3.1.2 Water Resources Development Plan and its Present Status

(1) Hydroelectric Power Development Plan

A Master Plan for hydroelectric power development plan for the Coruh River was prepared by EIE in 1982. According to the Master Plan, the development plan for the basin would consist of construction of 11 dams and power plants with installed capacity of 2,003 MW and annual energy production of 7,468 GWh. The breakdown of the plan is as follows:

Dam and Power Plant	Installed capacity (MW)	Annual energy production (GWh)
1. Laleli	85.00	180.79
2. Kilicci	27.10	74.90
3. Ispir	58.48	276.47
4. Gullbag	64.40	291.55
5. Akus	115.50	355.63
6. Karakale	201.60	801.51
7. Yusufeli	417.00	1,445.05
8. Artvin (Inanli)	192.60	746.13
9. Deriner (Artvin)	511.00	1,993.56
10. Borcka	230.00	870.93
11. Muratli	100.00	431.06
Total	2,002.68	7,467.58

With regard to the Yusufeli and Artvin projects mentioned above, a Feasibility Study was made by JICA from 1985 to 1986 as a part of technical cooperation provided by the Japanese Government.

As for the Deriner, Bortcka, and Muratli projects, it is scheduled for feasibility studies to be completed by EIE by the end of 1986. Feasibility studies have been started by EIE in 1986 on the remaining 6 projects also.

With respect to tributaries of the Coruh River, according to development plans of the reconnaissance level, 26 power plants would be constructed having a total installed capacity of 866.0 MW and total annual energy production of 2,414 GWh. The approximate breakdown of these are as follows:

	Number of power plants	Total installed capacity (MW)	Total annual energy production (GWh)
North Creeks Development Plan	7	144.6	381.0
Altiparmak Development Plan	4	223.0	509.6
Berta Development Plan	7	257.5	770.9
Oltu Development Plan	4	159.6	538.1
Lower Coruh Tributary Development Plan	4	81.5	214.4
Total	26	866.0	2,414.0

Other than the abovementioned plans, there is the Tortum No.1 Hydroelectric Power Plant with an installed capacity 26 MW which has been constructed on the Tortum River, a right-bank tributary of the Coruh River, and this is presently in operation. The power from this plant is connected to Hopa Substation by a transmission line.

(2) Irrigation Plan

Although an investigation of reconnaissance level has been conducted, there is an irrigation development plan for the Bayburt Plain in the upstream area of the Coruh river, according to which it is planned to irrigate a total area of 27,084 ha.

3.2 General Condition in Projects Area

3.2.1 Landform and Natural Conditions

(1) Landform

The project area generally consists of steep mountainland. The principal mountains in the project area are Mt. Tatos (3,937 m), Mt. Kop (2,953 m), and Mt. Cam (3,850 m), with all mountains having heights of 2,000 to 3,000 m or over forming divides of rivers. Accordingly, there is extremely little flat area, and when confined to the reservoir areas of Yusufeli and Artvin and their surroundings, no flat area can be seen.

The Coruh is a river having a total length of approximately 410 km and it originates at the northeastern end of Turkey. However, its mouth is located inside Soviet territory where the river empties into the Black Sea. The major tributaries of the Coruh are the Barhal River, Oltu River, and Tortum River, all located in the Yusufeli Reservoir. The catchment area at the Yusufeli dam site is 15,250 km^2 and the average annual inflow is 3,777 x 10^6 m^3.

(2) Natural Conditions

(a) Geology

The basement rocks at the dam site and reservoir area of the Project consist of the Berta Formation, the Pugey Formation and the Yusufeli Formation of the Mesozoic Era and Ikizdere granites of the Tertiary Period. The Pugey Formation partially consists of calcareous rocks, but these are not pure limestone and have interbeds of solution-resistant or insoluble rocks. Furthermore, the distribution area of this Pugey Formation is surrounded by insoluble formations so that watertightness of the reservoir is assured. The relationship of deposits of the various formations are the Berta Formation contacting the Pugey Formation by a thrust fault, and the Pugey Formation contacintng the Yusufeli Formation by inclined unconformity. As for the Ikizdere granites, they are large-scale rock bodies intruded into the various formations. Further, since this project area, seen from a geotectonic history point of view, is an area that was subjected to Hercinium orogeny of the Paleozoic Era and Alpine orogeny of the Mesozoic to Cenozoic Eras, there are comparatively numerous large and small faults.

(b) Seismicity

The eastern part of the Anatolian Peninsula is divided by two transform faults constituting the plate boundaries of the North Anatolian Fault and the East Anatolian Fault. The project area is located approximately 170 km north of the point where the two faults intersect each other and so is not in an area along a so-called active fault. However, it is at distances of 200 to 100 km from the cities of Erzincan and Erzurum which have experienced large-scale earthquakes in the past, and therefore, this is an area where care must be excercised.

(c) Meteorology

The Coruh River Basin can generally be divided into continental climate and Black Sea climate. Continental climate is predominent in the project area. The annual precipitation is 440 mm and about 50 percent of the annual rainfall comes in the wet season of March to June. There is also snowfall in January and February.

According to the records of Yusufeli Meteorological Observation Station, the maximum, minimum, and mean temperatures are 43.8°C, -14.3°C, and 14.2°C, respectively.

3.2.2 Natural Environment

(1) Scenery

Places that are especially considered to be scenic spots cannot be seen in the project area. However, there is a continuation of cliffs showing rare formations reminiscent of a natural museum of geology in the area along the Tortum River from the upstream end of the reservoir to Lake Tortum.

(2) Vegetation

No rare species of plant has been reported so far to exist in the project area.

The topography of the project area is of rugged mountains with little vegetation. Trees exist mainly scattered at hamlets along streams, and infrequently, there are short trees at mountainland. Especially, at the dam site sheer cliff rise at both banks with bare rock exposed and hardly any vegetation. There is also little vegetation in the area to be submerged by creation of the reservoir.

Vegetation is seen from the vicinity of Artvin downstream of the project area, from where to the Black Sea coast vegetation is comparatively abundant.

(3) Animal Life

So far, rare species of either land or aquatic animals have not been reported to exist in the project area.

With regard to fishes, there has been no report of the existence of migratory fish. The extent of fishes inhabiting the streams of the project area is that some carps and daces are found and there is no fishing industry.

(4) Water Quality

Water quality investigations of the Coruh River are being carried out at the Karsikoy (No. 2315) and Bayburt (No. 2304) gauging stations. Observations have been made once monthly (1971-1976). According to the results, pH values of 6.3 to 8.8 are indicated. According to the results of analyses the water quality is of C_2S_1 class.

Visual observations made at the times of the field reconnaissances carried out in June-July 1985 and February 1986 showed a substantial amount of turbidity of the river water in the vicinity of Borcka located in the downstream area of the Coruh River. However, when confined to the project site, impairment of water quality was not seen, except for turbidity of the river water during heavy rainfall.

Changes in water quality which can occur with creation of a large-scale reservoir are eutrophication, low water temperatures, and long-term turbidity.

A problem related to water quality that could conceivable occur as a result of implementation of the Project is long-term turbidity of reservoir water. However, there has been no case of water quality having been changed posing a problem that have been reported so far at existing reservoirs in Turkey.

Although the possibility of long-term turbidity of water caused by the Project is a topic for further study, it may be judged that this will not be a decisive matter to adversely affect implementation of the Project.

3.2.3 Social Environment

The project area is located in Artvin Province.

Artvin province covers an area from the Black Sea coast to the midstream part of the Coruh River and consists of seven counties, the areas and populations of which (as of 1980) are as follows:

	Area (km^2)	Population
Artvin Province	7,436	228,997
Artvin County	1,052	29,964
Ardanuc County	969	21,945
Arhavi County	314	17,772
Borcka County	1,168	43,601
Hopa County	289	29,426
Savsat County	1,317	45,179
Yusufeli County	2,327	41,110

The capital of Artvin Province is the city of Artvin located approximately 47 km southeast of Hopa on the Black Sea coast, and faces the mainstream, Coruh River.

The population of Artvin City (as of 1980) was 14,307. The city has governmental offices, banks, hospitals, schools, hotels, communication facilities, commercial shops, etc., and therefore, has the various facilities indispensable for commercial activity and daily livelihood.

The project area is located in Yusufeli County of Artvin Province. The following paragraphs mainly describe the features of the project area.

(1) Population

The Project consists of the Yusufeli Project and the Artvin Project. When the Yusufeli Project is implemented, the town of Yusufeli and villages in the vicinity will be affected by Yusufeli Reservoir. These communities are Yusufeli, Yeniyuva, Irmakyani, Uysallar, Kabandibi, Demircubuk, Vacekent, Hazuket, Tasbasi, part of Takkale, Celtiktuzu, Cevreli, Ballidut, Medan, Kirazli, Ginler, part of Arpacik, Gorgulu, Boylar, and Yarbasi. The populations of these communities were 6,806, 7,164 and 7,473 according to the population census of 1970, 1975 and 1980, respectively.

When the Artvin Project is implemented, the villages of Inanli, Sebzeciler, and Bez will be affected by Artvin Reservoir.

The populations of these villages were 442, 419 and 363 according to the population census of 1970, 1975 and 1980, respectively.

The population growth in the Yusufeli district is extremely small, while in the Inanli district, the population is decreasing. The reasons are that it is difficult to find employment in the surrounding area, while land suitable for agriculture is insufficient, and there is practically no demand for seasonal laborers in the surroundings so that the younger generation have migrated to the cities.

(2) Culture and Public Facilities

The town of Yusufeli which is the center of the Yusufeli project area has an elementary school, junior high school, high school, and a vocational school. Larger villages in the area have elementary schools.

Elementary schools do not exist at the villages in the Artvin project area. An elementary school, a junior high school and a vocational school exist at Demirkent where a governmental office is located.

Besides these schools, there are mosques at Yusufeli Town and the various villages.

(3) Health and Sanitation

There is no problem of infectious disease affecting the health and sanitation of the people in the Yusufeli and Artvin project areas.

Health care administration of Yusufeli County is handled by the province with health center personnel making the rounds of the surrounding villages.

(4) Transportation and Communications

A two-lane national highway asphalt-paved over its entire length passes through the project area from Trabzon on the Black Sea coast, running through Hopa, Artvin, the Artvin site, and the Yusufeli site to Erzurum. The distance between Trabzon and Yusufeli is 335 km, while that between Erzurum and Yusufeli is 120 km.

There is daily regular bus service between Artvin City and Yusufeli Town. Jeepable roads connect to larger villages. Yusufeli Town has postal service where telephone and other communication services are handled.

(5) State of Economic Activity

(a) Agriculture

The greater part of the economy in the project area is supported by agriculture. Agricultural land has been developed at flat areas along the banks of streams and on mountain slopes, and water of the Coruh River and tributaries is utilized. The agricultural products are fruits, vegetables, rice, etc. Olive and grains such as barley are grown where water suply is inadequate.

Animal husbandry is practised at villages, but not very extensively.

(b) Mining and Manufacturing

Large-scale factories do not exist in the project area. Yusufeli Town has a flour mill, macaroni plant, lumber mill, automobile repair shop, etc., which are all of small scale. Mineral resources have not been discovered in the project area.

(c) Commerce and Tourism

Most of the items shipped consist of agricultural products which are mainly collected at Erzurum City and Artvin City.

There are no important historical sites for tourism in the project area.

There are relics of ancient castle walls and bridges at Sarigal close to the project area.

(d) Fishing and Boat Navigation

Fresh water fishing and boat navigation do not exist on the Coruh River in the project area.

(6) Submersion and Relocation

The objects of compensation such as houses and cultivated land to be submerged as a result of implementation of the Project and compensation costs were investigated in detail by EIE in 1984.

The population, cultivated land, and major items to be submerged by the reservoir of the Yusufeli Project are shown below.

(Figures correspond to high water level of 700 m)

Population: Approximately 7,000 persons

Cultivated land:

	(Decare)
Sb (vegetable field - tomato, pepper, beans)	320.60
ST_1 (wheat, barley, corn)	1,338.70
Mbk (orchard - cherry, apricot, pomegranate)	2,679.70
Bg (orchard - grape)	31.60
CL (paddy - rice)	1,297.00
Ma (pasture - grazing)	1,178.00
Cay (pasture - hay)	22.90

Principal buildings:

House	1,613 units
School	12
Mosque	10

The population, cultivated land, and major items to be submerged by the reservoir of the Artvin Project are as shown below.

(Figures correspond to the original site)

Population: Approximately 360 persons

Cultivated land:

	(Decare)
Sb (vegetable field - tomato, pepper, beans)	14.80
ST_1 (wheat, barley, corn)	12.80
Mbk (orchard - cherry, apricot, pomegranate)	50.50
Z_Y (olive)	196.90

Principal buildings:

House	65 units
School	0
Mosque	1

With regard to submersion and relocation accompanying implementation of the Project, since the population is relatively large, study of the plan concerning submersion and relocation will be extremely important subject for further study.

As mentioned under (4), Transportation and Communications, there is a national highway connecting Artvin and Erzurum. This national highway plays an extremely important role in transportation of freight. Due to implementation of the Project, it will be necessary to relocate the national highway to be submerged before starting water impoundment of the reservoir.

Especially, regarding the project site and the part of the national highway in the surroundings, it will be necessary to relocate the road before starting on the main work. Since transportation of passengers and freight can not be interrupted, the outcome of the national highway relocation work will govern the start of work in the Project.

(7) Water Utilization Rights

The water utilization rights of the Coruh River belong to the Turkish Government, and not to the local muncipality or private enterprises.

All dams and power plants are constructed by DSI. After completion, these dams and power plants are transferred from DSI to TEK.

CHAPTER 4 PRESENT STATE OF ELECTRIC ENTERPRISE

CHAPTER 4. PRESENT STATE OF ELECTRIC ENTERPRISE

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CHAPTER 4. PRESENT STATE OF ELECTRIC ENTERPRISE

4.1 Present Status of Electric Power

The national economy of the Republic of Turkey, which had been in a state of recession after the first oil crisis, started to recover gradually since 1980, owing to international assistance and the determined efforts for economic reconstruction by the Republic of Turkey itself.

