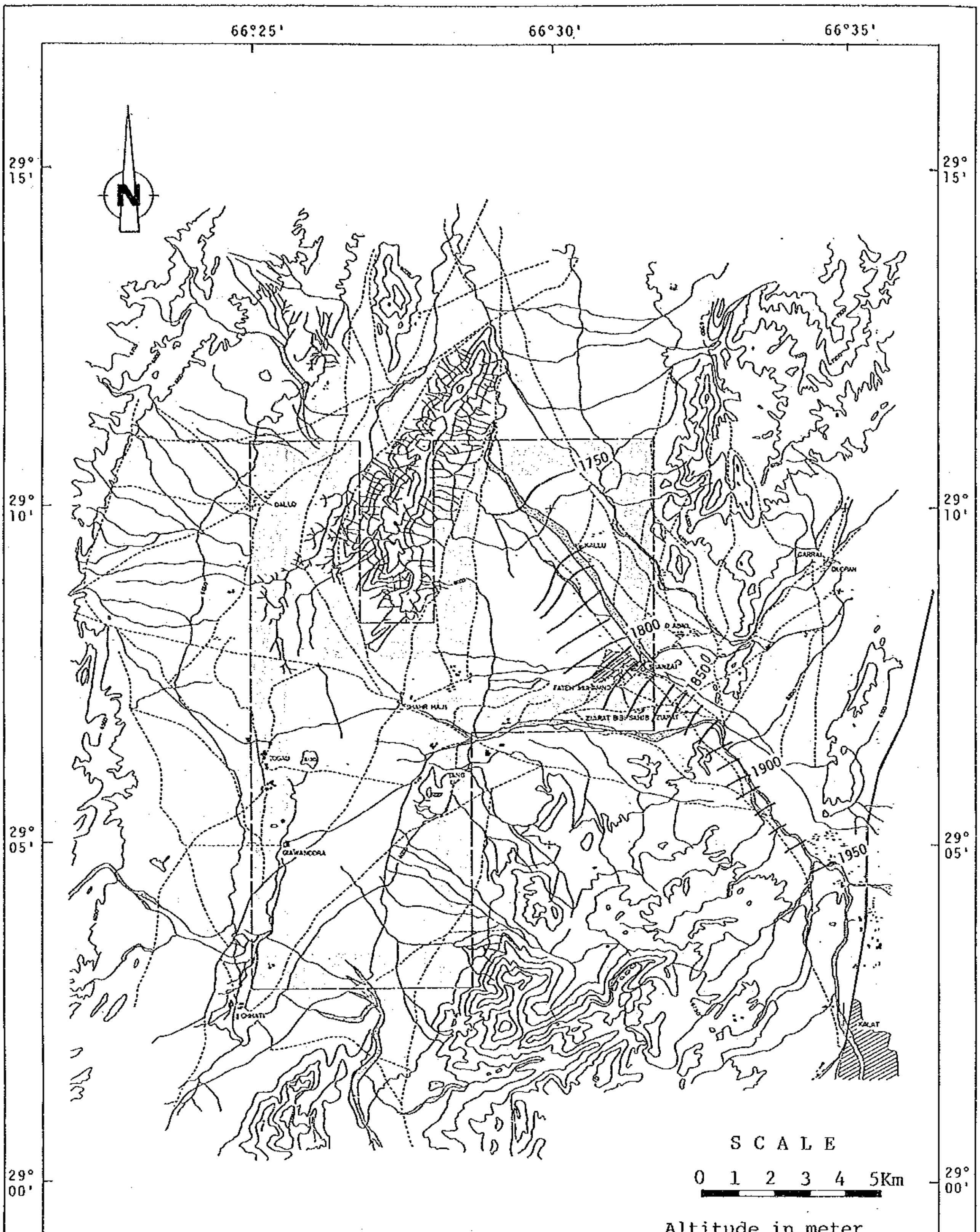


FIG 4.2.4 ALTITUDE OF GROUNDWATER SURFACE IN KALAT AREA

Sources: UNDP/WAPDA, Preliminary Hydrogeological Report No.4 Kalat Area, shirinab-Pishin Basin, 1978.

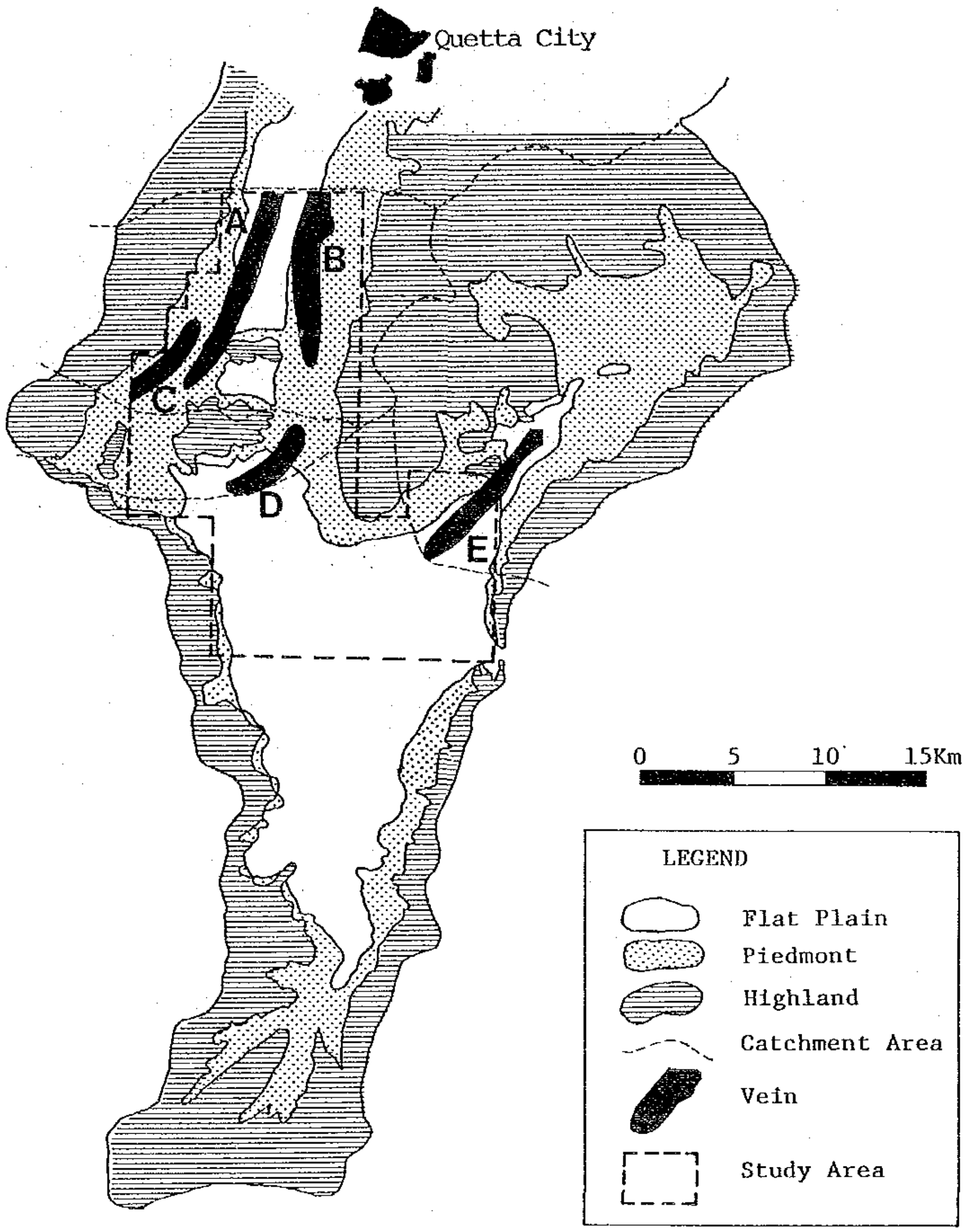


FIG 4.2.5 PHYSIOGRAPHY OF QUETTA AREA

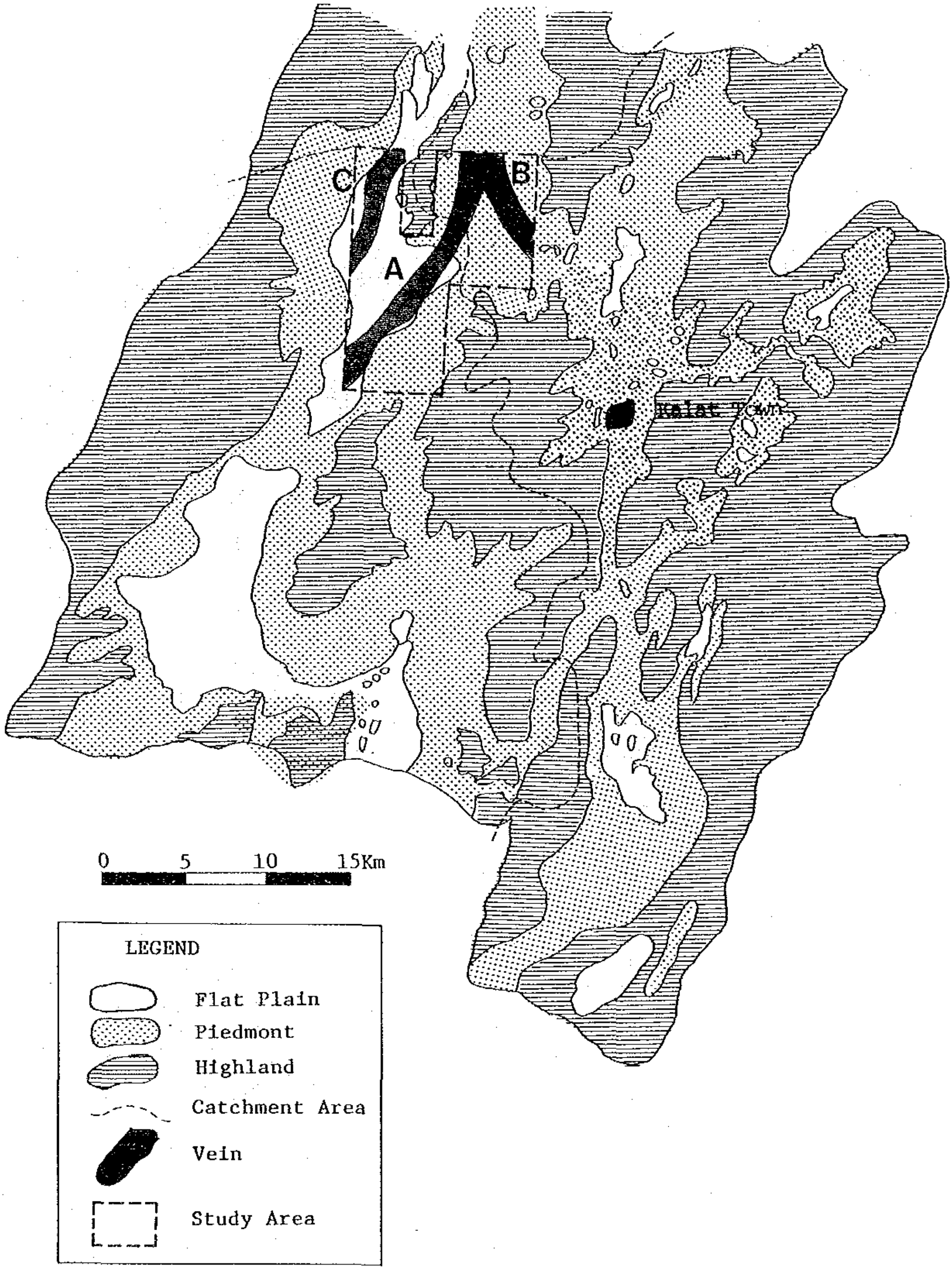
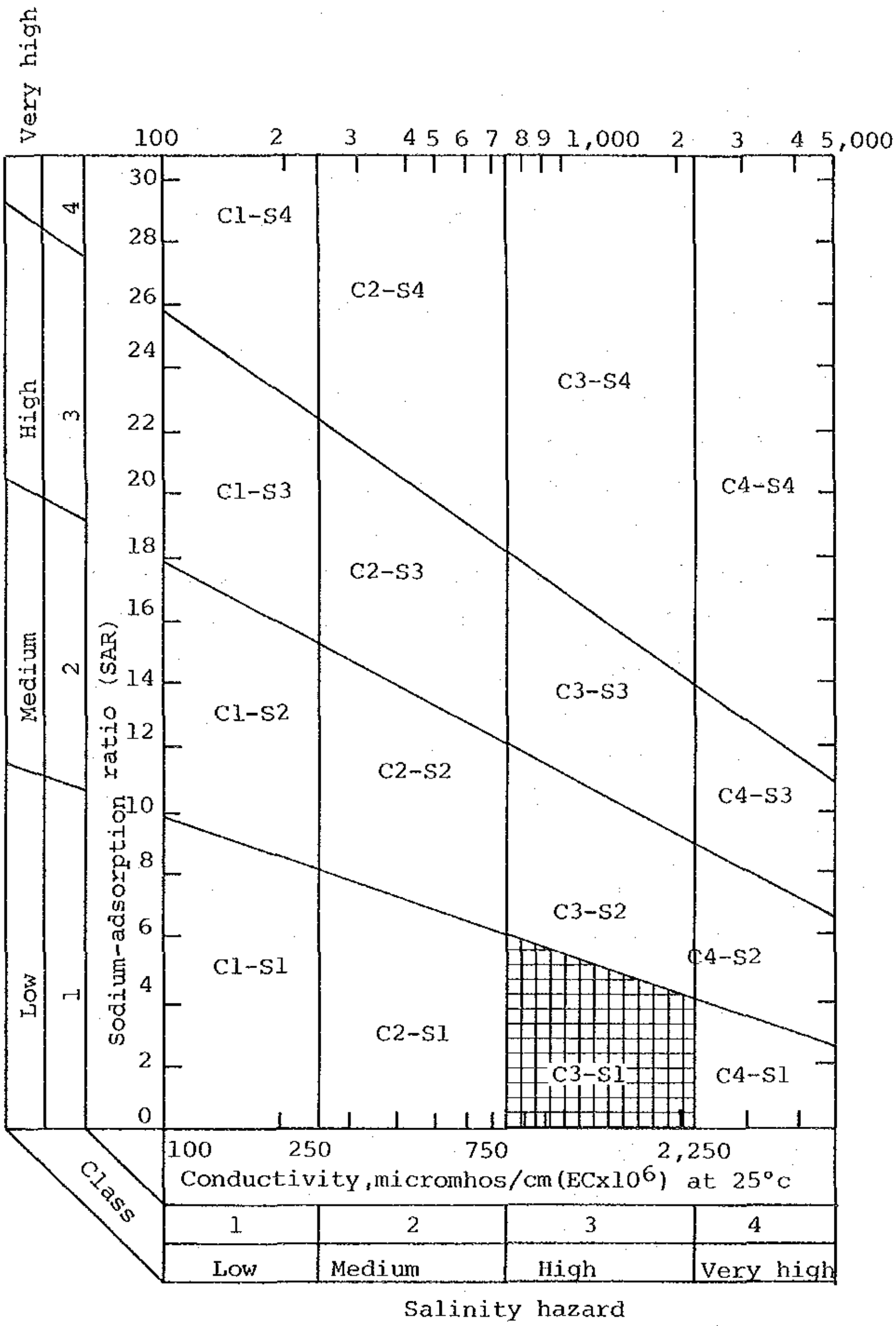


FIG 4.2.6 PHYSIOGRAPHY OF KALAT AREA



Source : USAD Salinity Lab. Handbook 60

FIG 4.2.7 DIAGRAM FOR THE CLASSIFICATION OF IRRIGATION WATER

4.3 HELI-BORNE AERIAL GAMMA-RAY SPECTRO PROSPECTING

(Refer to Volume III: Aerial Gamma-ray Spectro Prospecting for detail)

4.3.1 General

The groundwater investigation in the Study Area was conducted mainly by the heli-borne aerial gamma-ray spectro prospecting.

The aerial gamma-ray prospecting method and its support systems used in this survey are covered by Japanese Patents. The detection of intensity of gamma-rays is made by use of two detector packages and one detector unit. The function of two detector packages is to catch all the gamma-rays emitted from underground and also in the air. On the other hand, the function of one detector unit is to catch only the surrounding gamma-rays in the air. With the combination of these detectors of two different types, the detection of gamma-rays only from the fissured veins becomes possible by removing the effects of surrounding gamma-rays in the air such as cosmic rays that disturb its detection (FIGs 4.3.1 and 4.3.2).

The survey work at the site was conducted from September to October 1986 on the following conditions:

a. The prospecting lines are to be 1,000 m meshes (FIGs 4.3.3 and 4.3.4).

b. Quetta Area (28,000 ha) and Kalat Area (12,000 ha) are divided into 9 blocks and 4 blocks, respectively in consideration of the hectarage of the area to be surveyed a day.

c. The flight height is to be 100 m above the ground surface.

d. The flight speed is to be 90 km/hr.

e. The intensity of gamma-ray to be mainly prospected is to be 609 KeV due to its strong correlation with the groundwater vein/zone.

f. The radon and tritium of groundwater of the existing wells are to be analysed in order to make clear the movement and storage conditions of groundwater veins/zones.

4.3.2 Results of Prospecting

The fissured groundwater veins and zones have been detected by confirming prospecting lines, correcting flight height of helicopter, numerically analysing the analogue data and analysing the radon/tritium data of groundwater samples.

In the Quetta Area, four (4) moving groundwater veins (A, B, C and E) have been detected. Veins A and B are located on both sides of Quetta Valley and the groundwaters are flowing in the direction to Quetta City. Vein C is situated at the end portion of Vein A and Vein E is along the Zarakhu Nala. In addition to these veins, there are ten(10) stagnant groundwater zones (FIG 4.3.5).

In the Kalat Area, three (3) moving groundwater (veins A, B and C) have been detected. Vein A runs through the central part of the Area and meets with Vein B at the northern part of the Area. Vein C is located at the western side of Mt. Chhappai. The groundwater flow of all these veins is to the north. Additionally, there are two (2) stagnant groundwater zones on both sides of Vein A (FIG 4.3.6).

The widths of detected groundwater veins are 400 - 1,400 m and 600 - 1,300 m in the Quetta and Kalat Areas, respectively.

The specific capacities of respective veins are estimated as 40 - 70 m^3/day/m in the Quetta Area and 130 - 150 m^3/day/m in the Kalat Area based on the detected intensity of gamma-ray (FIGs 4.3.5 and 4.3.6).

4.3.3 Estimation of Possible Yield of Groundwater

(1) General

Through the survey conducted, the distribution of moving groundwater veins and stagnant groundwater zones has become clear. The possible yield of groundwater is estimated based on the detected moving and stagnant groundwaters respectively.

The possible yield of moving groundwater is determined to be 80% of flow capacity of groundwater. The flow capacity can be estimated on the basis of the results of aerial gamma-ray spectro prospecting and existing data on groundwater table and transmissibility.

On the other hand, the possible yield of stagnant groundwater is estimated on the basis of the estimated specific capacities in respective groundwater zones.

(2) Possible Yield of Groundwater

The possible yields of moving groundwater are estimated to be 17,730 m^3/day (153.2 l/sec) and 13,470 m^3/day (116.4 l/sec) in the Quetta Area and the Kalat Area, respectively (TABLE 4.3.1). On the other hand, those of stagnant groundwater are estimated to be 7,880 m^3/day (68.1 l/sec) and 3,880 m^3/day (33.5 l/sec) in the Quetta Area and the Kalat Area, respectively (TABLE 4.3.2).

TABLE 4.3.1 POSSIBLE YIELD OF MOVING GROUNDWATER

(QUETTA AREA)

VEIN NAME	VEIN LENGTH IN STUDY AREA (km)	VEIN WIDTH UPST.-DWST. (m)	GROUNDWATER HYDRAULIC GRADIENT	TRANSMISSIBITY COEFFOCIENT (m2/d)	GROUNDWATER FLOW CAPACITY (m3/d)	AVERAGE SPECIFIC CAPACITY (m3/d/m)	POSSIBLE YIELD (m3/d)
A	11.5	500 - 700	1 / 66	582	5,380	51	4,310
B	9.0	500 - 1,400	1 / 265	486	2,480	43	1,980
C	6.0	500 - 800	1 / 46	396	6,650	37	5,320
E	6.5	400 - 550	1 / 46	707	7,650	74	6,120
TOTAL							17,730

(KALAT AREA)

VEIN NAME	VEIN LENGTH IN STUDY AREA (km)	VEIN WIDTH UPST.-DWST. (m)	GROUNDWATER HYDRAULIC GRADIENT	TRANSMISSIVITY COEFFICIENT (m2/d)	GROUNDWATER FLOW CAPACITY (m3/d)	AVERAGE SPECIFIC CAPACITY (m3/d/m)	POSSIBLE YIELD (m3/d)
A	17.5	700 - 1,300	1 / 372	700	2,430	141	1,940
B	6.0	750 - 1,000	1 / 53	610	9,260	132	7,410
C	7.0	600 - 1,100	1 / 106	678	5,150	150	4,120
TOTAL							13,470

TABLE 4.3.2 POSSIBLE YIELD OF STAGNANT GROUNDWATER

Quetta Area

Zone Name	Area	Average Specific Capacity	Number of Pumping Point	Total Specific Capacity	Possible Yield from Groundwater Development 1/
	(km^2)	($m^3/d/m$)		($m^3/d/m$)	(m^3/d)
D	5.6	69	6	414	4,140
F	2.0	35	2	70	700
G	1.1	33	1	33	330
H	0.9	35	1	35	350
I	1.9	29	2	58	580
J	1.2	23	1	23	230
K	0.4	33	1	33	330
L	0.4	34	1	34	340
M	1.5	30	2	60	600
N	0.8	28	1	28	280
Total					7,880

Kalat Area

Zone Name	Area	Average Specific Capacity	Number of Pumping Point	Total Specific Capacity	Possible Yield from Groundwater Development 1/
	(km^2)	($m^3/d/m$)		($m^3/d/m$)	(m^3/d)
D	3.1	51	3	153	1,530
E	4.7	47	5	235	2,350
Total					3,880

Note: 1/ The permissible critical groundwater drawdown of 10 m is adopted in the estimation.