A great deal of emphasis is placed on the development of electric power, which is regarded as one of the important pillar for the economic reconstruction. In particular, the power generation capacity is being steadily expanded, with hydroelectric power development playing the central role.

The past trend of the total installed generation capacity and the total amount of electricity generation are illustrated in Fig. 4-1.

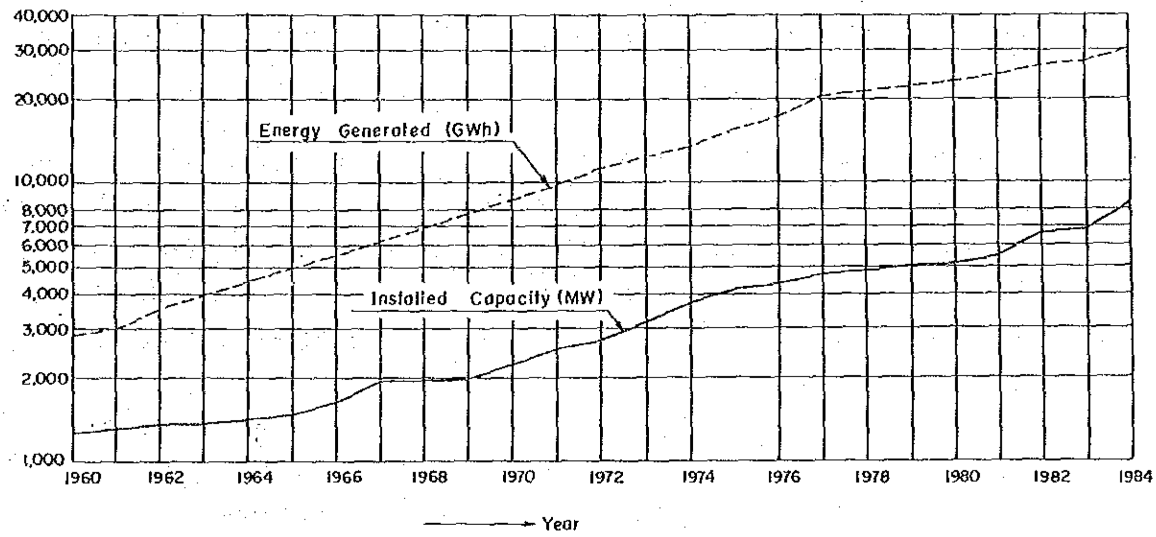

Fig. 4–1 Installed Capacity and Energy Generated

The installed capacity as of 1984 was 8,459 MW, which consisted of 54% thermal power and 46% hydro power.

The annual generation was 30,614 GWh, of which the hydroelectric power accounts for 46%.

The annual power generation per capita is 630 kWh. Although this figure is low as compared to per capita consumption of 5,000 to 7,000 kWh in the highly industrialized countries, the growth of power generation in Turkey is large. The annual growth rate was over 10% before the first oil crisis. Thereafter, the growth rate declined to a relatively low level of 4 to 5% due to deteriorated economic conditions, but in 1984, it recorded a high growth rate of 11.9% over the previous year, reflecting the recovery of economic activities.

This rapid growth of electric demand had caused shortage in the supply capacity, and the Republic of Turkey started import of electricity from Bulgaria in 1975, and from U.S.S.R. in 1979. This import of electricity still continues today.

The amount of electricity import has increased year by year, amounting to 2,653 GWh in 1984, which accounts for approximately 8% of the total electricity consumption in this country.

Also, there is strong latent demand for electric power, and it can be estimated that the future growth rate will even exceed 10%. The electric power development projects are being aggressively implemented to meet this future demand.

According to the power development plan, large hydroelectric and thermal power plants will be completed and connected to the Turkish national power grid in succession in the period around 1987 to 1990, including Elbistan Thermal Power Plant (4,200 MW) and hydroelectric power plants such as Karakaya (1,800 MW), Altinkaya (700 MW) and Ataturk (2,400 MW).

More emphasis is placed on hydroelectric power projects from the point of view of effective utilization of water resources, which is a genuine indigenous primary energy source of Turkey. Thus it is planned to bring the ratio of hydro power to thermal power between 50:50 and 55:45 by the year 2000.

In the long-range plan, nuclear power is also expected to play an important role. It is planned to commission the first nuclear power plant (1,000 MW) in 1992, and a total of 9 nuclear power plants (10,000 MW) will start operation in succession before 2005.

Power consumption in 1984 by categories was 65% in mining and manufacturing industries, 33% in agriculture, commerce and household uses, and 2% in transportation. These ratio have not changed substantially in the past 10 years.

The power system in the Republic of Turkey is interconnected throughout the country, and independent power systems accounts for only 4% of the total capacity.

The major transmission system consists of 380 kV lines (4,464 km), 154 kV lines (15,679 km) and 66 kV lines (2,182 km). The 66 kV lines and 34.5 kV lines are used for local transmission systems. The transmission/distribution network of voltages of 34.5 kV and less have a total length of 110,000 km and are being expanded year by year. Yet a substantial number of villages without electric service exists in local agricultural regions.

The rate of electrification of households is around 70% at present.

As of April 1, 1985, the electric rate in the Republic of Turkey is determined by the following two different rate systems, and a consumer can select one of them at his option.

a) 2-Stage Rate System

   i) kW rate: Annual rate of 18,600 TL or monthly rate of 1,500 TL per kW of electric demand.

   ii) kWh rate: 29.2 TL per kWh.

   iii) Time band rates

      Peak hours: 40.5 TL/kWh.

      Daytime: 29.2 TL/kWh.

      Nighttime: 19.4 TL/kWh.

      (This rate is applied to a consumer having contract capacity exceeding 700 kW.)

b) Uniform Rate System: 32.8 TL/kWh

4.2 Electric Power Enterprises

Electric power administration in the Republic of Turkey is under the jurisdiction of the Ministry of Energy and Natural Resources.

The greater part of the electric enterprise are made up of state-owned systems, and these are operated by the Turkish Electricity Authority (TEK). In addition, there are the General Directorate of Electrical Power Resources Survey and Development Administration (EIE) and the General Directorate of State Hydraulic Works (DSI) which are government agencies.

(a) Electric Power Development Planning and Investigation: (EIE)

(b) Construction of dams and hydroelectric power plants: (DSI)

(c) Operation of hydroelectric power plant, construction and operation of thermal power plant, transmission and distribution: (TEK)

Most of the electric enterprises are state owned, and powerplants and power system operated by TEK, although there are some privately owned enterprises.

EIE is an organization entrusted with the tasks of conducting surveys and formulating plans for electric power development. EIE carries out investigations of power development sites, and determines their scales, and implementation schedule taking into consideration predicted future power demand and supply.

DSI is an organization established in 1953 with 25 regional offices throughout the country, and is in charge of construction and operation of dams for flood control, irrigation and drainage, and supply of domestic and industrial water, and in addition construction of hydroelectric power plants. With regard to hydroelectric power projects, there are cases where DSI implements them independently and cases where EIE participates in the survey stage.

TEK is an electric power enterprise which undertakes construction, maintenance and operation of thermal power plants, nuclear power plants and transmission lines, and maintenance and operation of hydroelectric power stations constructed by DSI. Of the entire power generating capacity in the Republic of Turkey, 85% is operated by TEK. The remaining 15% consists of municipally-owned power plants and plants operated by private enterprises.

There are three patterns for power distribution - one is territory directly supplied by TEK, two is distribution undertaken by municipal organizations supplied with power by TEK, and three is areas supplied by Electricity and Gas Services. Since the service areas of these three patterns of distribution overlap at places, study is underway to remedy this situation from the standpoint of rationalization.

4.3 Present Status of Power Supply Facilities

The past trend of the power generation capacity in Turkey, and the ratio of hydroelectric power in the total installed capacity are presented in Table 4-1 and Fig. 4-2 respectively for each year. The ratio of hydroelectric power is 46% of the total capacity (3,875 MW) as of 1984. The hydroelectric power plants, including Hasan Ugurlu (500 MW) and Oymapinar (540 MW) which were commissioned after 1980, play very important roles in power system.

The present policy of the Government of Turkey, which places priority on domestic energy source utilization with the objective of improving international balance of trade, is not expected to change in the future, and the development of hydroelectric power and lignite-fired thermal power plant will be promoted.

The major power plants in operation are listed in Table 4-2.

As discussed before, the transmission line voltages in Turkey is 380 kV and 154 kV. The 220 kV transmission voltage is also used for interconnection with the power system of U.S.S.R.

The major transmission lines are listed in Table 4-3.

Keban-Golbasi Line and Golbasi-Umraniya Line extend over a distance of 900 km, being the trunk line that spans central Turkey. This line interconnects the large power sources in the East and the load centers in the West.

The past trends in the expansion of total lengths of transmission lines and distribution lines are given in Table 4-4.

Table 4–1 Installed Generating Capacity

Unit: MW

Year	Operated by TEK			Operated by Others			Total		
	Thermal	Hydraulic	Total	Thermal	Hydraulic	Total	Thermal	Hydraulic	Total
1960	237	331	568	623	81	704	860	412	1,272
1961	237	348	585	642	97	739	879	445	1,324
1962	237	348	585	664	122	786	901	470	1,371
1963	237	352	589	666	126	792	903	478	1,381
1964	237	353	590	684	144	828	921	497	1,418
1965	302	360	662	683	145	828	985	505	1,490
1966	302	471	773	726	145	871	1,028	616	1,644
1967	522	557	1,079	735	145	880	1,257	702	1,959
1968	522	577	1,099	722	146	868	1,244	723	1,967
1969	522	582	1,104	721	142	863	1,243	724	1,967
1970	905	582	1,487	605	143	748	1,510	725	2,235
1971	1,095	669	1,764	611	203	814	1,706	872	2,578
1972	1,188	690	1,878	631	202	833	1,819	892	2,711
1973	1,568	782	2,350	639	203	842	2,207	985	3,192
1974	1,643	1,191	2,834	640	258	898	2,283	1,449	3,732
1975	1,708	1,521	3,229	699	259	958	2,407	1,780	4,187
1976	1,771	1,614	3,385	720	259	979	2,491	1,873	4,364
1977	2,071	1,614	3,685	783	259	1,042	2,854	1,873	4,727
1978	2,179	1,622	3,801	809	259	1,068	2,988	1,881	4,869
1979	2,179	1,872	4,051	809	259	1,068	2,988	2,131	5,119
1980	2,179	1,872	4,051	809	259	1,068	2,988	2,131	5,119
1981	2,345	2,097	4,442	836	259	1,095	3,181	2,356	5,537
1982	2,720	2,823	5,543	836	259	1,095	3,556	3,082	6,638
1983	2,938	2,998	5,936	758	241	999	3,696	3,239	6,935
1984	3,543	3,644	7,187	1,041	231	1,272	4,584	3,875	8,459

Table 4–2 Major Power Plants in Operation

Name	Thermal Power Plants Installed Capacity (MW)	Thermal Power Plants Energy Generated (GWh)	Name	Hydraulic Power Plants Installed Capacity (MW)	Hydraulic Power Plants Energy Generated (GWh) Average	Hydraulic Power Plants Energy Generated (GWh) Firm
Ambarali	630	4,200	Almus	27	80	40
Hopa	50	350	Demirkopru	69	190	100
Caralagzi	129	600	Gokcekaya	278.4	562	460
Ankara	22.1	11	Hirfanli	128	400	180
Izmir	35	120	Keban 1 - 8	1,330	6,000	5,820
Soma A	44	300	Kemer	48	135	65
Tuncbilek A	129	830	Kesikkopru	76	250	110
Tuncbilek B 1,2	300	1,800	Sariyar	160	400	330
Soma B 1,2,3	495	2,970	Suat Ugurlu	46	273	206
Yatagan 1,2,3	630	3,780	Hasan Ugurlu	500	1,217	820
Seyitomer 1,3	450	2,700	Oymapinar 1 - 4	540	1,620	482
Elbistan A 1,2	680	3,900	Aslantas 1 - 3	138	569	360
Jeotermal	15	90	Cildir	15.4	30	26
Aliaga - Cevrim	180	540	Tortum	26.18	85	85
Bornova	30	90	Kovada 1	8.25	41	20
Seydisehir	120	360	Kovada 2	53	220	121
Engil	15	45	Hazar 1	20.12	128	16
Petkim - Aliaga	120.8	340	Dogankent (A+B)	73.3	314	62
Erdemir	50	300	Cag-Cag 1	14.4	42	42
ISDEMIR	90	540	Goksu	10.8	65	55
IPRAS	30	150	Ikizdere	15.2	100	65
AKSA	20	70	Seyhan	60	350	290
Izmit - SEKA	18	75	Kadincik 1	70	315	190
Dalaman - SEKA	21	80	Kadincik 2	56	307	200
Silifke - SEKA	16	70	Kepez	26.4	160	130
Eskisehir - Seker	17	25				
Turhal - Seker	16.8	30				
Karabuk	16	58				

Table 4-3 Major Transmission Line in Operation

Name	Nominal Voltage (kV)	Length (Km)	Conductor (MCM)
Keban-Golbasi	380	550	2 x 954
Golbasi-Umraniya	380	355	954
Golbasi-Gokcekaya	380	167	954
Gokcekaya-Umraniaya	380	216	954
Osmaniya-Seydisehir	380	418	2 x 954
Balikesir-Bursa	380	120	2 x 954
Yatagan-Ismir II	380	150	2 x 954
Elbistan-Kayseri	380	138	2 x 954
Oymapinar-Kepez	380	100	2 x 954
Bursa-Adapazari II	380	154	2 x 954
Gokcekaya-Seyitomer - Ismir II	380	435	954
Hopa - S.S.C.B.	220	31	954

Table 4–4 Transmission and Distribution Lines

Year	Transmission Lines				Distribution Lines	Total
	380 kV & 220 kV	154 kV	66 kV	Total		
1962	–	2,166	1,024	3,190	2,432	5,622
1967	–	4,129	1,870	5,999	6,071	12,070
1972	355	6,010	2,436	8,801	44,861	53,662
1977	2,684	10,748	2,481	15,913	70,583	86,496
1978	2,856	12,527	2,490	17,873	77,214	95,087
1979	2,890	13,677	2,494	19,061	83,714	102,775
1980	2,897	14,351	2,498	19,746	96,393	116,139
1981	2,915	15,143	2,498	20,556	99,104	119,660
1982	3,469	15,602	2,490	21,561	102,589	124,150
1983	3,638	15,662	2,315	21,615	110,961	132,576
1984	4,480	15,679	2,182	22,341	116,241	138,582

4.4 Present Status of Power Demand and Supply

The total electricity generation in Turkey was 30,614 GWh as of 1984, which was about 2.3 times the amount in a decade before. The average annual growth rate is 8.6%. The past trend in the electricity generation is given in Table 4-5.