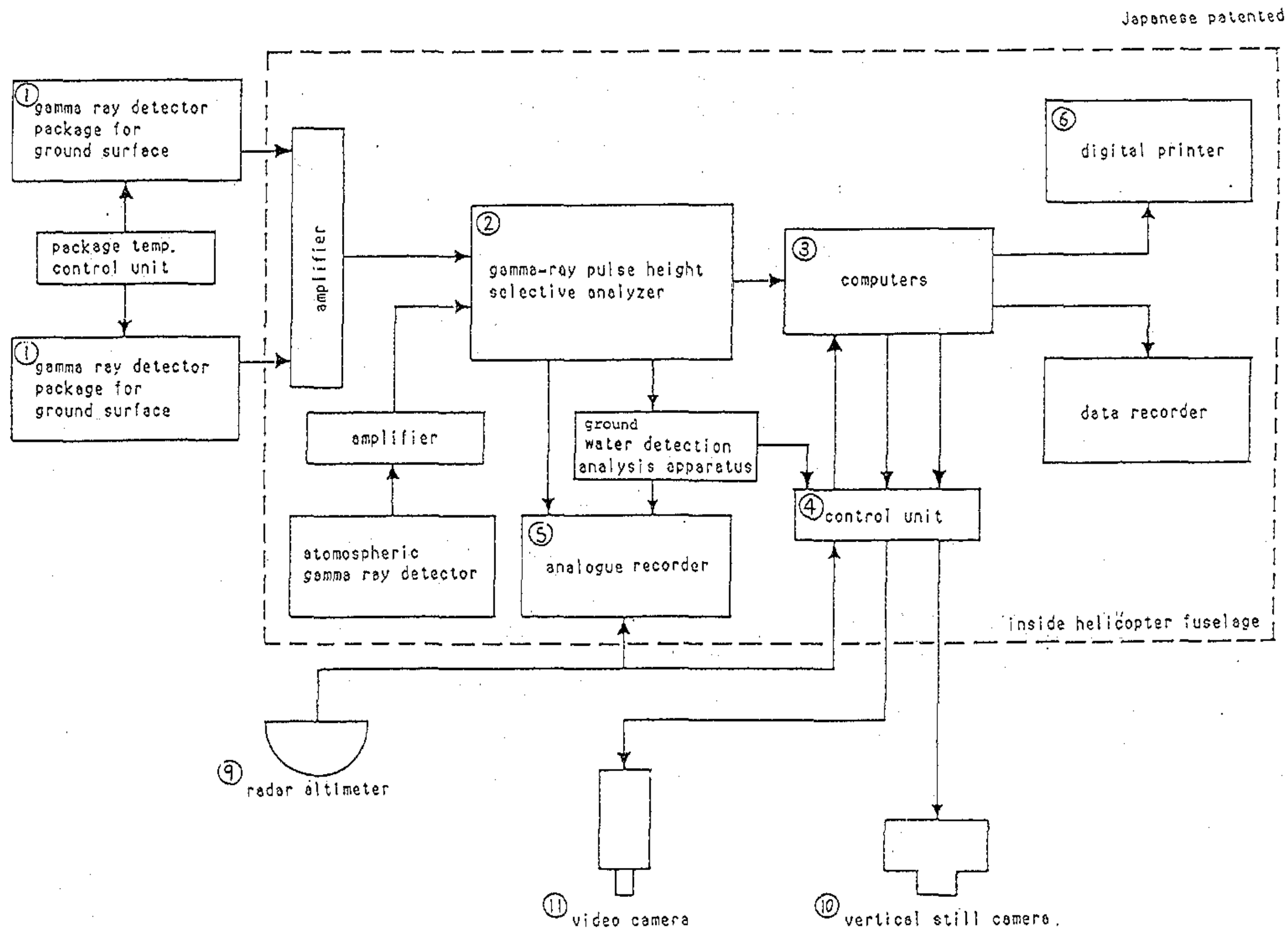
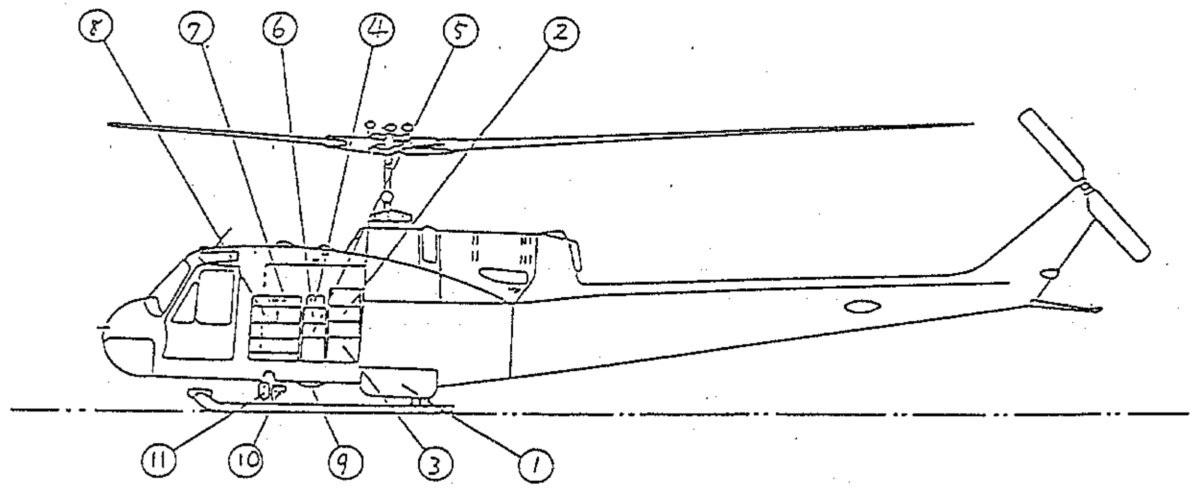


FIG 4.3.1 SYSTEM DIAGRAM OF HELI-BORNE AERIAL GAMMA-RAY SPECTRO PROSPECTING



① Gamma ray detector package
② Gamma ray pulse height selective analyzer
③ Computers
④ Computer controler
⑤ Analogue recorder
⑥ Digital printer
⑦ Video recorder
⑧ Video monitor
⑨ Radar altimeter
⑩ Vertical still camera
⑪ Vertical video camera

FIG 4.3.2 INSTRUMENTATION OF HELI-BORNE AERIAL GAMMA-RAY SPECTRO PROSPECTING

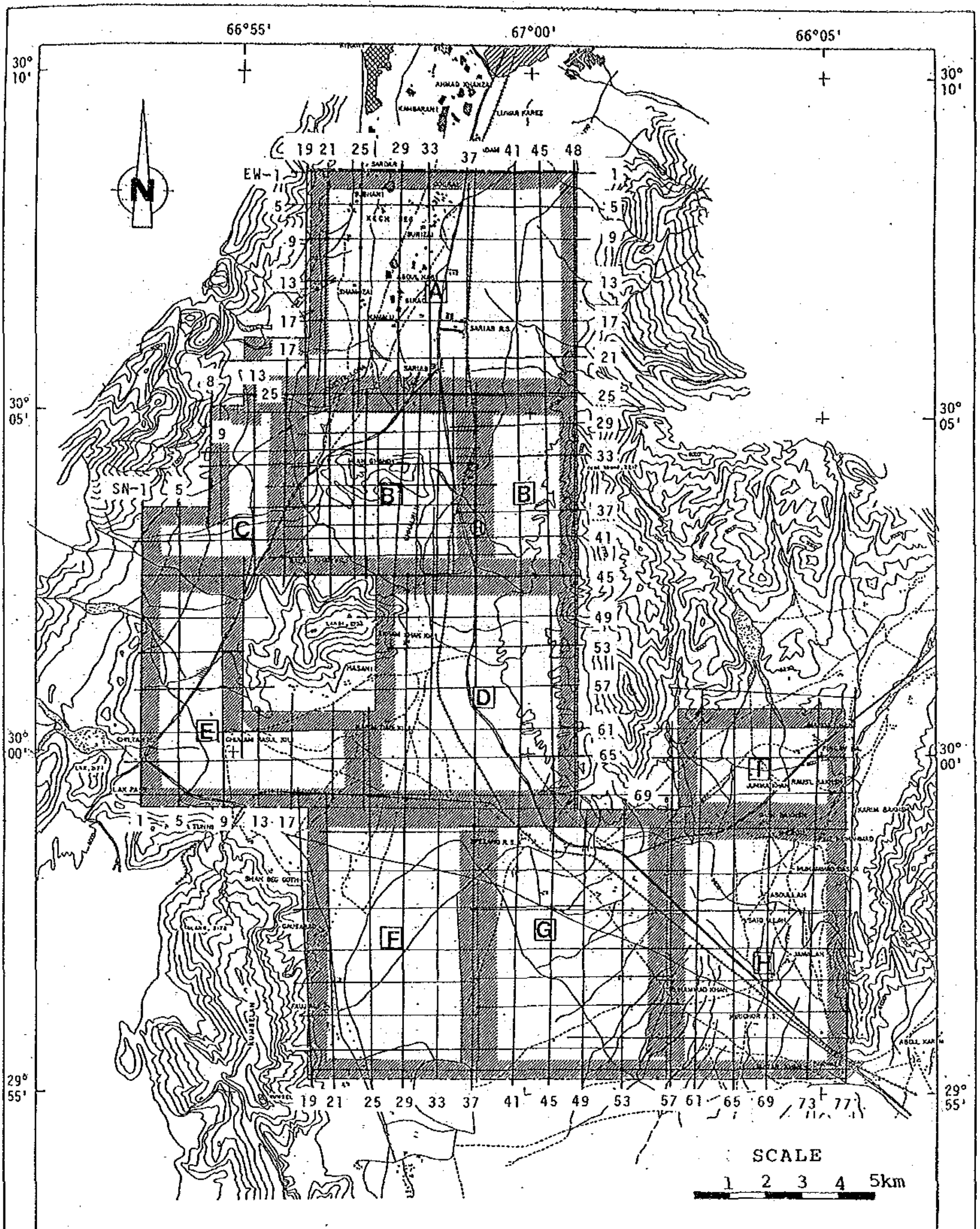


FIG 4.3.3 PROSPECTING LINE AND BLOCKING IN QUETTA AREA

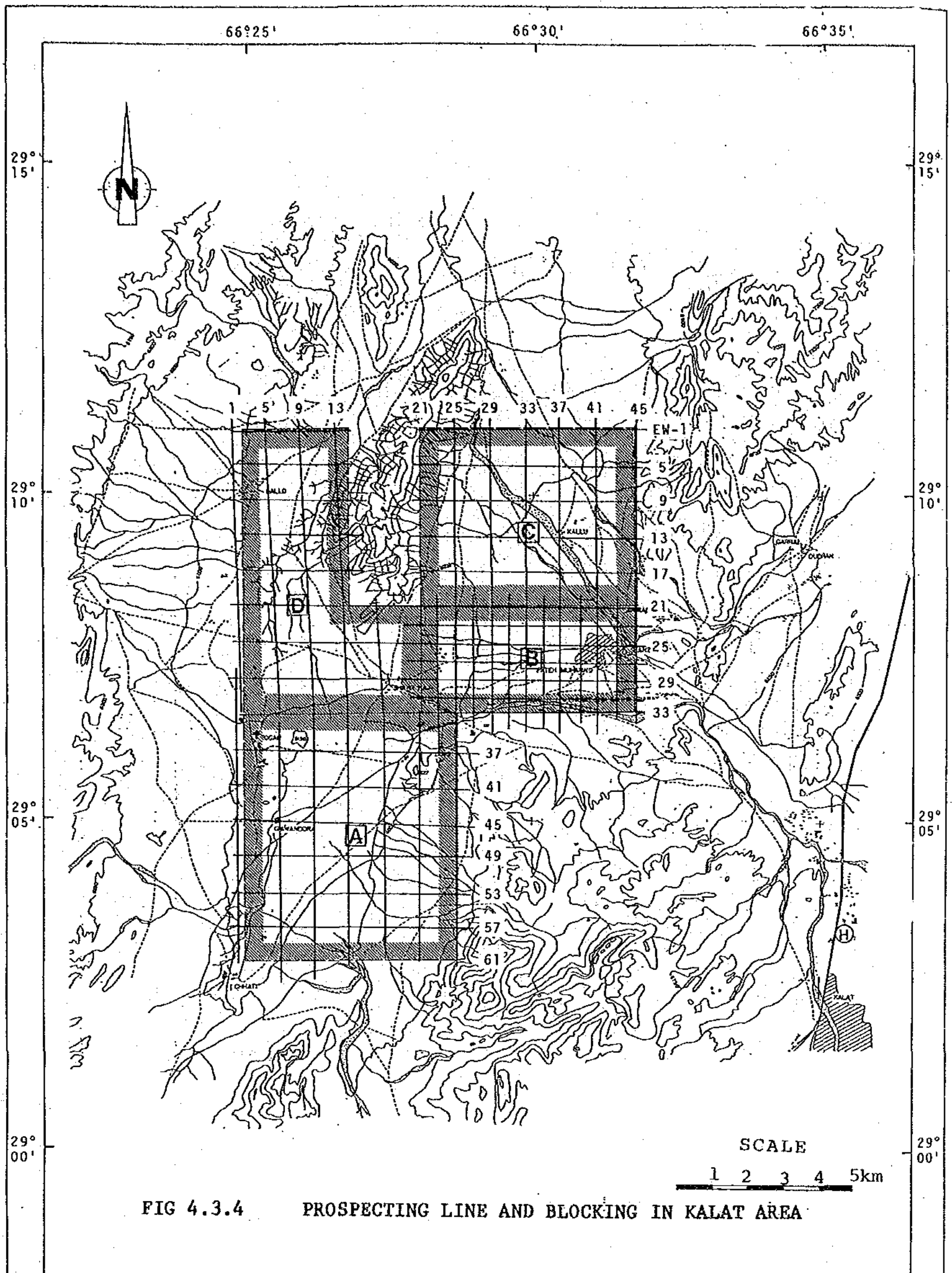


FIG 4.3.4 PROSPECTING LINE AND BLOCKING IN KALAT AREA

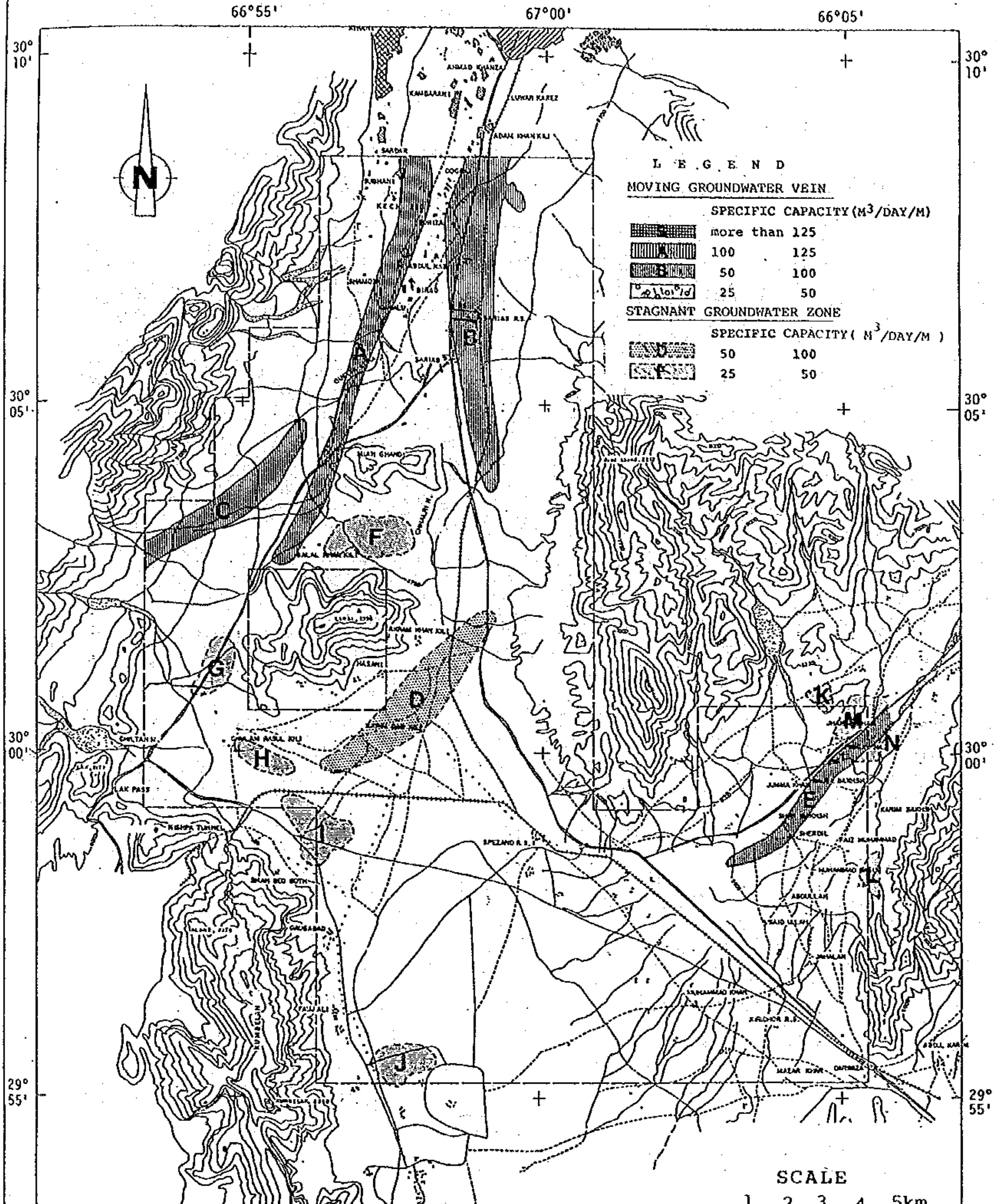


FIG 4.3.5 FISSURED GROUNDWATER VEIN ZONE DISTRIBUTION IN QUETTA AREA

66°55' 67°00' 67°05'

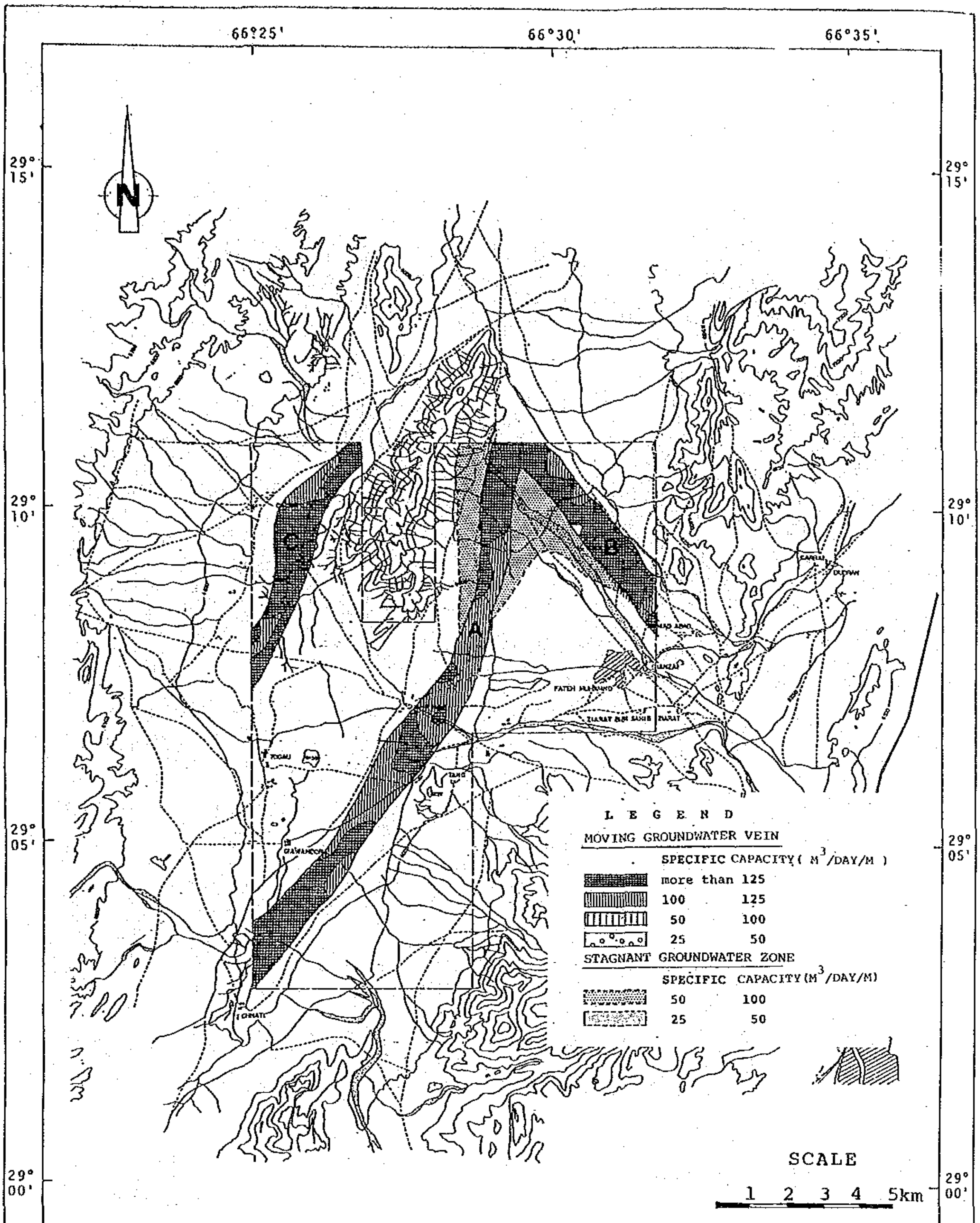


FIG 4.3.6 FISSURED GROUNDWATER VEIN ZONE DISTRIBUTION IN KALAT AREA

4.4 SEISMIC PROSPECTING

(Refer to VOLUME II: Appendices for detail)

4.4.1 General

In order to verify the depth of basement at the sites that had been roughly detected to have the high potentiality for groundwater development through field aerial gamma-ray prospecting, the seismic prospecting was conducted from November to December 1986 with the following procedures:

a. Method: Refraction method

b. Survey Line (FIGs 4.4.1 and 4.4.2)

- Quetta A-Line : 2,200 m
- " B-Line : 1,500 m
- Kalat Line : 2,300 m

c. Dynamite : WABOX 80% - 200 kg

Detonator : No 8 - 500 pcs

4.4.2 Results of Prospecting

(1) Quetta A-Line

Based on the seismic velocities analysed, the geological section is divided into 5 layers. Layers 1 to 4 are included in the unconsolidated Quaternary Formation and Layer 5 is the base rock of Chiltan limestone of Mesozoic Formation. The depth up to the base rock is approx. 200 - 250 m.

(2) Quetta B-Line

The geological section is divided into 4 layers. Layers 1 to 3 are included in the unconsolidated Quaternary Formation and Layer 4 is the base rock of Tertiary or Mesozoic Formation. The seismic velocity in the base rock is generally high but the low-value results of velocities shown in the base rock may be due to the fact that the base rock is composed of

Tertiary Formation of comparatively young age or there exists weathered or fissured rock zone. The estimated depth up to the base rock is 150m.

(3) Kalat Line

The geological section is divided into 4 layers. Layers 1 to 3 are included in the unconsolidated Quaternary Formation and Layer 4 is the base rock of Tertiary or Mesozoic Formation. The seismic velocity in the base rock is generally high but the low-value results of velocities shown in the base rock may be due to the fact that the base rock is composed of Tertiary Formation of comparatively young age or there exists weathered or fissured rock zone. The depth up to the base rock is comparatively shallow; 70 m around the deep section.