The trend in the ratio of hydroelectric power in the total energy generation is illustrated in Fig. 4-3. The ratio of hydroelectric power grew steadily since 1973, and recorded 46% as of 1984.

The past trends in the maximum load of each month are given in Table 4-6. The annual maximum load was normally observed in December. Since 1978, however, the yearly maximum sometimes occurred in months other than December, the peak month being November in 1978 and 1980, and September in 1983. The reason for this may be that the supply shortage became serious from 1978, and the load in December was suppressed due to load restrictions enforced.

The annual average growth rate of the peak demand in the past ten years is 8.1%, being at a similar level as the energy growth.

A typical daily load curve is presented in Fig. 4-4. The yearly trends of the power demand and supply in TEK's power system is presented in Table 4-7. The ratio of different energy sources in the supply power in meeting the peak load, and the status of power shortage are given in Table 4-8. The ratio is different energy sources in annual generations from 1981 to 1984 are given in Table 4-9.

The analysis of the power demand and supply balance in 1984 in the TEK power system indicates that the proportion of the imported electricity was 9.9% - Bulgaria accounting for 7.4% and U.S.S.R. 2.5%. The purchase of electricity by TEK from other companies account for 1.1% of the total. The rate of transmission loss of 5.9% is a universal level.

Regarding the proportion of source of power for the peak load, the weight of hydroelectric power was 53.6% in 1984, and contribution of the dam type hydroelectric power plants were remarkable. The imported power also accounts for 5% of the peak supply.

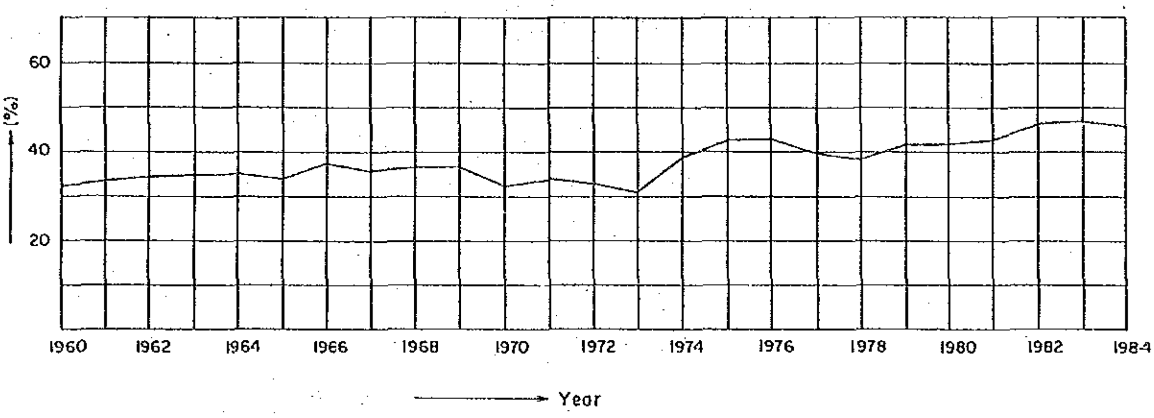

Fig. 4–2 Percentage of Hydraulic Power Plants in Total Installed Capacity

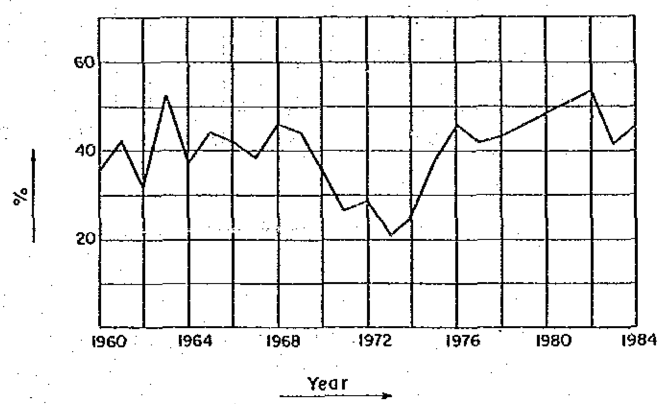

Fig. 4–3 Percentage of Hydraulic Energy in Gross Energy Generated

Tuesday December 18, 1984

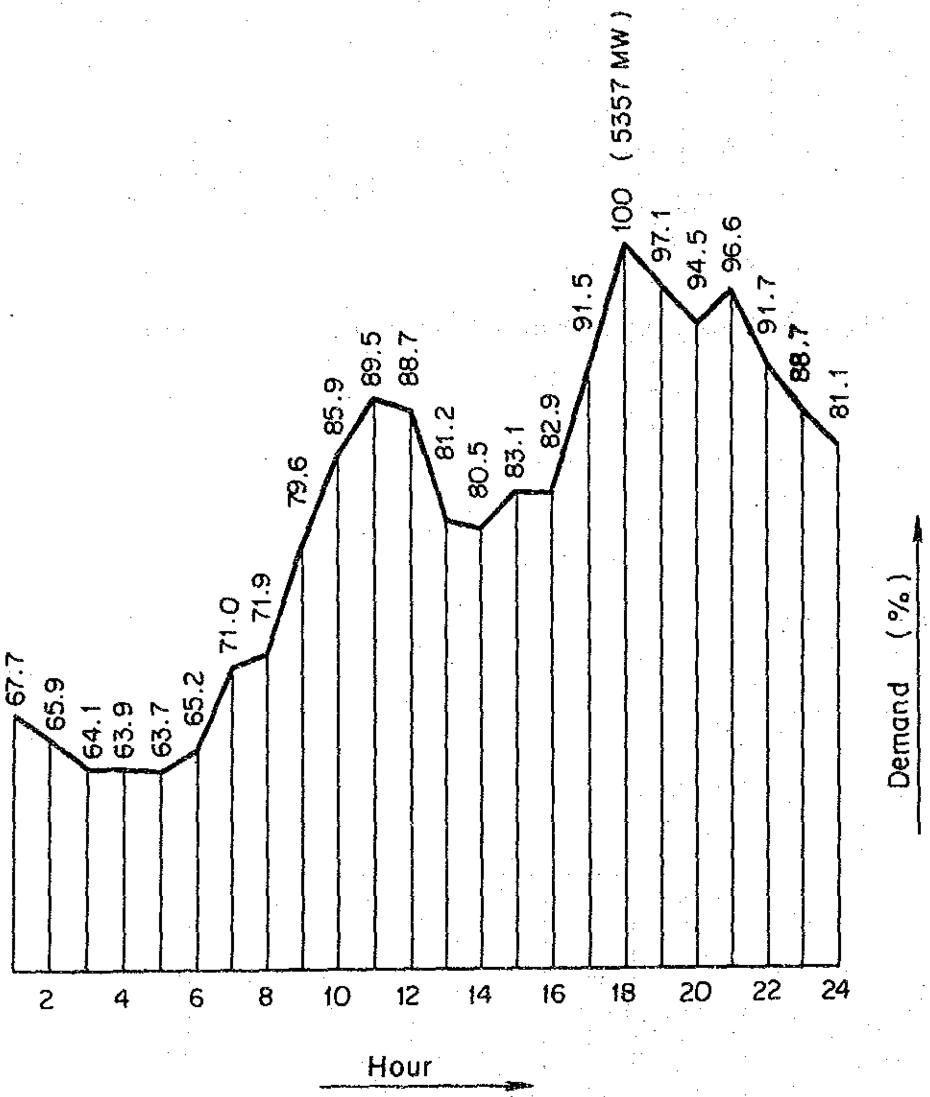

Fig. 4–4 Typical Daily Demand Curve

Table 4–5 Gross Energy Generated

Unit: GWh

Year	Furnished by TEK			Furnished by Others			Total		
	Thermal	Hydraulic	Total	Thermal	Hydraulic	Total	Thermal	Hydraulic	Total
1960	920	751	1,671	894	250	1,144	1,814	1,001	2,815
1961	974	997	1,971	772	268	1,040	1,746	1,265	3,011
1962	1,280	809	2,089	1,156	315	1,471	2,436	1,124	3,560
1963	849	1,740	2,589	1,030	364	1,394	1,879	2,104	3,983
1964	1,451	1,236	2,687	1,352	412	1,764	2,803	1,648	4,451
1965	1,442	1,682	3,124	1,332	497	1,829	2,774	2,179	4,953
1966	1,746	1,771	3,517	1,467	567	2,034	3,213	2,338	5,551
1967	2,453	1,787	4,240	1,382	595	1,977	3,835	2,382	6,217
1968	2,485	2,535	5,020	1,276	640	1,916	3,761	3,175	6,936
1969	2,841	2,749	5,590	1,552	696	2,248	4,393	3,445	7,838
1970	3,915	2,358	6,273	1,675	675	2,350	5,590	3,033	8,623
1971	5,890	1,912	7,802	1,281	698	1,979	7,171	2,610	9,781
1972	6,833	2,291	9,124	1,205	913	2,118	8,038	3,204	11,242
1973	8,223	2,035	10,258	1,599	568	2,167	9,822	2,603	12,425
1974	8,585	2,604	11,189	1,536	752	2,288	10,121	3,356	13,477
1975	8,201	4,644	12,845	1,518	1,260	2,778	9,719	5,904	15,623
1976	8,254	7,200	15,454	1,654	1,175	2,829	9,908	8,375	18,283
1977	9,804	7,433	17,237	2,168	1,160	3,328	11,972	8,593	20,565
1978	9,907	8,061	17,968	2,454	1,300	3,754	12,361	9,365	21,726
1979	9,800	9,134	18,934	2,418	1,170	3,588	12,215	10,304	22,522
1980	9,382	10,033	19,415	2,545	1,315	3,860	11,927	11,348	23,275
1981	9,463	11,125	20,588	2,594	1,491	4,085	12,057	12,616	24,673
1982	10,256	12,987	23,243	2,129	1,180	3,309	12,385	14,167	26,552
1983	13,542	10,147	23,689	2,456	1,202	3,658	15,998	11,249	27,347
1984	14,426	12,260	26,686	2,221	1,707	3,928	16,647	13,967	30,614

Table 4–6 Monthly Maximum Demand

Unit: MW

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1966	790	791	806	776	771	763	737	763	814	863	908	928
1967	903	909	916	893	895	873	840	843	944	1,018	1,027	1,058
1968	1,026	1,006	1,014	988	977	977	963	987	1,054	1,145	1,134	1,179
1969	1,170	1,147	1,122	1,108	1,102	1,091	1,098	1,112	1,178	1,248	1,285	1,287
1970	1,296	1,292	1,272	1,268	1,250	1,256	1,260	1,258	1,357	1,442	1,434	1,508
1971	1,520	1,503	1,540	1,504	1,466	1,467	1,478	1,502	1,521	1,621	1,740	1,787
1972	1,758	1,713	1,702	1,683	1,696	1,645	1,668	1,687	1,747	1,842	1,904	1,951
1973	1,947	1,891	1,930	1,892	1,861	1,838	1,815	1,864	1,914	1,986	2,064	2,139
1974	2,087	2,069	2,052	2,014	2,037	2,059	2,034	2,078	2,215	2,269	2,490	2,511
1975	2,352	2,284	2,321	2,321	2,268	2,248	2,281	2,342	2,484	2,550	2,703	2,782
1976	2,783	2,808	2,839	2,775	2,709	2,712	2,759	2,850	2,959	3,095	3,217	3,223
1977	3,216	3,305	3,282	3,317	3,226	3,186	3,186	3,182	3,306	3,350	3,370	3,376
1978	3,243	3,325	3,356	3,340	3,335	3,327	3,288	3,349	3,402	3,513	3,641	3,591
1979	3,594	3,614	3,628	3,607	3,443	3,448	3,436	3,485	3,547	3,596	3,623	3,667
1980	3,586	3,579	3,692	3,663	3,679	3,549	3,683	3,671	3,793	3,804	3,947	3,894
1981	3,634	3,732	3,839	3,847	3,851	3,681	3,863	3,750	3,780	3,738	3,838	4,086
1982	4,080	4,097	4,132	4,196	4,210	4,307	4,264	4,346	4,510	4,411	4,477	4,513
1983	4,434	4,422	4,501	4,545	4,564	4,542	4,423	4,511	4,731	4,529	4,608	4,601
1984	4,615	4,831	4,818	4,872	5,000	4,954	5,029	5,161	5,412	5,436	5,450	5,457

Table 4–7 TEK's Energy Balance

Year	1977	1978	1979	1980	1981	1982	1983	1984
Gross Generation (GWh)	17,230	17,968	19,934	19,415	20,588	23,243	23,689	26,686
Power Plant Internal Consumption (GWh)	985	1,060	1,117	1,074	1,099	1,212	1,463	1,632
Net Generation (GWh)	16,245	16,908	17,817	18,341	19,489	22,031	22,226	25,054
Energy Purchased (GWh)	809	912	1,172	1,484	1,752	1,895	2,484	2,948
Energy Supplied to the Network (GWh)	17,054	17,820	18,989	19,824	21,241	23,926	24,710	28,002
Network Loss (GWh) (%)	841 (4.9)	923 (5,2)	1,033 (5,4)	1,200 (6.1)	1,160 (5.6)	1,410 (6.1)	1,556 (6.6)	1,577 (5.9)
Energy Sold (GWh)	16,213	16,897	17,956	18,624	20,081	22,516	23,154	26,425

Table 4–8 Meeting of the Peak

	1982		1983		1984	
	(MW)	(%)	(MW)	(%)	(MW)	(%)
Power Plants with dam	2,291.0	50.8	1,886.0	39.8	2,694.0	49.4
Rivers	208.5	4.6	238.0	5.0	232.0	4.2
Fuel-Oil	771.4	17.1	723.4	15.3	799.1	14.6
Stone-coal	117.2	2.6	64.8	1.4	92.1	1.7
Lignite	698.4	15.5	1,271.4	26.8	1,361.6	25.0
Diesel-Oil	176.1	3.9	189.1	4.0	3.0	0.1
Supplied						
from Bulgaria	200.0	4.4	250.0	5.3	205.0	3.7
from U.S.S.R.	50.0	1.1	108.0	2.3	70.0	1.3
TOTAL	4,512.6	100.0	4,730.7	100.0	5,456.8	100.0
Total Peak without interruption	5,001.5		5,333.1		5,456.8	
Interruption and Rstriction imposed	488.9	(9.8)	602.4	(11.3)	0	
Date	December 15th. 1982, Wednesday at 18.35 p.m.		September 14th. 1983, Wednesday at 20.50 p.m.		December 15th. 1984, Wednesday at 17.30 p.m.	

Table 4–9 Distribution of Electrical Energy Generated

Year	1981		1982		1983		1984	
	GWh	%	GWh	%	GWh	%	GWh	%
Thermal Power Plants	12,057	48.9	12,385	46.6	16,004	58.5	17,187	56.1
Coal	892	3.6	913	3.4	787	2.9	705	2.3
Lignite	5,244	21.3	6.011	22.6	7,790	28.5	9,413	30.7
Oil	5,196	21.1	4,823	18.2	6,348	23.2	6,711	21.9
Others	725	2.9	638	2.4	1,079	3.9	358	1.2
Gas. Tur.								
Diesel								
Geothermal								
Hydraulic Power Plants	12,616	51.1	14,167	53.4	11,343	41.5	13,427	43.9
Total	24,673	100.0	26,552	100.0	27,347	100.0	30,614	100.0

CHAPTER 5 ELECTRIC POWER DEMAND AND SUPPLY FORECAST

CHAPTER 5. ELECTRIC POWER DEMAND AND SUPPLY FORECAST

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CHAPTER 5. ELECTRIC POWER DEMAND AND SUPPLY FORECAST

5.1 Electric Power Demand Forecast

This chapter is devoted to the outline of demand forecast performed by TEK, the long term demand forecast by the macroscopic method prepared by the JICA team, and a comparison of the results of these forecasts.

The Yusufeli Project is scheduled to commence operation around the year 2000, and as the long term demand forecast was prepared up to the year 2008, the trend of power demand in the period around the commissioning of this project can be studied.

5.1.1 Power Demand Forecast Conducted by TEK

TEK's method of electric power demand forecast is as described below.

The period of demand forecast is divided into two periods. For the first period, forecast by category of demand, in which the consumers (factories, shops, general residence, etc.) are surveyed concerning their production plans, trend of consumption, behavior of consumption, etc., and the survey results are converted to electric demands, and such demands are added to the predicted total demand. For the second period, the macroscopic method is used. The past records of total power generation (from 1970 to 1982) and the forecast values for the first period are taken as the basis, and the prediction is made by means of the correlation between the power demand and the macroscopic indices such as population growth rate and GNP per capita growth rate.

The following calculation conditions have been used.

(1) Period of forecast: 22 years (from 1984 to 2005)
(2) Reference year: 1983
(3) Population growth rate: 2.1%
(4) Growth rate of GNP per capita: 5.55% p.a.
(5) Forecast of maximum demand:

The load factor is assumed as 64% based on past record. The maximum demand in each year is calculated by the following equation.

$$P_{max} = E_g/(L_f \times 365 \times 24) \quad (MW)$$

where: P_{max} ; maximum demand (MW)

E_g ; total annual generation (MWh)

L_f ; load factor (=0.64)

The result of demand forecast conducted by TEK is presented in Table 5-1. The average growth rates of annual generation for each five years are given in Table 5-2.

In the demand forecast method of TEK, the first period is defined only for the very near future (3 to 5 years), and this method can be regarded as a combination of microscopic and macroscopic methods when it is applied to a long range forecast.

As indicated in Table 5-2, the demand growth rate dropped sharply in the period from 1978 to 1983 due to the economic recession caused by the oil crisis. Later, the annual growth rate revived to more than 10% reflecting the recovery in economic activities.

The forecast projects that the total annual generation in the year 2003 will be approximately 206,000 GWh, and the per capita electricity consumption will amount to 2,895 kWh.

The trend of per capita electricity consumption for the period of forecasting is presented in Table 5-3.

Table 5-1 Results of Demand Forecast by TEK

Year	Gross Energy Generated (GWh)	Maximum Demand (MW)
1984	33,175	5,790
1985	36,850	6,570
1986	41,000	7,300
1987	45,800	8,170
1988	51,200	9,130
1989	57,050	10,180
1990	63,300	11,290
1991	70,000	12,480
1992	77,200	13,770
1993	84,950	15,150
1994	93,300	16,640
1995	102,450	18,270
1996	112,550	20,100
1997	123,600	22,045
1998	135,800	24,220
1999	148,800	26,540
2000	162,600	29,000
2001	177,130	31,000
2002	189,822	33,100
2003	205,958	35,400
2004	223,232	37,900
2005	239,938	40,500

Table 5-2 Average Growth Rate of Energy Generation

Period (Year)	Growth Rate (%)
1963 - 1968	11.7
1968 - 1973	12.4
1973 - 1978	12.5
1978 - 1983	5.8
1963 - 1983	10.6
1983 - 1988	11.3
1988 - 1993	10.7
1993 - 1998	9.8
1998 - 2003	8.7
1983 - 2003	10.1

Table 5-3 Energy Generation per Capita

Planned Period	Energy Generation (GWh)	Population	kWh	Growth Rate (%)
End of 1988	51,200	52,370	978	9.2
End of 1993	84,950	58,000	1,465	8.4
End of 1998	135,800	64,240	2,114	7.6
End of 2003	205,958	71,150	2,895	6.5

5.1.2 Electric Power Demand Forecast by Macroscopic Method

Several methodology of electric power demand forecasting are in practical use, including; (1) the method utilizing past trend, (2) the cross section method, (3) the forecasting by demand category method, and (4) the method utilizing correlations with economic indices such as GNP. The methods from (1) to (3) can be regarded as empirical methodology. All methods except the forecasting by demand category method are macroscopic in nature.

In this study, the demand forecast has been conducted based on a method utilizing the correlation between the electric power demand and GNP.

(1) Demand Forecast Based on GNP

It has been statistically proven that strong correlations exist between the energy or electric power demand and economic indices.

In particular, if the relation between the per capita GNP and the per capita electricity consumption is studied, a strong correlation can be found which is expressed by an approximation equation. Thus the power demand forecasting is very often performed by utilizing this correlation.

The following indices and basic conditions were used in the demand forecast of this study.

(a) Criteria and Statistical Indices

"New Method of Long Range or Very Long Range Demand Forecast of Energy Including Electricity Viewed from Worldwide Standpoint: Edited by EPDC"

(b) Period of Forecast; 25 years (from 1984 to 2008)

Although Yusufeli and Artvin Projects are to commence operation in 1997 according to the Master Plan, the actual year of commissioning is estimated to be around 2000 according to the studies made this time.

One of the objectives of the power demand forecast is to determine the time of commissioning a project, and a sufficient time band in the demand forecast is required in determining the start of operation. For this reason, the forecast was made for 25 years from 1984, or up to the year 2008.

(c) Calculation condition

i) Reference year; 1983

ii) Per capita GNP (1968 value); US$540

The gross national products in the reference year (1983) divided by the population of that year was converted to the value of the reference year for the economic indices.

GNP in 1983; US$25,653 x 10^6
Population in 1983; 47,279 x 10^3

Based on these statistics, the GNP per capita was calculated as US$540.

iii) Growth rate of GNP per capita; 4.0%

The growth rate of GNP per capita had been 4.2% for the 15 years before the oil crisis (1962 to 1977). (See Table 5-4.)

Even including the low growth rates that were caused by the oil crisis, the average growth rate for the 22 years including the period after the oil crisis (from 1962 to 1984) remains at 3.0%.

The general status of economy of Turkey is recovering from the recession that have continued from 1977. This tendency is indicated by the GNP growth rate of 3.7% in 1984.

Thus it was assumed that the oil crisis and the economic recession that followed is a temporary phenomenon, and the long term growth rate was assumed as 4.0%.

iv) Per capita electricity consumption; 630 kWh (in 1983)

The value 630 kWh was obtained by dividing the total electricity consumption of 29,658 GWh in the reference year (1983) with the population of 47,279 x 10^3.

v) Population; 47,279,000 (in 1983)

The total population of 47,279,000 in the reference year of 1983 was taken from "The Turkish Economy, '84".

vi) Population growth rate; 2.1%

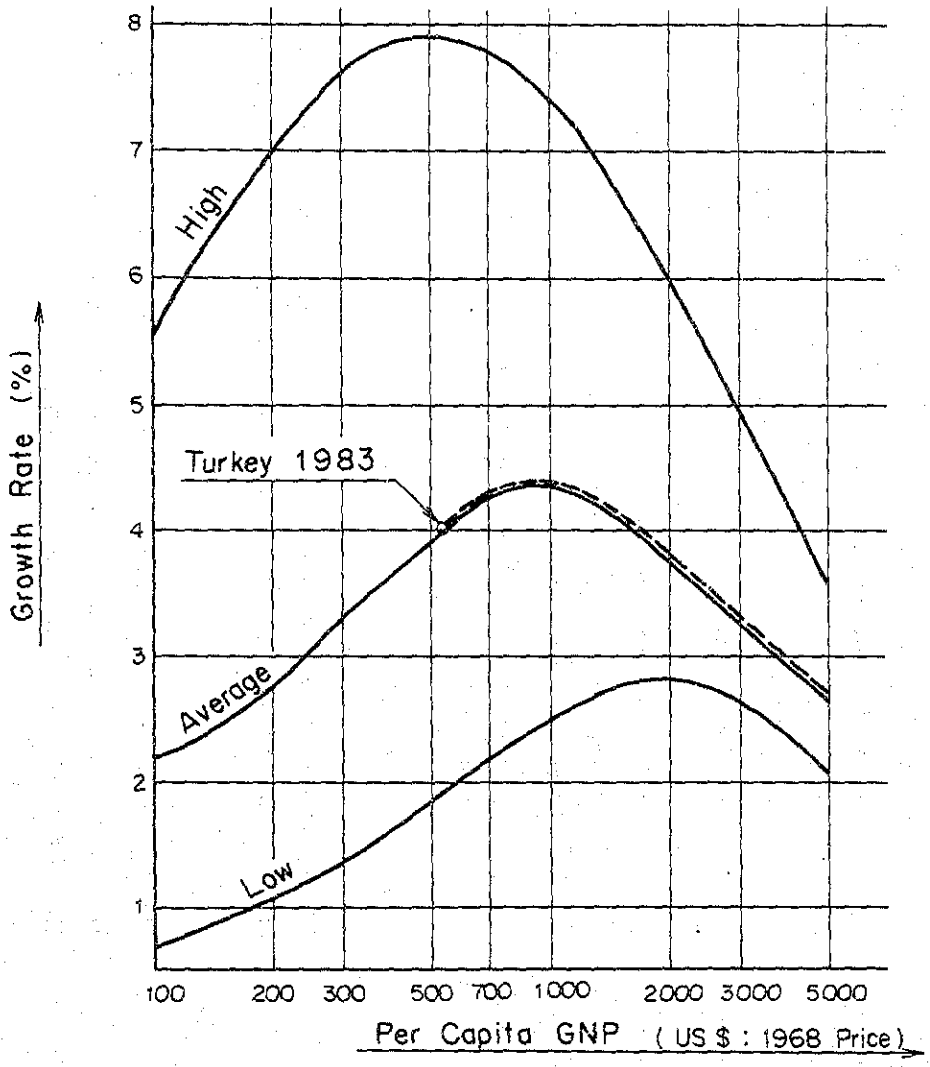
The population growth rate in Turkey was at a level of 2.5% in the period before 1977. Thereafter the growth rate tended to decrease, being 2.1% in the 7 years from 1977 to 1984. (See Table 5-4.) The growth rate of 2.1% recorded in the recent period was taken as the basis of this study.

The correlation between the per capita GNP and its growth rate was obtained from the data in Fig. 5-1, and the correlation between the per capita GNP and per capita electricity consumption is based on the data in Fig. 5-2.

(2) Result of Forecast

The forecast values of total annual generation calculated based on data of Table 5-4, Fig. 5-1 and Fig. 5-2 are presented in Table 5-5.

The forecast of the maximum demand was obtained by equation (5) in 5.1.1, based on the total generation obtained above and on the 64% load factor projected by TEK.