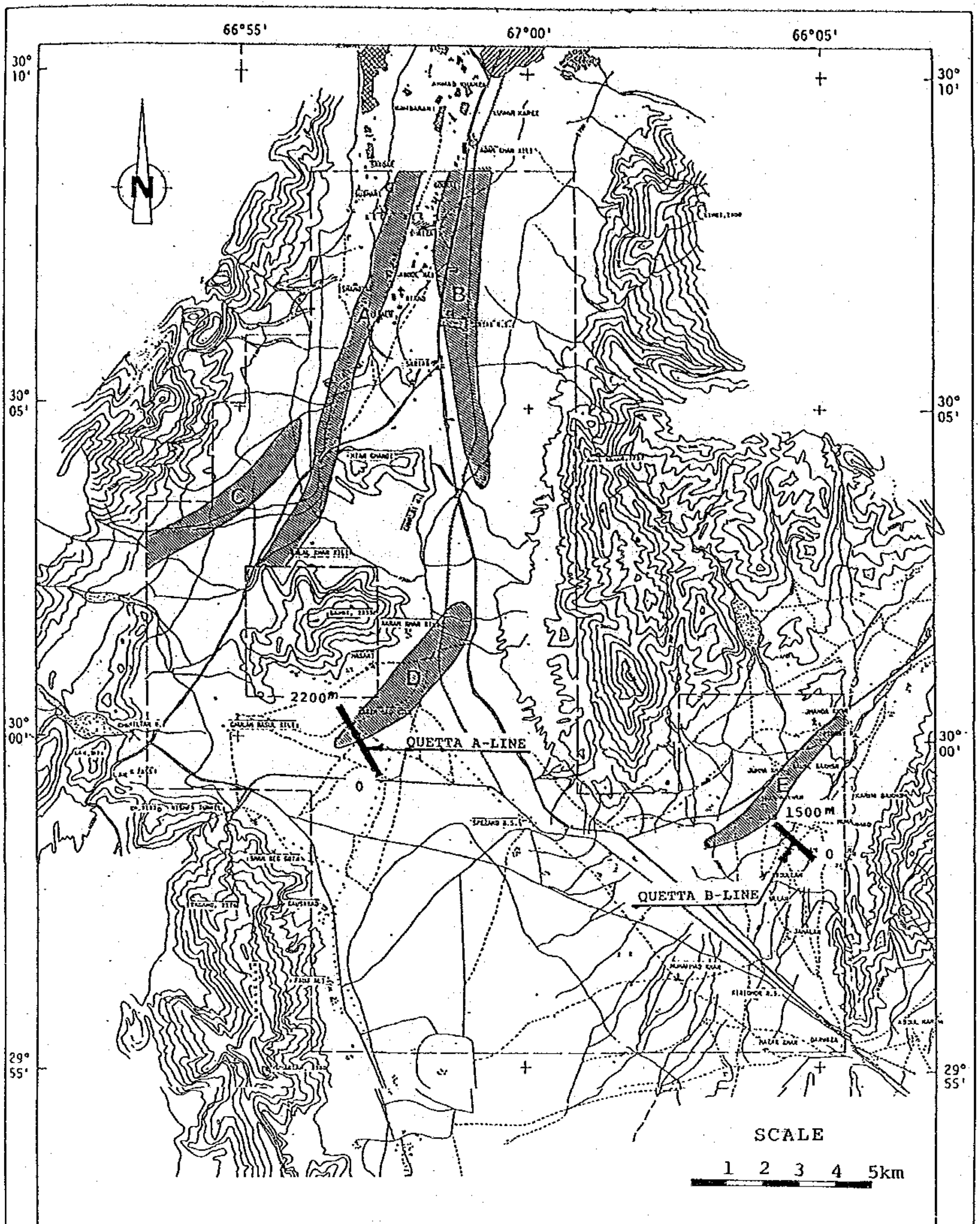


FIG 4.4.1 LOCATION OF SEISMIC PROSPECTING LINES IN QUETTA AREA

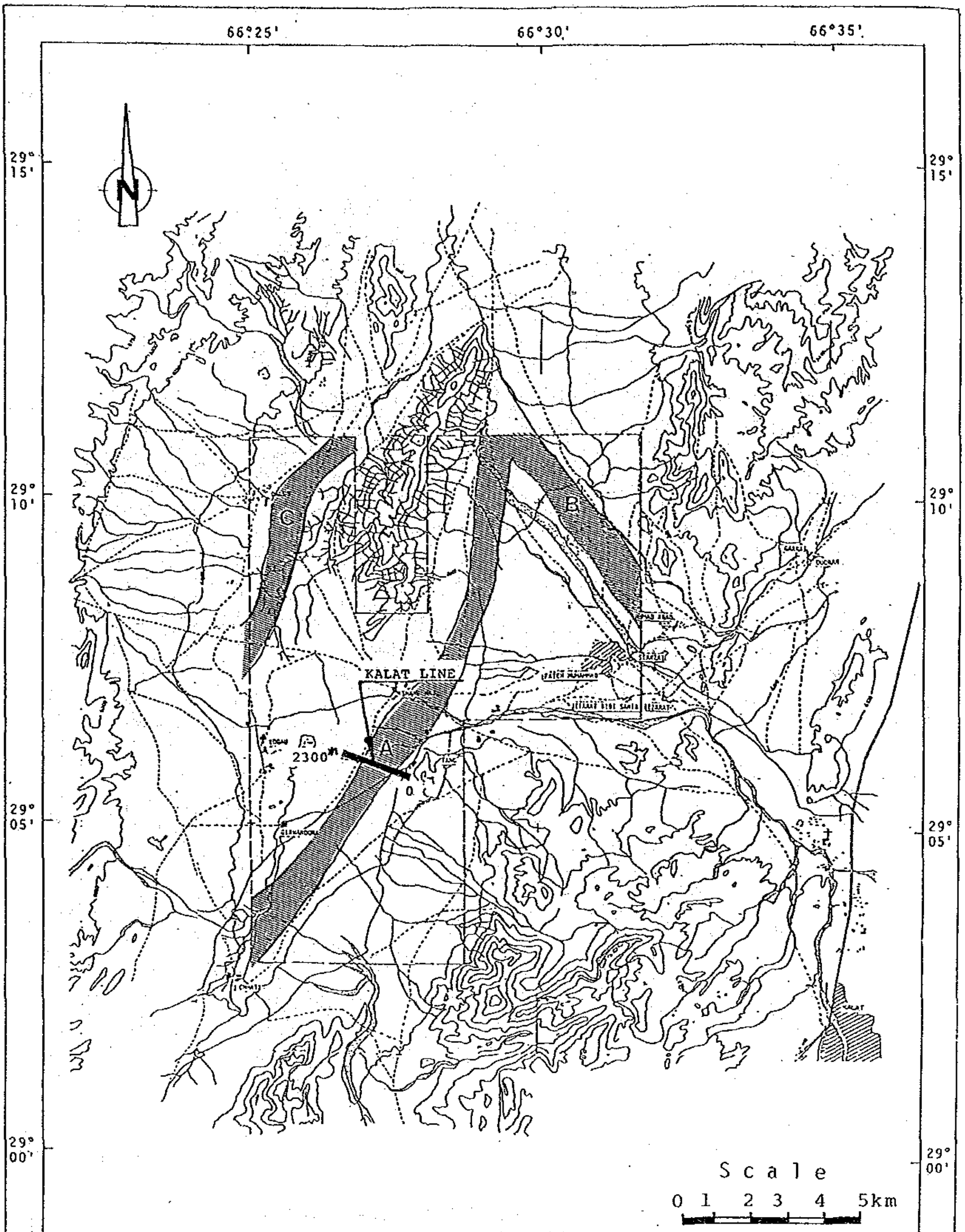


FIG 4.4.2 LOCATION OF SEISMIC PROSPECTING LINE IN KALAT AREA

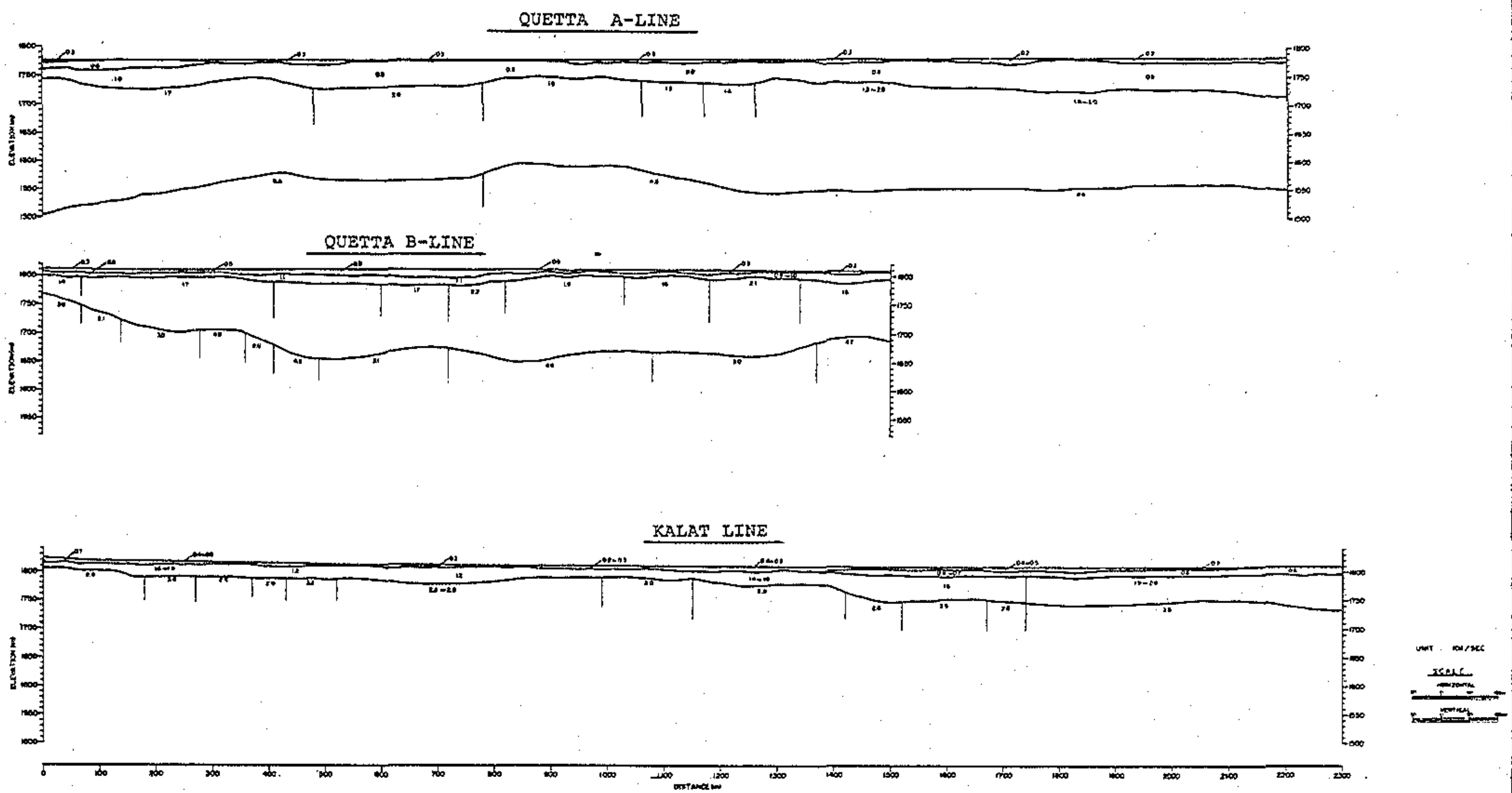


FIG 4.4.3 DISTRIBUTION OF SEISMIC SPEED

4.5 WELL TEST

4.5.1 General

(1) Objectives

The field well test was carried out to confirm the results obtained through the aerial gamma-ray spectro prospecting conducted in the First Phase of the Study.

All the well test works are being executed by Hydrogeology Project, WAPDA, Quetta under the assistance of the JICA Study Team using two (2) drilling rigs granted by Japanese Government.

(2) Locations

The locations of the test wells were selected on the basis of the results of the groundwater survey in consideration of the possibility of future irrigation development, the necessity of test result to supplement the existing test results, the verification of the uncertain results come up through the analysis, etc. The following seven (7) sites were selected through discussions between the Government agencies concerned and the Study Team and site investigations (FIGs 4.5.1 and 4.5.2).

Vein Name	Location	Boring No.
Quetta Area		
Vein A:	1,000 m NNE of Balal Khal Village	QT-JICA-4
Vein B:	1,500 m NNE of cross of Bolan Road and Railway	QT-JICA-3
Vein D:	Beside Karam Dad Village	QT-JICA-2
Vein E:	600 m west of Rasul Bukhsh Village	QT-JICA-1

Vein Name	Location	Boring No.
Kalat Area		
Vein A:	1,000 m SEE of Shahr Haji Village	KL-JICA-1
Vein B:	1,000 m east of Kallu Village	KL-JICA-2
Vein C:	1,000 m SE of Dallo Village	KL-JICA-3

(2) Well Details

The test results are summarized as follows:

a) KL-JICA-1

Drilling depth : 300 m (pilot dia: 8-3/4")

Casing program : 0 - 104 m: 10" dia. casing
104 - 300 m: open

Strainer depth : 48 - 54 m
60 - 66 m (total length: 12 m)

Static water level: 57.0 m

Specific capacity : 1.5 $m^3/d/m$

b) KL-JICA-2

Drilling depth : 300 m (pilot dia: 8-3/4")

Casing program : 0 - 107 m: 10" dia. casing
107 - 300 m: open

Strainer depth : 47 - 53 m
56 - 62 m
64 - 97 m (total lengths: 45 m)

Static water level: 44.1 m

Specific capacity : 17 $m^3/d/m$

c) KL-JICA-3

Drilling depth : 300 m (pilot dia: 8-3/4")

Casing program : 0 - 120 m : 10" dia. casing
120 - 300 m : open

Strainer depth : 54 - 57 m
61 - 67 m
69 - 93 m
95 - 104 m
107 - 110 m (Total length: 45 m)

Static water level:

Specific capacity : 78 $m^3/d/m$

d) QT-JICA-1

Drilling depth : 205 m (pilot dia: 8-3/4")

Casing program : 0 - 135 m: 10" dia. casing
135 - 205 m: Open

Strainer depth : Nil

Static water level: 100.0 m

Specific capacity : Not yet tested

e) QT-JICA-2

Drilling depth : 263 m (pilot dia: 8-3/4")