GNP/Capita (US $)	Growth Rate (%)	Average Growth Rate (%)
540	4.00	
		4.05
600	4.10	
		4.2
700	4.25	
		4.3
800	4.30	
		4.3
900	4.35	
		4.35
1 000	4.35	
		4.3
1 100	4.30	
		4.3
1 200	4.25	
		4.2
1 300	4.20	
		4.2
1 400	4.15	
		4.1
1 500	4.10	
		4.05
1 600	4.05	

Fig. 5–1 Correlation between per Capita GNP and Growth Rate

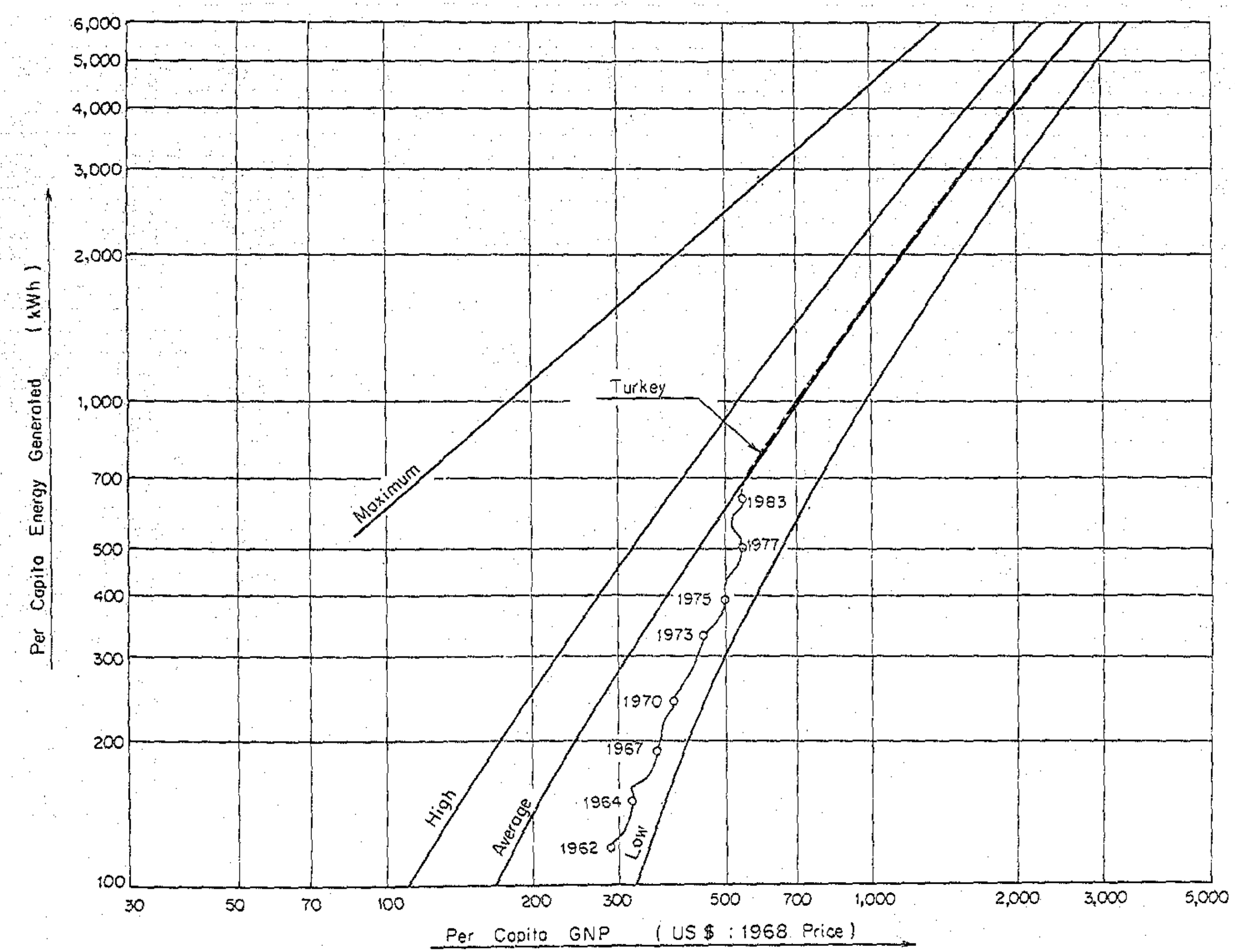


Fig. 5–2 Correlation between per Capita GNP and per Capita Energy

Table 5–4 Basic Data for Demand Forecast

	GNP (Constant Price in 1968)			Energy Generated		Population	Per Capita			
							GNP		Energy Generated	
	TL (billion)	US $ (million)	Growth Rate (%)	GWh	Growth Rate (%)	(Thousand)	US $	Growth Rate (%)	kWh	Growth Rate (%)
1962	76.8	8,496	6.2	3,560	18.2	28,933	290		120	
1963	84.2	9,314	9.6	3,983	11.9	29,655	310	6.9	130	8.3
1964	87.6	9,690	4.0	4,451	11.7	30,394	320	3.2	150	15.4
1965	90.4	10,000	3.2	4,953	11.3	31,391	320	0	160	6.7
1966	101.2	11,194	11.9	5,551	12.1	31,934	350	9.4	170	6.3
1967	105.5	11,670	4.3	6,217	12.0	32,750	360	2.9	190	11.8
Average			6.6		11.8	(2.5)		4.4		9.6
1968	112.5	12,444	6.6	6,936	11.6	33,585	370	2.8	210	10.5
1969	118.6	13,119	5.4	7,838	13.0	34,442	380	2.7	230	9.5
1970	125.4	13,872	5.7	8,623	10.0	35,605	390	2.6	240	4.3
1971	138.2	15,288	10.2	9,781	13.4	36,215	420	7.7	270	12.5
1972	148.5	16,420	7.4	11,242	14.9	37,132	440	4.7	300	11.1
Average			7.1		12.6	(2.5)		4.1		9.6
1973	156.5	17,312	5.4	12,425	10.5	38,072	450	2.3	330	10.0
1974	168.0	18,584	7.3	13,477	8.5	39,036	480	6.7	350	6.1
1975	181.4	20,060	7.9	15,623	15.9	40,348	500	4.2	390	11.4
1976	195.8	21,659	8.0	18,283	17.0	40,915	530	6.0	450	15.4
1977	203.4	22,500	3.9	20,565	12.5	41,768	540	1.9	490	8.9
Average			6.5		12.8	(2.4)		4.2		10.3
1978	209.2	23,142	2.9	21,726	5.6	42,640	540	0	510	4.1
1979	208.3	23,042	– 0.4	22,522	3.7	43,530	530	– 1.9	520	2.0
1980	206.1	22,799	– 1.1	23,275	3.3	44,737	510	– 3.9	520	0
1981	214.7	23,750	4.2	24,673	6.0	45,366	520	2.0	540	3.8
1982	224.5	24,834	4.6	26,552	7.6	46,312	540	3.8	570	5.6
Average			2.0		5.2	(2.1)		0		3.1
1983	231.9	25,653	3.3	27,347	3.0	47,279	540	0	580	1.8
1984	245.5	27,157	5.9	30,614	11.9	48,265	560	3.7	630	8.6
Average			4.6		7.3	(2.1)		1.8		5.1

Table 5–5 Results of Demand Forecast by Macro-Method

Year	Per Capita GNP Growth Rate (%)	Per Capita GNP US$ (1968 Price)	Per Capita kWh kWh	Per Capita kWh Growth Rate (%)	Population (10^3)	Gross Energy Generated GWh	Gross Energy Generated Growth Rate(%)	Maximum Demand (MW)
1983	4.0	540	630	3.9	47,279	29,568 1/		4,731
1984	4.05	562	670		48,270	32,300		5,800
1985	4.05	585	720		49,280	35,500		6,300
1986	4.05	609	770		50,310	38,800		6,900
1987	4.2	635	830		51,370	42,600		7,600
1988	4.2	662	890		52,450	46,700		8,300
Average	4.1			7.2	(2.1)		9.6	
1989	4.2	690	960		53,550	51,400		9,200
1990	4.2	719	1,010		54,670	55,200		9,800
1991	4.3	740	1,040		55,800	58,000		10,300
1992	4.3	782	1,130		57,000	64,700		11,500
1993	4.3	816	1,215		58,200	70,700		12,600
Average	4.25			6.4	(2.1)		8.6	
1994	4.3	851	1,295		59,400	76,900		13,700
1995	4.3	888	1,380		60,650	83,700		14,900
1996	4.3	926	1,470		61,920	91,000		16,200
1997	4.35	966	1,540		63,220	97,400		17,400
1998	4.35	1,008	1,630		64,550	105,200		18,800
Average	4.3			6.1	(2.1)		8.3	
1999	4.3	1,051	1,730		65,910	114,000		20,300
2000	4.3	1,096	1,840		67,290	123,800		22,100
2001	4.3	1,143	1,940		68,700	133,300		23,800
2002	4.3	1,192	2,050		70,140	143,800		25,700
2003	4.3	1,243	2,170		71,610	155,400		27,700
Average	4.3			5.9	(2.1)		8.1	
2004	4.2	1,295	2,290		73,110	167,400		29,900
2005	4.2	1,349	2,420		74,650	180,700		32,200
2006	4.2	1,406	2,550		76,220	194,400		34,700
2007	4.1	1,464	2,710		77,820	210,900		37,600
2008	4.1	1,524	2,850		79,450	226,400		40,400
Average	4.15			5.6	(2.1)		7.8	

1/ Including imported energy of 2,221 GWh

5.1.3 Comparison of Results of Forecasts

The power demand forecast obtained by the macroscopic method and that prepared by TEK are compared and given in Table 5-6 and Fig. 5-3.

The values of annual total generation obtained by the macroscopic method are lower than TEK's forecast, the difference being 22.5% in 1988.

In terms of annual growth rate of demand, however, the difference between the two forecasts is small. The average annual growth rate for a period of 22 years up to 2005 is 9.9% according to TEK's forecast, and 8.6% according to the macroscopic method.

This difference is based on the growth rate of per capita GNP adopted in the forecast. This value is 5.55% in TEK's forecast, and 4.0% in the macroscopic forecast conducted in this study.

5.2 Power Supply Program

This chapter pertains to the electric power development plan for economic development and economic operation of power facilities which are required to secure stable power supply meeting the demand projected in the above forecast, and the analysis of electric power demand and supply balance.

5.2.1 Electric Power Development Plan

It is estimated at present that the hydroelectric power potential that can be economically developed in Turkey amounts to 30,800 MW, which will provide firm energy of 72,500 GWh annually and annual generation of 102,500 GWh. As of 1984, only about 13% of this hydroelectric potential has been developed.

The electric power development plan formulated for the period from 1985 to 2003 is given in Table 5-7 and Table 5-8. This plan is based on the plans formulated by DSI and TEK, and the original plans were modified to some extent so that it is compatible to the power demand forecast obtained by the macroscopic method. According to this plan, the total installed capacity in the year 2000 will become 3.9 times the present value, amounting to 33,038 MW.

The firm generation will also be 3.9 times, and will be 132,923 GWh annually.

In the development program, a number of lignite-fired thermal power plants, typically represented by Elbistan Thermal Power Plant, will be developed in succession until the end of the 1990's. The first nuclear power plant will be completed in mid-1990's, and the thereafter the weight of development programs will be shifted toward the nuclear power.

Large hydroelectric projects, typically represented by Altinkaya and Karakaya will be completed around 1990. Thereafter large hydroelectric projects, such as Ataturk, Kayraktepe and Boyabat will be implemented in the period from early 1990's to the late 1990's.

The details of this electric power development plan is presented in Table.AP.1-1 in Appendix 1.

In 2000, the hydroelectric power will account for approximately 55% of the total installed capacity. The trend of this proportion is presented in Fig. 5-4.

As indicated in Fig. 5-5, the degree of utilization of the hydroelectric potential of Turkey will advance year by year. By year 2000, 61.5% of the hydroelectric resources available will be utilized, and the hydroelectric power will substantially contribute to the power supply of Turkey as valuable indigenous energy resource. The hydroelectric power plants now under construction are listed in Table 5-9.