Casing program : 0 - 160.5 m: 10" dia. casing
160.5 - 247.9 m: 6" dia. casing

Strainer depth : 162.20 - 169.51 m
171.95 - 174.39 m
176.83 - 184.15 m
190.55 - 202.74 m
207.62 - 210.06 m
213.11 - 215.55 m
217.99 - 232.62 m
234.45 - 236.89 m
239.33 - 241.77 m
(Total length: 53.4 m)

Static water level: 65.0 m

Specific capacity : Not yet tested

f) QT-JICA-3

Not applied as a well

g) QT-JICA-4

Drilling depth	:	230m (pilot dia. 8-3/4")
Casing program	:	0 - 122.5m : 10"dia. casing
		122.5-228.1m 6"dia. casing
Strainer depth	:	89.12 - 94.00m
		98.00 - 102.88m
		112.56 - 115.00m
		117.60 - 122.48m
		128.40 - 133.28m
		137.50 - 142.38m
		150.00 - 162.20m
		166.00 - 175.76m
		211.00 - 223.20m
		Total length 70.76m
Static Water Level	:	59.0 m
Specific capacity	:	not yet tested

4.5.2 Test Results

(1) KL-JICA-1

Gravel rich layer of the Quaternary Formation exists from around ground surface to 69 m depth and then changes to clay. At the depth of 103 m, the formation enters the base rock and shale predominant layers with very thin limestone continue upto the bottom of drilling of 300 m. The water sampling tests detected very few discharge. It is judged that a few groundwater is stored in the Quaternary Formation due to its shallow depth, limestone is not fully developed in the base rock and the fissures in the shale layers are collapsed due to the softness of layers. From the recovery observation of water level, the average specific capacity will be 1.5 $m^3/d/m$ d.d, ranging 0.6 to 2.4 $m^3/d/m$ d.d.

(2) KL-JICA-2

Gravel of the Quaternary Formation continues from ground surface upto the depth of 93 m and then changes to clay rich layer. The base rock appears at 150 m depth and shale layer is superior upto the depth of 300 m, the bottom of drilling, with the limestone layer of 8 m thick at 160 m depth. The water sampling test results show that the upper part of gravel layer contains water at maximum discharge 25 gpm (95 lit/min.) but that the limestone layer from 160 m has no sign of water holding. It is judged that the Quaternary Formation is good condition for aquifer due to thick gravel layers but that the base rock in deeper portion has less possibility due to poor limestone. From the pumping test, the specific capacity is estimated to be about 17 $m^3/d/m$.

(3) KL-JICA-3

Gravel layer of the Quaternary Formation continues from the depth of 9 to 108 m and then changes to clay layer. Gravel layer appears again at the depth of 186 m and continues upto 205 m from where limestone layer of base rock starts. Limestone layer continues upto the depth of 220 m and then change to combined layers of shale and limestone. The drilling stopped at the depth of 300 m. The water sampling test results show that the upper part of gravel layer contains water with maximum discharge of 35 gpm (132 l/min.) and that gravel layer from the depth of 86 to 205 m and limestone layer from the depth of 205 to 220 m have no discharge. It is judged that the upper part of the Quaternary Formation is good condition for aquifer due to thick gravel layers but that its lower part and limestone layer of base rock have less possibility to be an aquifer because of their thin thickness even if they may have high permeability judging from to the electric logging. From the pumping test, the specific capacity is estimated to be about 78 $m^3/d/m$.

(4) QT-JICA-1

Gravel layer continues from the depth of 3 to 105 m and then changes to limestone of base rock. Limestone layer continues upto 205 m, the bottom of drilling. The water sampling test results show that limestone of base rock is bearing water with maximum discharge of 20 gpm (76 l/min.) The final pumping test is not yet performed due to insufficient pumping capacity of existing facilities.

(5) QT-JICA-2

Clay dominant layer continues from the depth of 0 to 163 m containing very thin gravel layer at the depth of 39 to 40 m and 49 - 50.5 m. These layers change to limestone layer of base rock and continue upto 263 m of the bottom of drilling. From the water sampling test results, limestone of base rock displays a sign for a good aquifer with maximum discharge of 35 gpm (132 l/min.). The final pumping test is not conducted due to insufficient capacity of existing facilities.

(6) QT-JICA-3

Gravel layer covers the range from the ground surface to the depth of 25.0m. Between 25m to 43m depth, clay and gravel appears alternately. From 43.0m to 264.0m, the clay fills the range completely with only slight layer of gravel between 206.0m to 212.0m. Thin gravel layers appear in the clay dominant layer from 264.0m to 300.0m.

(7) QT-JICA-4

From the ground surface to 125.0m, alluvial of clay and gravel is dominant and appear alternately. These layers change to limestone layer of base rock and continue up to 230m of the bottom of drilling.