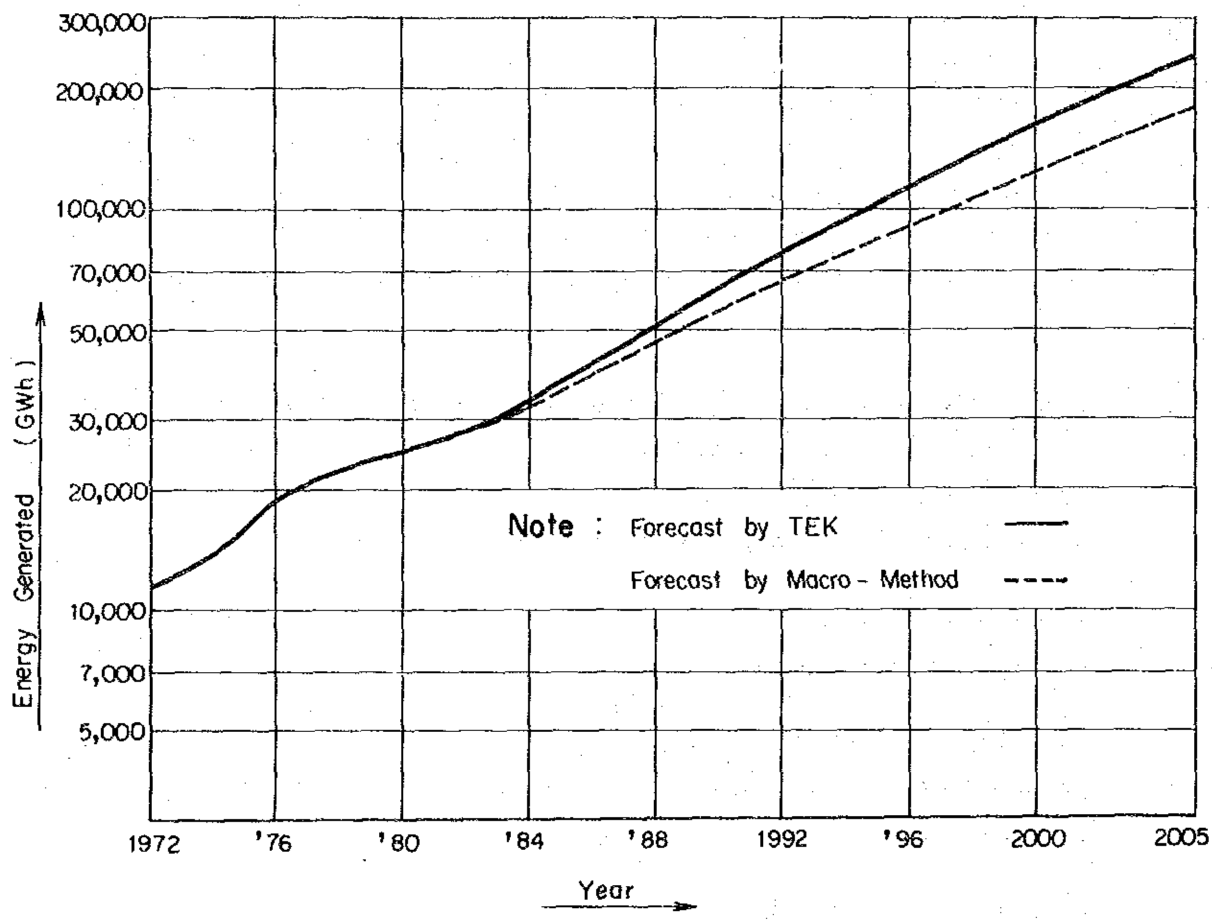


Fig. 5–3 Comparison of Demand Forecasts: Energy

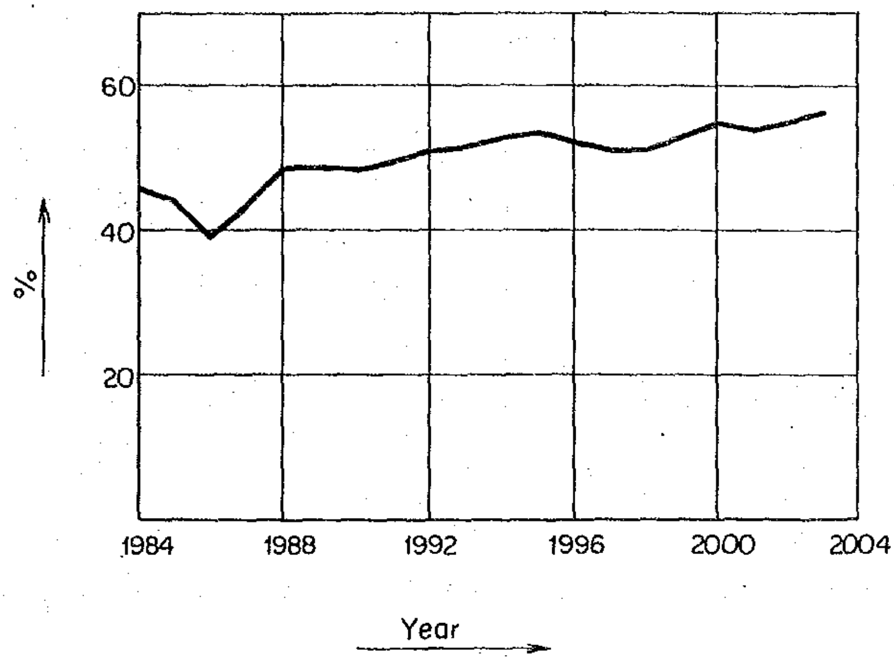


Fig. 5–4 Ratio of Hydraulic Power Plants in Total Installed Capacity (Forecast)

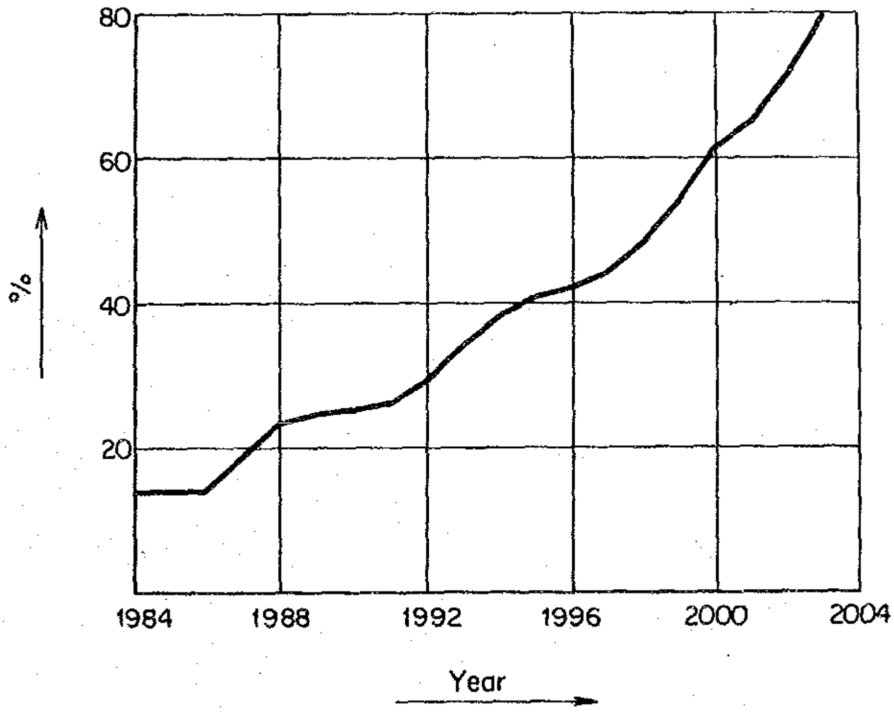


Fig. 5–5 Utilization of the Hydroelectric Potential of Turkey

Table 5-6 Comparison of Demand Forecasts

Period (Year)	By TEK		By Macro-method		Difference	
	GWh : (a)	Growth Rate (%)	GWh : (b)	Growth Rate (%)	(c) (a)-(b)	% (c)/(a)
End of 1983	30,000 1/	6.1	29,568 2/	5.8	432	1.4
End of 1988	51,200	11.3	46,700	9.6	4,500	8.8
End of 1993	84,950	10.7	70,700	8.6	14,250	16.8
End of 1998	135,800	9.8	105,200	8.3	30,600	22.5
End of 2003	205,958	8.7	155,400	8.1	50,558	24.5
End of 2005	239,938	7.9	180,700	7.8	59,238	24.7
1983 - 2005		9.9		8.6		

1/ Estimated by JICA Team

2/ Actural record

Table 5–7 Construction Schedule of Power Plant in Tuekey

(Unit: MW)

Year	Installed Capacity					Average Capacity		Continuous Capacity	
	Thermal		Hydraulic		Total	Hydraulic	Total	Hydraulic	Total
	New Plant	Total (1)	New Plant	Total (2)	(1) + (2)	(3)	(1) + (3)	(4)	(1) + (4)
Existing		4,584		3,875	8,459	1,621	6,205	1,194	5,778
1985	340	4,924	-	3,875	8,799	1,621	6,545	1,194	6,118
1986	1,010	5,934	30	3,905	9,839	1,637	7,571	1,204	7,138
1987	300	6,234	950	4,855	11,089	2,210	8,444	1,731	7,965
1988	150	6,384	1,151	6,006	12,390	2,755	9,139	2,136	8,520
1989	350	6,734	390	6,396	13,130	2,891	9,625	2,200	8,934
1990	720	7,454	656	7,052	14,506	2,949	10,403	2,223	9,677
1991	200	7,654	327	7,379	15,033	3,059	10,713	2,292	9,946
1992	500	8,154	1,022	8,401	16,555	3,388	11,542	2,470	10,624
1993	600	8,754	975	9,376	18,130	4,012	12,766	3,016	11,770
1994	600	9,354	1,110	10,486	19,840	4,511	13,865	3,407	12,761
1995	600	9,954	931	11,417	21,371	4,785	14,739	3,592	13,546
1996	1,000	10,954	790	12,207	23,161	4,926	15,880	3,678	14,632
1997	1,320	12,274	740	12,947	25,221	5,178	17,452	3,840	16,114
1998	900	13,174	947	13,894	27,068	5,703	18,877	4,149	17,323
1999	900	14,074	2,000	15,894	29,968	6,395	20,469	4,607	18,681
2000	900	14,974	2,170	18,064	33,038	7,191	22,165	5,158	20,132
2001	1,300	16,274	1,059	19,123	35,397	7,628	23,902	5,421	21,695
2002	1,000	17,274	1,995	21,118	38,392	8,433	25,707	5,934	23,208
2003	1,100	18,374	2,762	23,880	42,254	9,329	27,703	6,490	24,864
Total (Additional)	13,790	-	20,005	-	-	-	-	-	-

Table 5-8 Schedule of Energy Generation

(Unit : GWh)

Year	By Thermal: (1)	By Hydraulic Firm: (2)	By Hydraulic Average: (3)	Total Firm : (1)+(2)	Total Average : (1)+(3)
Existing	23,420	10,460	14,200	33,880	37,620
1985	25,370	10,460	14,200	35,830	39,570
1986	31,250	10,544	14,342	41,792	45,592
1987	33,050	15,161	19,358	48,211	52,408
1988	33,950	18,714	24,132	52,664	58,082
1989	36,050	19,272	25,326	55,322	61,376
1990	40,370	19,473	25,837	59,843	66,207
1991	41,570	20,076	26,799	61,646	68,369
1992	44,720	21,635	29,683	66,355	74,403
1993	48,620	26,423	35,146	75,043	83,766
1994	52,220	29,848	39,514	82,068	91,734
1995	56,120	31,462	41,919	87,582	98,039
1996	62,120	32,217	43,151	94,337	105,271
1997	70,340	33,639	45,359	103,979	115,699
1998	76,190	36,346	49,955	112,536	126,145
1999	82,040	40,358	56,021	122,398	138,061
2000	87,740	45,183	62,997	132,923	150,737
2001	95,690	47,488	66,824	143,178	162,514
2002	101,690	51,980	73,872	153,670	175,562
2003	108,290	56,849	81,726	165,139	190,016
Total (Additional)	84,870	46,389	67,526	131,259	152,396

Table 5–9 Major Hydraulic Power Plants under Construction

Project	Installed Capacity (MW)	Energy Generated (GWh)		Year of Commissioning
		Average	Firm	
Adiguzel	61	280	150	1986
Kilickaya	120	332	277	1986
Karakaya	1,800	7,354	6,800	1989
Catalan	156	491	271	1990
Karacaoren	32	142	84	1986
Gezende	150	528	130	1988
Altinkaya	700	1,632	1,236	1988
Menzelet	120	334	192	1987
Ataturk	2,400	8,900	7,400	1991
Kralkizi	90	140	111	1991

5.2.2 Demand and Supply Balance

The balance of demand and supply was evaluated for both kW and kWh based on the demand obtained by the forecast described above.

In evaluating the kW balance, it was checked if sufficient supply capacity is secured for the peak load in the dry season, and in the summer and winter peak periods.

In this evaluation, it is required to assume the daily load curves for the years around the time of commissioning of Yusufeli Project. These daily load curves were formulated based on the typical load curves in the past and present, and on the total maximum demand obtained by the forecast, and it was checked if the sufficient supply capacity can be secured. In assuming the load curve, the load characteristics in the past had to be analyzed.

The following factors were taken into consideration in the analysis.

* Monthly electricity demands in the past, maximum demand of each month, annual electricity demand, and annual load factor.

* Typical daily load curves in each month in the past, and the daily load factor.

* Wet season and dry season in Turkey

The kWh balance was checked in terms of the annual total kWh demand and the kWh demand in the most dry month.

In checking the adequacy of the supply capability, it was studied whether the supply capability of both hydro and thermal plants are sufficient for the maximum demand obtained by the forecast in each year.

In estimating the supply capability of the thermal power plants, the reduction of output of old thermal power plants, the rate of decommissioning, the rate of faults and repair shutdowns were taken into consideration.

In estimating the hydroelectric power supply, the fault and repair shutdown rates were considered as in the case of thermal plants. At the same time, the firm power in the most dry year was estimated to calculate the supply capability to be secured by hydro power.

The conditions assumed in calculating the supply capability are presented below.

* Thermal Power

Output reduction and decommissioning rate:

It was assumed that the present plant capacity is reduced at the rate of 5% per year.

Fault and repair shutdown rate: 7.3%/year

* Hydro Power

Fault shutdown rate: 0.5%
Repair shutdown rate: 2% x 1/12 months

The results of the studies discussed above are summarized in Table 5-10 and Table 5-11 in the form of kW and kWh balances up to the year 2003. The demand and supply balance trends are presented as charts in Fig. 5-6 and Fig. 5-7.

As indicated by these tables and charts, sufficient supply capability satisfying the demand can be secured in terms of both firm output and firm generation. However, the present status is such that electric power amounting to 8% of the total consumption is being imported as of 1984. This is due to the low availability of the generating facilities in Turkey which, in combination with problems in the power system and load dispatching operations, creates supply shortage.

Considering this situation, it is concluded that prompt implementation of the established power development projects is indispensable, and it is expected that the stable balance in power demand and supply will gradually be secured after 1989.

It is estimated that Yusufeli and Artvin Power Plants will commence services around the year 2000. The additional supply capability of

540 MW and 320 MW provided by these Project at that time means that an about 7.8% supply margin will be created for the total demand.

An about 7.4% margin will also be created in terms of the firm electricity supply.

Thus it can be concluded that the proposed timing of completion of this Project is appropriate in securing proper balance of electric power demand and supply.