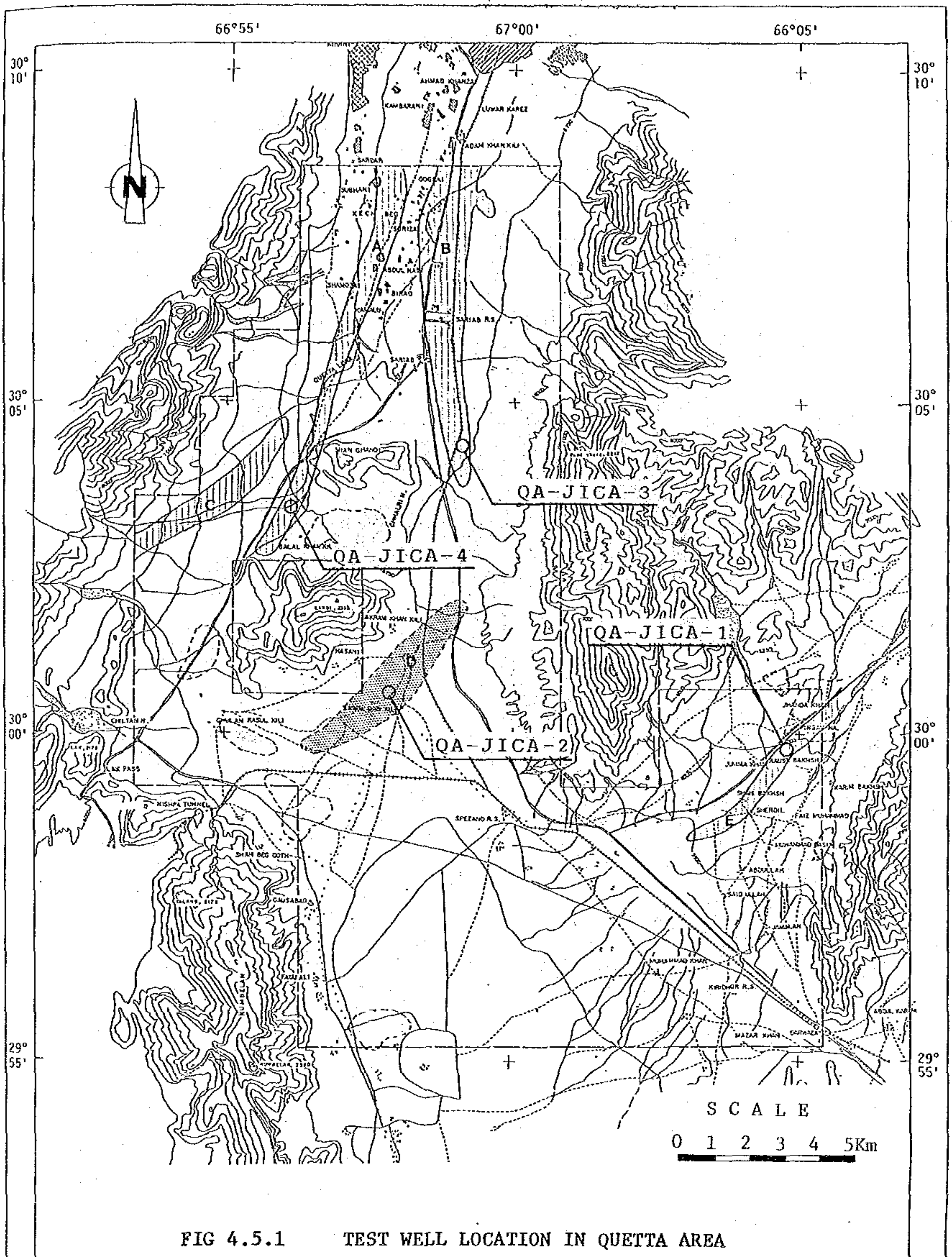


FIG 4.5.1 TEST WELL LOCATION IN QUETTA AREA

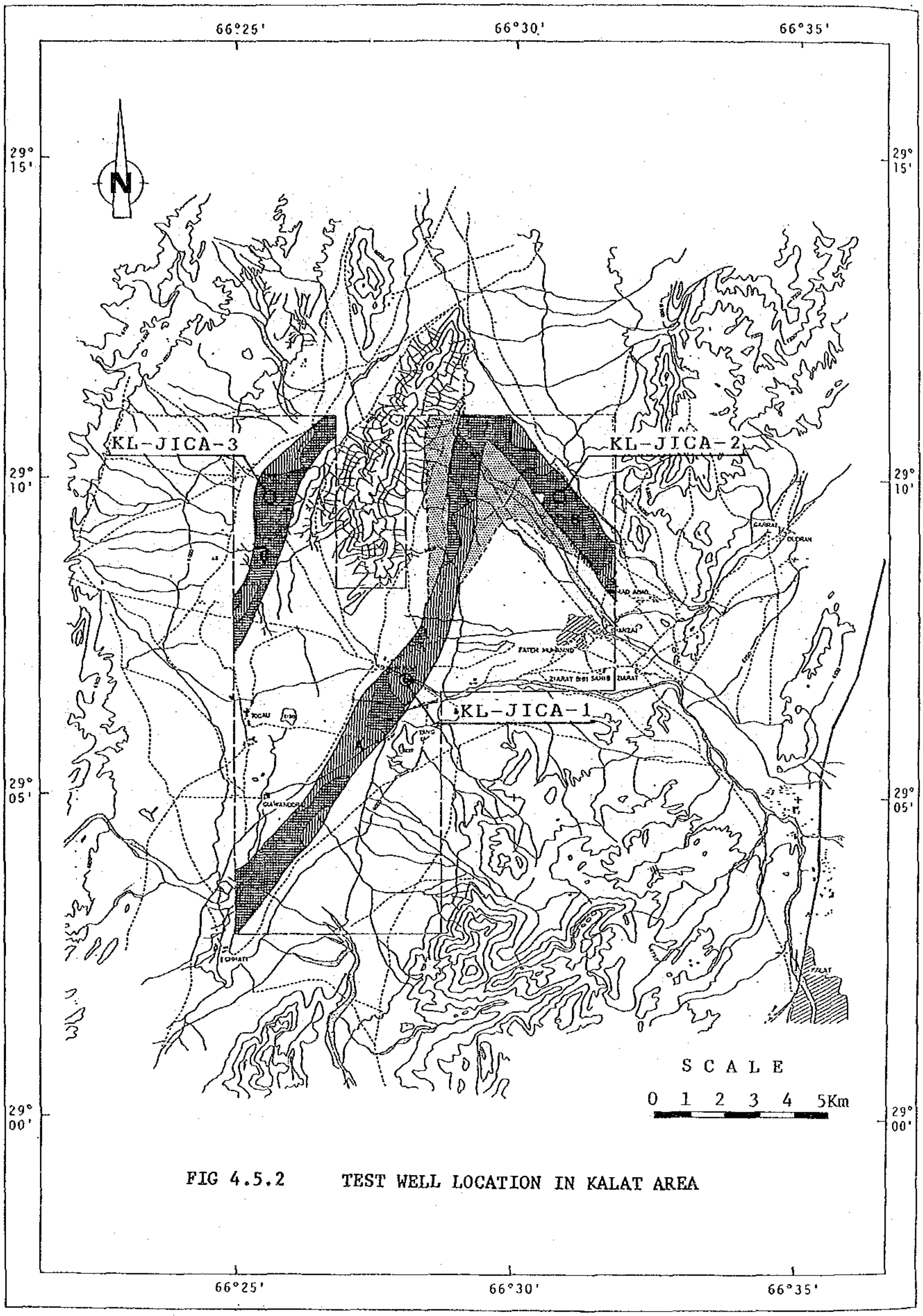


FIG 4.5.2 TEST WELL LOCATION IN KALAT AREA

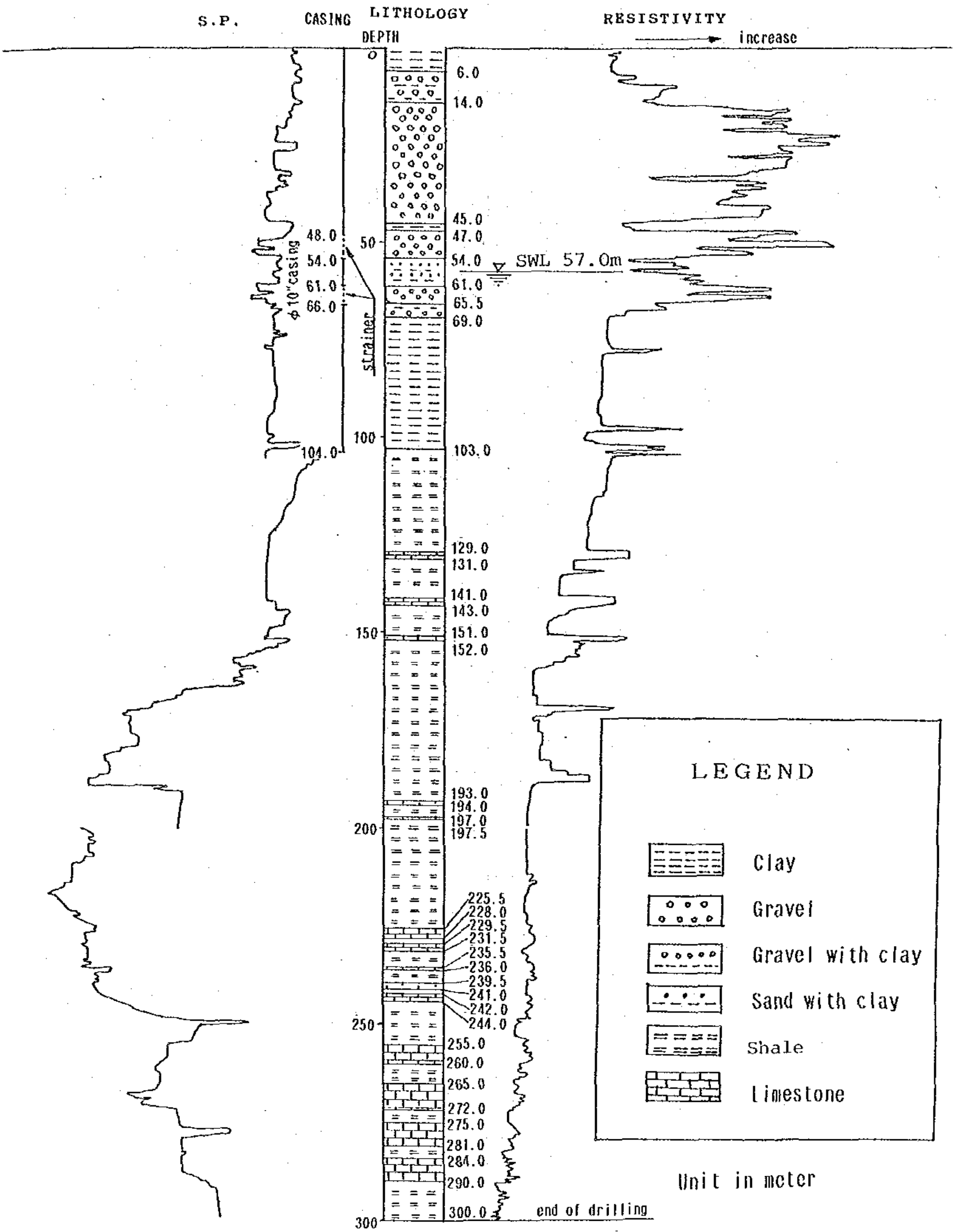


FIG 4.5.3 WELL LOG OF KL-JICA-1

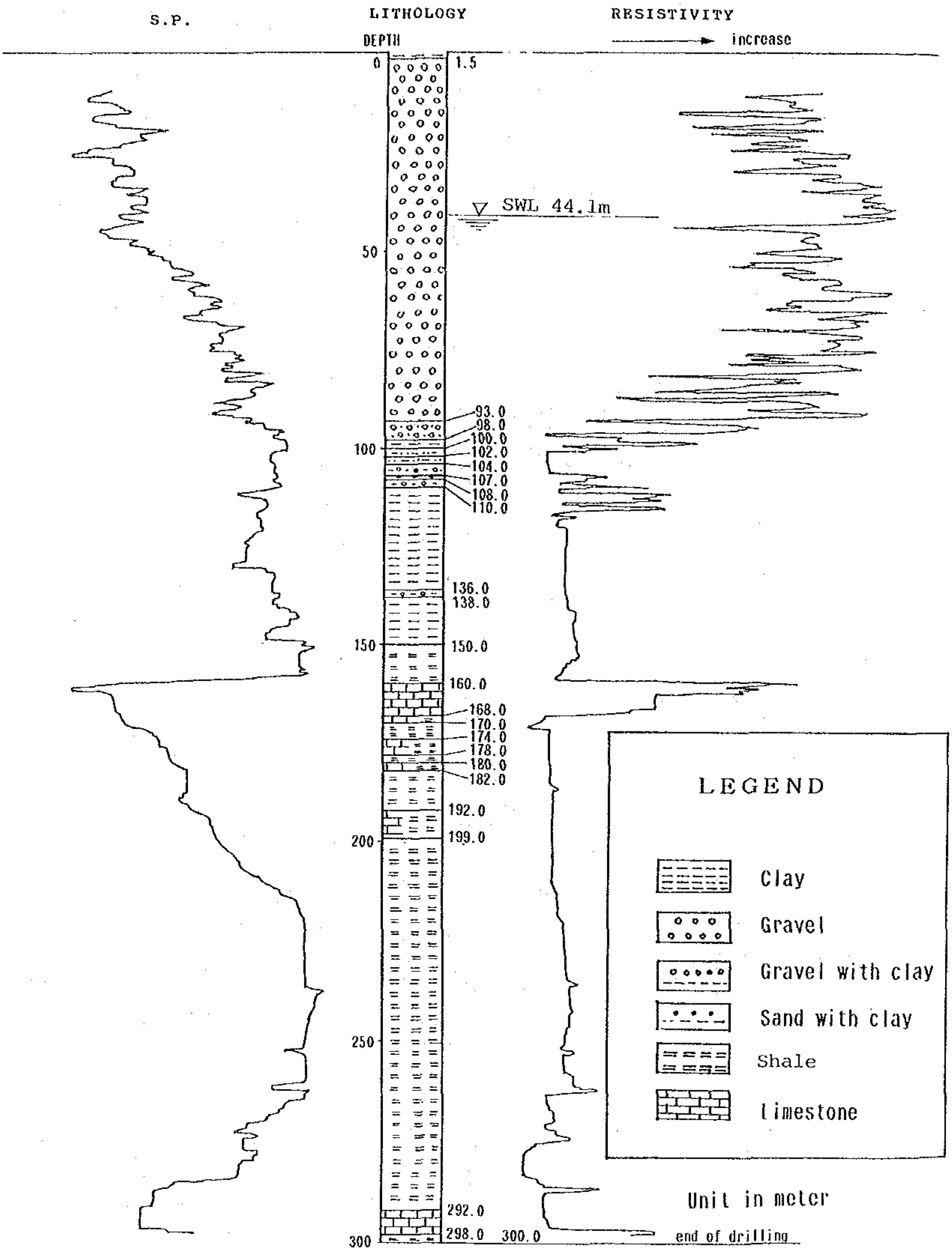
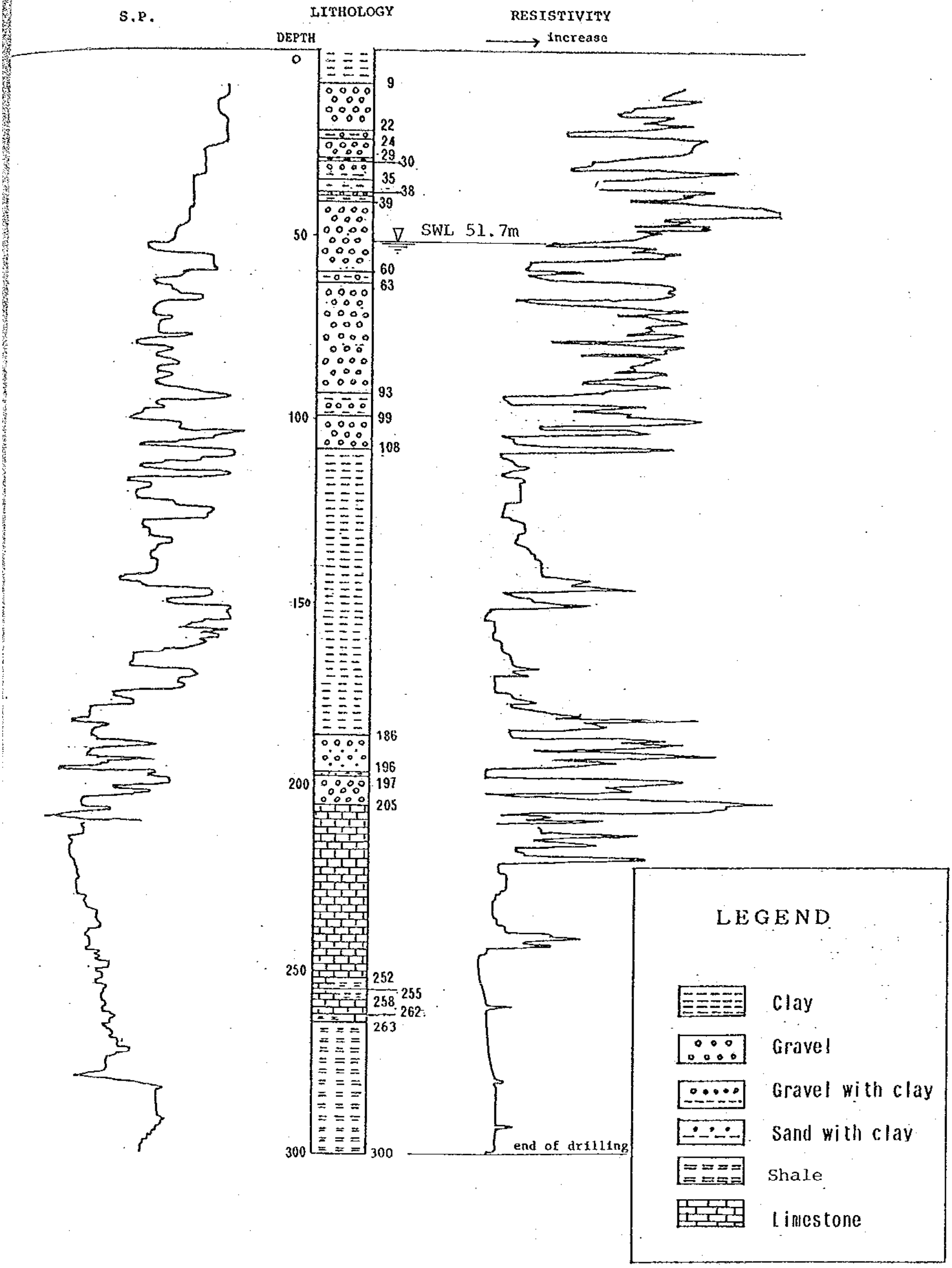
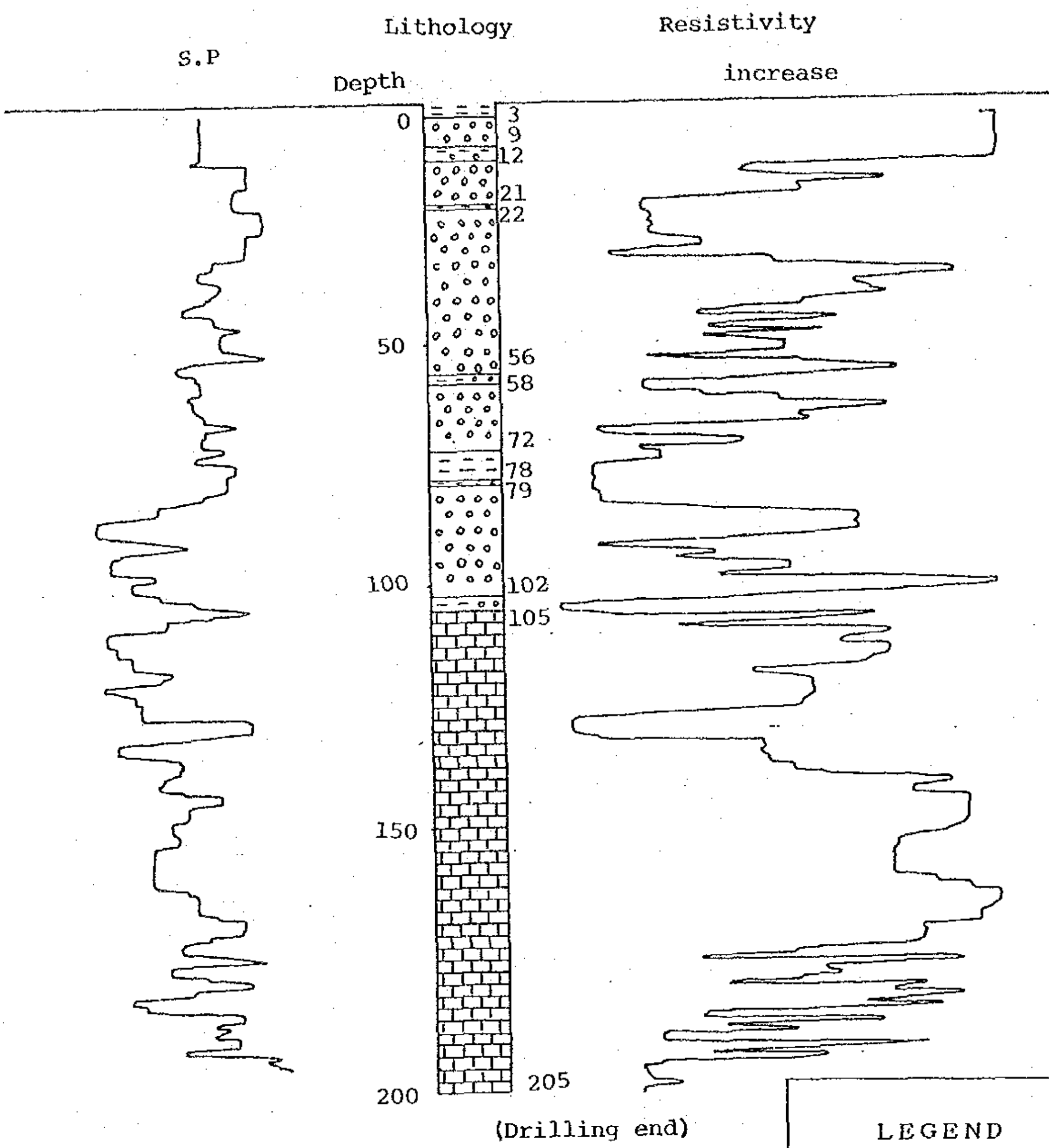