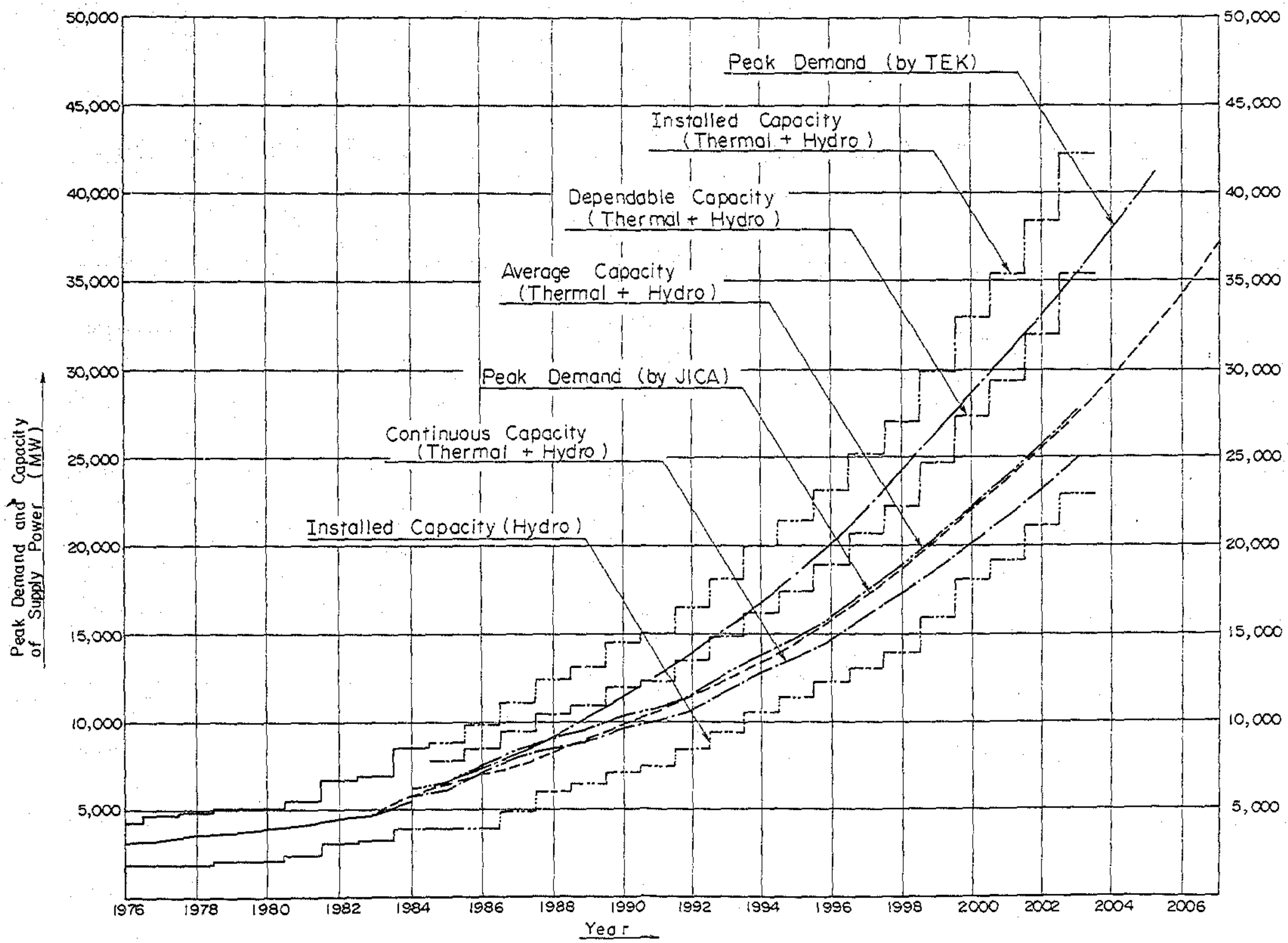


Fig. 5–6 Demand Forecast: Power

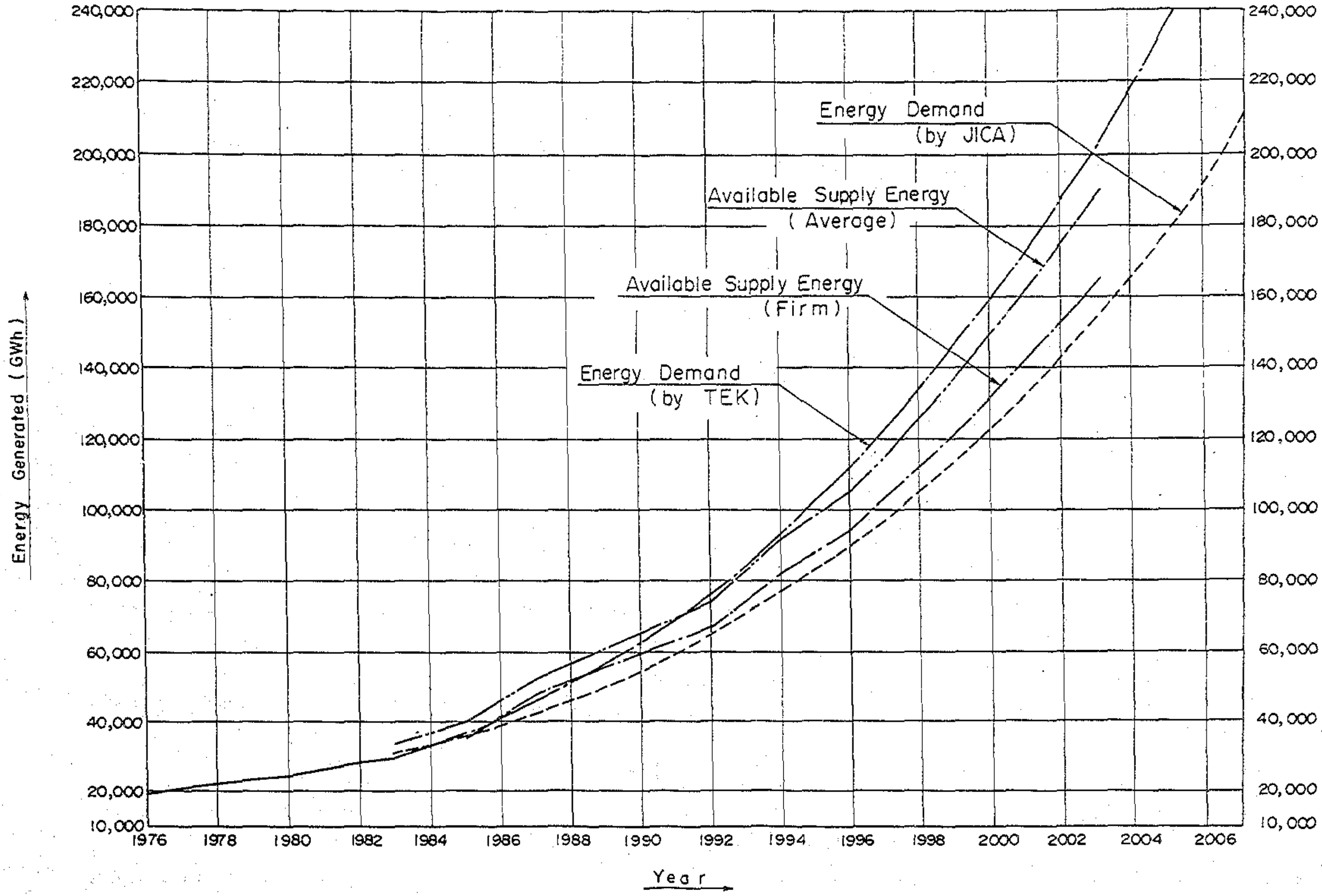


Fig. 5–7 Demand Forecast: Energy

Table 5-10 Power Demand and Supply Balance

Year	Peak Demand (MW) (1)	Reserve Capacity (MW) (1)x 1.15 =(2)	Installed Capacity (MW)	Available Power Supplied		Dependable Capacity (MW) (3)	Allowance	
				Average (MW)	Continuous (MW)		(MW) (3)-(2)=(4)	% (4)/(2)
1985	6,300	7,245	8,799	6,545	6,118	7,784	539	7.4
1986	6,900	7,935	9,839	7,571	7,138	8,529	594	7.5
1987	7,600	8,740	11,089	8,444	7,965	9,446	706	8.1
1988	8,300	9,545	12,390	9,139	8,520	10,413	868	9.1
1989	9,200	10,580	13,130	9,625	8,934	10,897	317	3.0
1990	9,800	11,270	14,506	10,403	9,677	11,972	702	6.2
1991	10,300	11,845	15,033	10,713	9,946	12,279	434	3.7
1992	11,500	13,225	16,555	11,542	10,624	13,493	268	2.0
1993	12,600	14,490	18,130	12,766	11,770	14,765	275	1.9
1994	13,700	15,755	19,840	13,865	12,761	16,165	410	2.6
1995	14,900	17,135	21,371	14,739	13,592	17,413	278	1.6
1996	16,200	18,630	23,161	15,880	14,632	18,911	281	1.5
1997	17,400	20,010	25,221	17,452	16,114	20,670	660	3.3
1998	18,800	21,620	27,068	18,877	17,323	22,230	610	2.9
1999	20,300	23,345	29,968	20,469	18,681	24,733	1,388	5.9
2000	22,100	25,415	33,038	22,165	20,132	27,392	1,977	7.8
2001	23,800	27,370	35,397	23,902	21,695	29,438	2,068	7.6
2002	25,700	29,555	38,392	25,707	23,208	32,045	2,490	8.4
2003	27,700	31,855	42,254	27,703	24,864	35,432	3,577	11.2

Table 5-11 Estimated Energy Balance

Year	Energy Demand Estimated :(1) (GWh)	Available Energy Supplied Firm : (2) (GWh)	Available Energy Supplied Average :(3) (GWh)	Allowance Firm GWh:(4) (2)-(1)	Allowance Firm % (4)/(1)	Allowance Average GWh:(5) (3)-(1)	Allowance Average % (5)/(1)
1984	32,300	33,880	37,620	1,580	4.9	5,320	16.5
1985	35,500	35,830	39,570	330	0.9	4,070	11.5
1986	38,800	41,794	45,592	2,994	7.7	6,792	17.5
1987	42,600	48,211	52,408	5,611	13.2	9,808	23.0
1988	46,700	52,664	58,082	5,964	12.8	11,382	24.4
1989	51,400	55,322	61,376	3,922	7.6	9,976	19.4
1990	55,200	59,843	66,207	4,643	8.4	11,007	19.9
1991	58,000	61,646	68,369	3,646	6.3	10,369	17.9
1992	64,700	66,355	74,403	1,655	2.6	9,703	15.0
1993	70,700	75,043	83,766	4,343	6.1	13,066	18.5
1994	76,900	82,068	91,734	5,168	6.7	14,834	19.3
1995	83,700	87,582	98,039	3,882	4.6	14,339	17.1
1996	91,000	94,337	105,271	3,337	3.7	14,271	15.7
1997	97,400	103,979	115,699	6,579	6.8	18,299	18.8
1998	105,200	112,536	126,145	7,336	7.0	20,945	19.9
1999	114,000	122,398	138,061	8,398	7.4	24,061	21.1
2000	123,800	132,923	150,737	9,123	7.4	26,937	21.8
2001	133,300	143,178	162,514	9,878	7.4	29,214	21.9
2002	143,800	153,670	175,562	9,870	6.9	31,762	22.1
2003	155,400	165,139	190,016	9,739	6.3	34,616	22.3

CHAPTER 6 METEOROLOGY AND HYDROLOGY

CHAPTER 6. METEOROLOGY AND HYDROLOGY

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CHAPTER 6. METEOROLOGY AND HYDROLOGY

6.1 General

The Coruh river basin is situated in the northeastern part of Turkey near the boundary between Turkey and the Soviet Union. Average elevation of the basin is approximately 2,000 m. The Coruh river is the longest river in the northeastern part with the length of about 410 km. The Coruh river flows from the Dilek Daglari mountains to the Black Sea. The most downstream 20 km part of the River belongs to the territory of the Soviet Union. The drainage area of the River is 19,750 km^2 in Turkey. Its mean annual runoff is 5.96 billion cubic meter, or 189 m^3/sec at the border.

General climatological characteristics of the Coruh river basin could be classified into Continental and Black Sea climate. Continental climate is predominant over the catchment basin of the Yusufeli dam site with mean annual rainfall of 440 mm. While over the Yusufeli basin rainy season extends from March to June when fifty percent of annual precipitation concentrates, rainy season in the most downstream part of the Coruh river extends from autumn to winter with annual precipitation over 1,000 mm. Maximum, minimum and mean annual temperatures at Yusufeli station are 43.8°C, -14.3°C and 14.2°C respectively.

Locations of meteorological stations and stream gaging stations are given in Fig. 6-1. Isohyetal lines of annual rainfall over the basin are also given in Fig. 6-1. Mean monthly precipitations at stations are shown in Table 6-1. Monthly mean temperatures at Yusefeli and Bayburt stations are shown in Tables 6-2 and 6-3.

6.2 River Runoff

The Yusufeli damsite is located just downstream of Oltu-Tortum and Altiparmak tributaries so as to regulate the river flow including the major tributaries. There are a number of stream gaging stations established in the Coruh river basin as shown in Fig. 6-1, some of which are not in operation. Existing runoff data on the Coruh river including major tributaries are given in Fig. 6-2.