FIG 4.5.4 WELL LOG OF KL-JICA-2



Unit in meter

FIG 4.5.5 WELL LOG OF KL-JICA-3



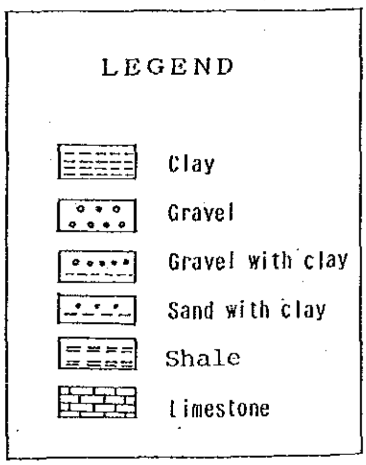


FIG 4.5.6 WELL LOG OF QT-JICA-1

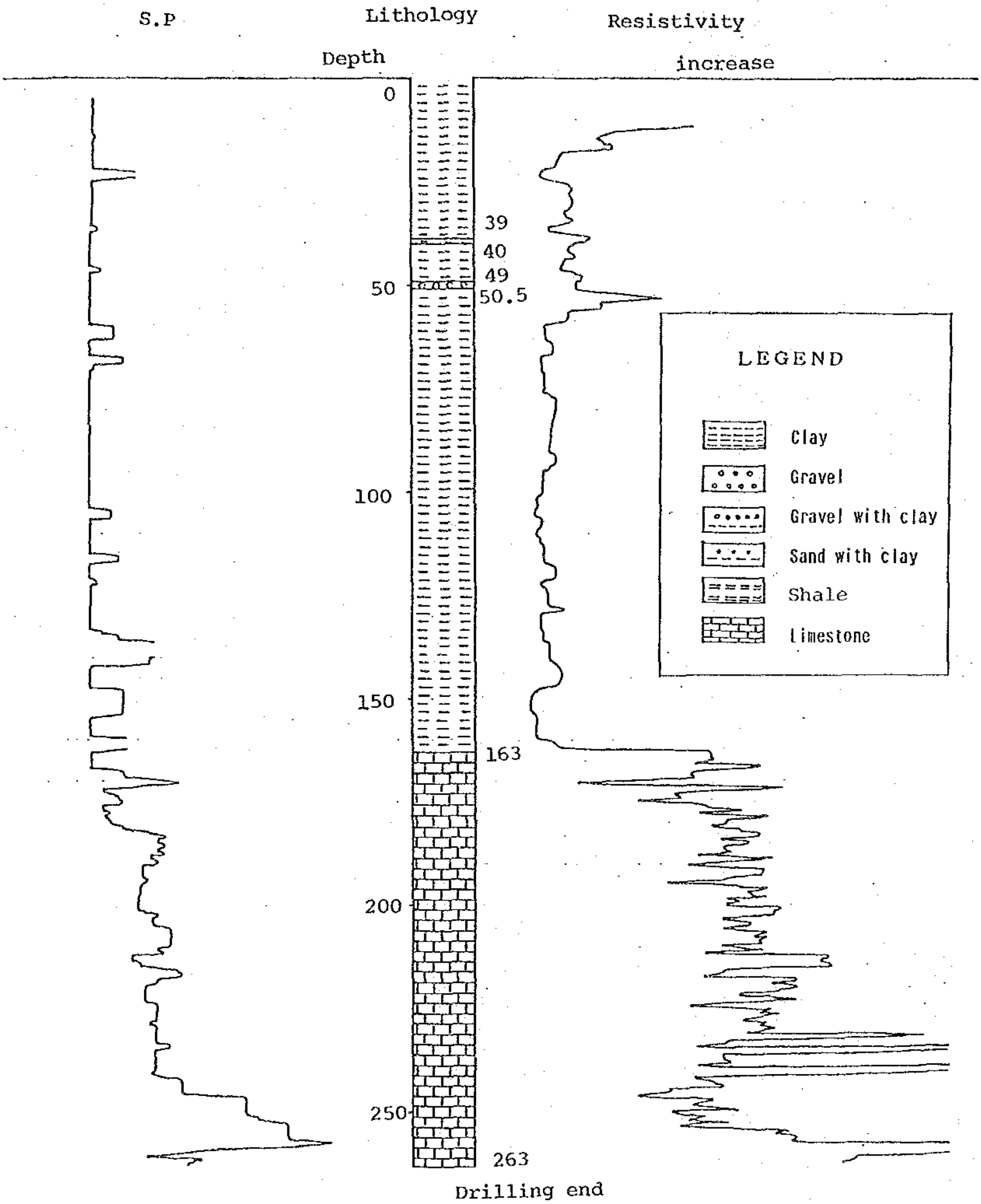


FIG 4.5.7 WELL LOG OF QT-JICA-2

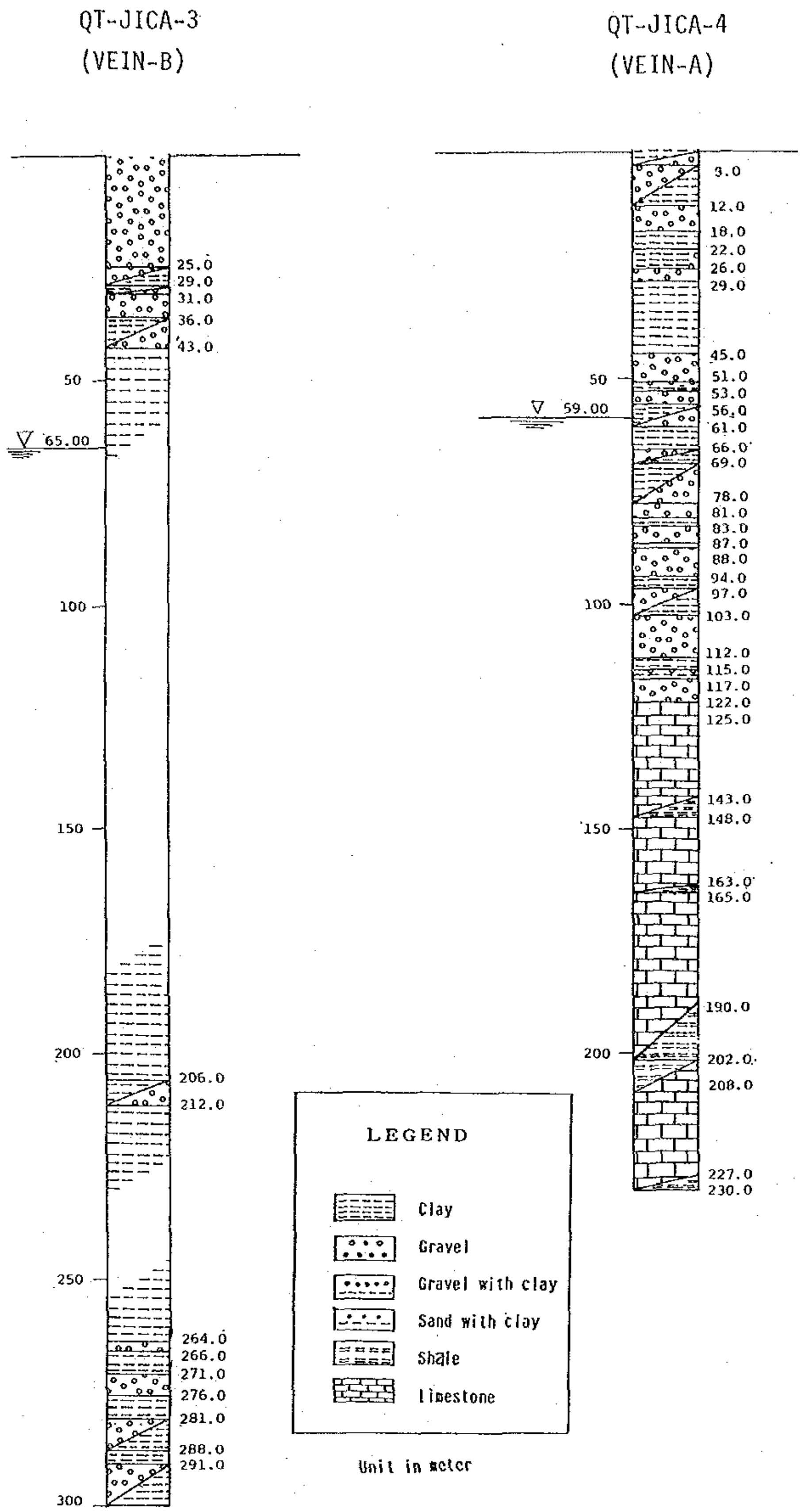


FIG 4.5.8 LITHOLOGY MAP OF QT-JICA-3 AND QT-JICA-4