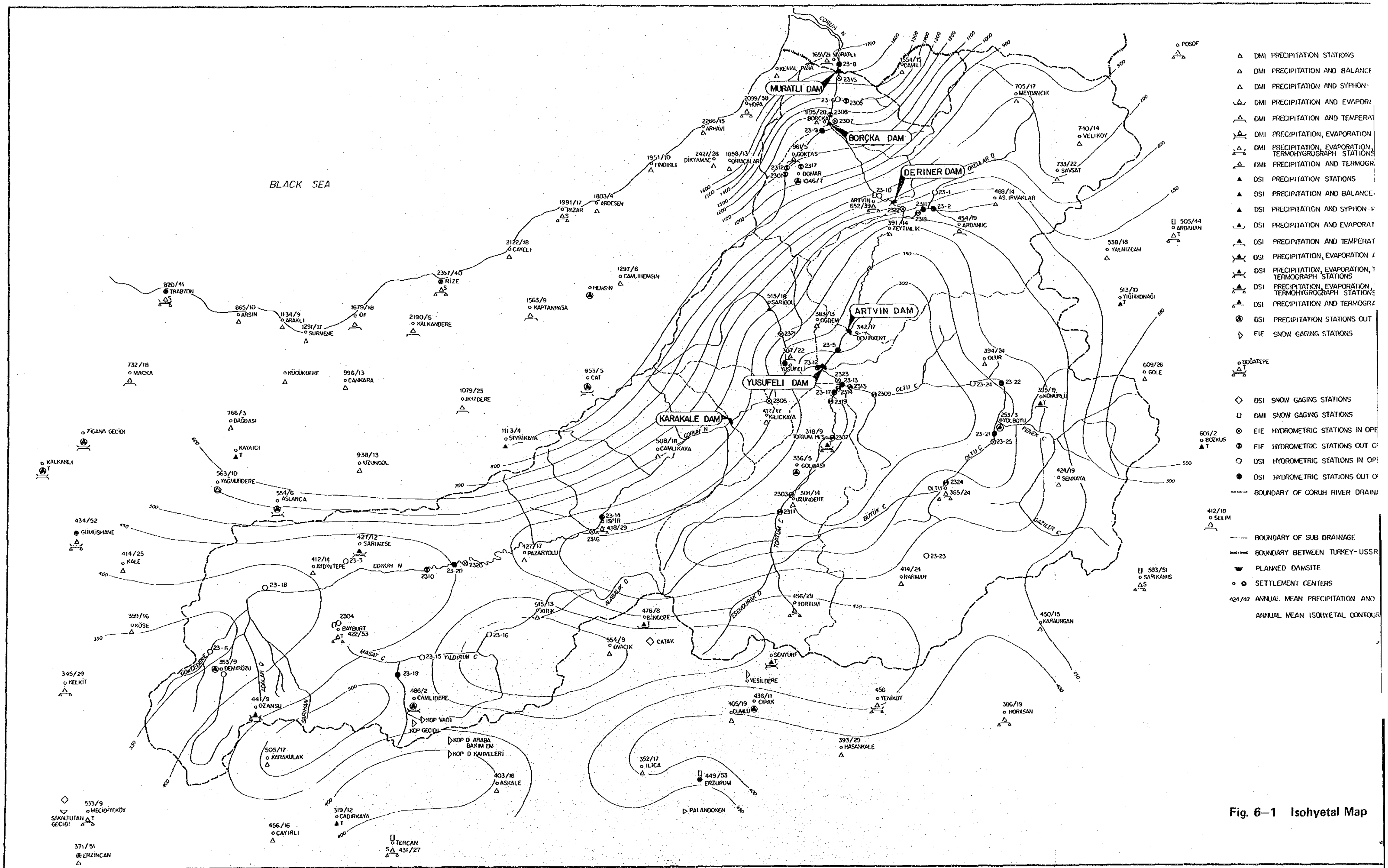

Fig. 6–1 Isohyetal Map

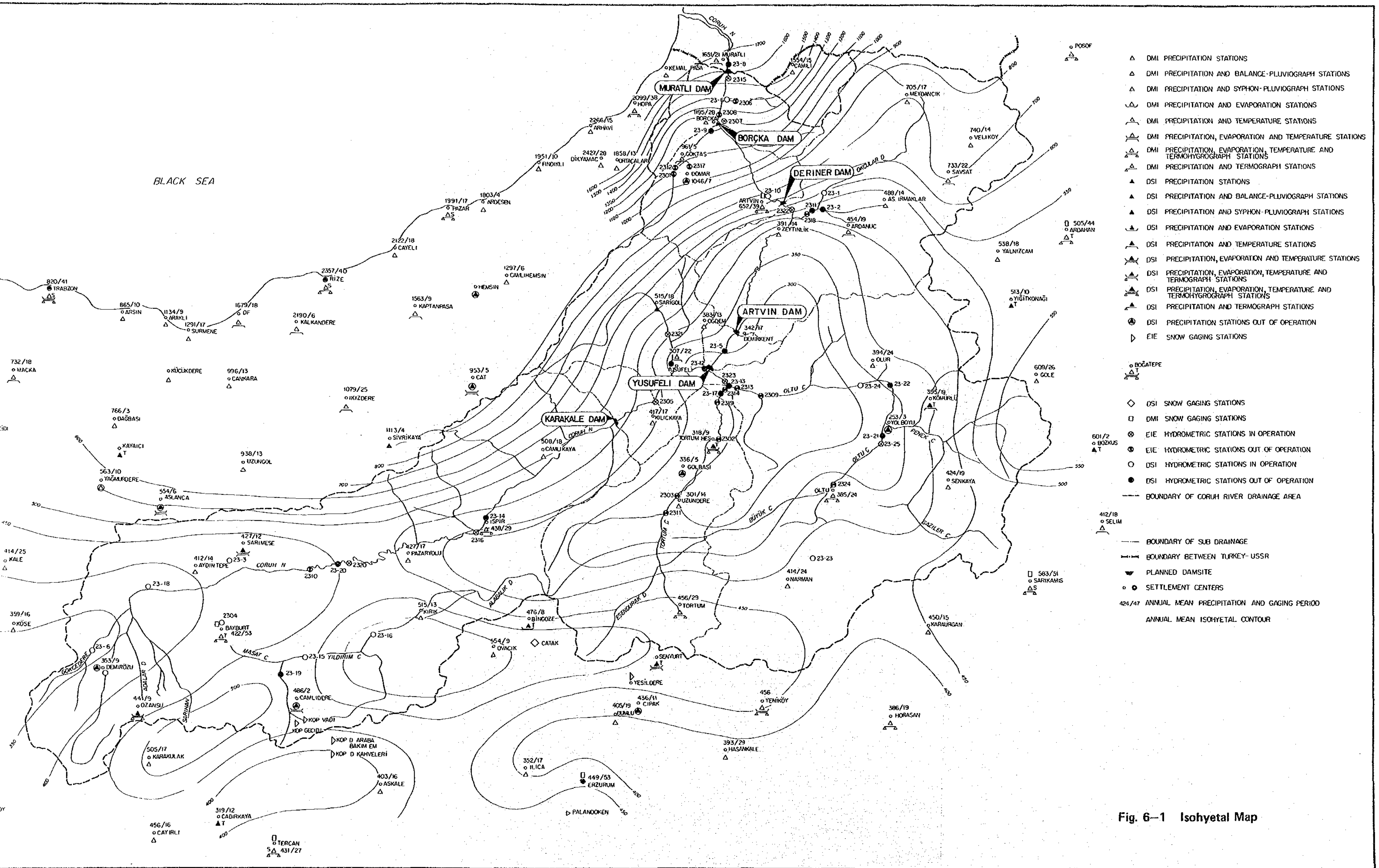

Fig. 6–1 Isohyetal Map

Station No.	Station Name	River	Observation Period (Years)
2302	Tev Köprüsü	Tortum	1941 – 1966, 1968
2304	Bayburt	Çoruh	1942 – 1984
2305	Peterek	Çoruh	1942 – 1984
2314	Catakköprü	Tortum	1963 – 1967
2315	Karşıköy	Çoruh	1965 – 1984
2316	Ispir Köprü	Coruh	1965 – 1984
2320	Laleri	Çoruh	1970 – 1984
2321	Dutdere	Altiparmak	1972 – 1984
2322	Altınsu	Çoruh	1972 – 1984
2323	Ishan· Köprü	Oltu	1963, 1965 – 1984
2325	Asağı Kumlu	Oltu	1974 – 1984

Fig. 6–2 Existing Stream Gaging Stations

Table 6–1 Monthly Precipitation at Meteorological Station

(unit: mm)

Station	Years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Aydintepe	15	30.5	25.2	41.8	60.2	61.5	40.9	9.1	10.9	19.0	40.4	36.3	39.8	415.6
Bayburt	54	24.3	27.2	38.6	57.0	67.1	53.4	21.4	13.7	20.8	38.5	44.0	26.3	432.3
Kirik	14	40.2	35.6	48.0	64.6	75.1	60.2	23.9	19.0	19.5	40.3	45.5	43.0	514.9
Pazaryolu	18	32.7	31.9	41.5	62.4	54.2	47.3	15.3	10.3	20.9	33.8	38.8	41.7	430.8
Ispir	30	29.7	38.9	38.8	59.4	60.4	46.8	23.8	15.4	22.6	31.4	36.0	39.2	442.4
Camlikaya	19	38.7	35.7	48.3	59.8	65.6	54.9	25.3	22.1	28.1	39.5	40.8	52.6	511.4
Kilickaya	18	23.8	22.8	37.8	42.3	60.9	59.4	21.1	27.5	23.9	28.5	31.2	34.5	413.7
Yusufeli	23	18.1	16.3	25.6	32.7	42.1	43.3	24.7	15.0	17.6	20.0	26.2	23.5	305.1
Tortum	30	27.5	29.0	38.6	55.3	67.3	62.8	34.8	24.0	20.2	38.1	33.4	24.9	455.9
Narman	25	20.0	21.0	30.0	49.1	70.0	64.2	33.2	29.9	17.3	30.4	27.0	18.1	410.2
Oltu	25	18.8	21.8	26.1	41.6	65.2	54.4	41.7	23.2	19.6	29.3	23.8	17.6	383.1
Olur	25	19.4	20.5	29.1	46.6	64.4	53.2	38.7	24.6	18.9	28.1	29.4	23.5	396.4
Senkaya	20	14.2	15.0	25.2	46.8	81.7	66.1	38.5	31.6	23.5	38.8	24.4	15.4	421.2
Sarimese	13	29.7	25.3	45.3	72.0	59.8	41.7	10.1	16.8	15.9	39.1	31.3	41.8	428.8
Average	-	26.3	26.2	36.8	53.6	64.0	53.5	25.8	20.3	20.6	34.0	33.4	31.6	426.1

Note; The observation periods in this table cover the duration from the beginning of the observation period until the end of 1983. There are some breaks in observation periods of several stations.

Table 6-2 Observed Monthly Average Temperatures at Yusufeli Station

(unit: °C)

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1965	2.2	2.8	9.4	12.6	19.5	22.7	25.2	26.3	22.3	12.2	7.5	4.3
66	6.5	8.4	10.6	15.9	18.7	23.0	27.7	27.5	21.5	17.7	12.0	6.3
67	1.6	0.6	7.5	13.1	17.5	20.6	22.6	24.0	20.5	16.1	8.4	2.0
68	-1.3	1.3	7.3	16.1	20.2	21.4	25.8	24.9	21.4	16.4	10.8	3.1
69	1.9	3.0	9.6	12.8	20.1	24.9	24.5	27.2	21.4	14.1	7.8	5.7
1970	4.4	6.8	10.5	17.8	19.0	23.0	26.5	24.3	21.5	14.4	10.6	3.0
71	2.4	4.4	9.5	14.6	19.7	20.9	26.9	24.0	25.0	14.6	8.7	1.3
72	-4.1	1.0	7.7	16.4	18.2	22.4	27.0	27.8	22.2	17.9	7.3	1.5
73	-0.1	5.8	7.9	13.8	18.7	20.2	25.4	24.7	21.9	16.7	5.4	1.9
74	-1.2	3.3	10.3	11.1	20.0	24.4	25.0	25.3	20.1	19.4	10.0	4.3
75	1.9	1.7	7.8	17.8	19.2	24.6	26.8	26.0	21.4	14.5	9.2	0.1
76	-1.2	-2.1	6.8	14.2	18.4	21.2	24.6	25.6	21.4	15.7	9.0	4.6
77	1.0	6.2	8.6	14.7	18.3	20.6	24.9	25.8	21.2	12.4	8.3	2.1
78	0.8	5.0	10.2	12.0	18.4	18.0	24.9	24.0	21.4	16.4	6.0	2.1
79	1.0	6.2	10.2	14.6	20.2	22.3	23.9	27.8	22.8	15.4	10.1	2.8
1980	0.8	2.1	9.2	13.5	19.0	23.7	27.2	24.8	20.2	14.1	9.7	5.5
81	4.4	6.4	9.9	12.5	16.5	23.1	27.3	26.0	23.1	17.0	7.7	6.6
82	-	-	-	-	-	-	-	-	22.1	15.5	7.0	1.5
83	-1.7	3.2	7.8	16.0	19.8	22.3	26.4	24.3	21.6	15.0	9.2	3.5
84	4.2	4.4	10.1	14.0	17.8	22.7	25.3	22.8	23.9	15.8	9.6	1.2

Table 6–3 Observed Monthly Average Temperatures at Bayburt Station

(unit: °C)

Month / Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1977	-9.3	-0.7	1.2	7.7	11.4	14.5	17.4	18.7	15.4	4.9	3.2	-6.5
1978	-6.5	-2.0	1.3	5.2	10.8	13.3	20.2	17.3	16.0	10.1	-0.6	-0.6
1979	-3.7	-0.9	2.1	7.8	12.2	14.7	16.6	21.2	16.5	8.8	4.8	-5.4
1980	-10.0	-8.3	-1.3	6.3	12.0	16.4	21.8	18.3	14.0	8.5	4.0	-2.8
1981	-2.6	-0.6	2.5	5.2	8.9	14.9	19.7	17.9	16.3	10.7	1.3	2.0
1982	-6.8	-8.4	1.8	9.6	11.5	14.8	17.2	17.4	14.2	8.2	-0.2	-4.1
1983	-10.9	-7.2	0.2	7.4	11.9	14.8	19.0	17.5	13.7	8.6	4.1	-1.0
1984	-1.3	-2.0	3.1	6.3	10.5	14.8	19.0	15.6	16.5	8.6	3.1	-8.7

The average values of runoff serve an important role for hydropower planning, especially significant are those variations of streamflow such as seasonal variations in runoff and yearly variations in total runoff. Seasonal variations in runoff at No. 2305 gaging station and in precipitation at Bayburt from 1942 to 1983 are shown in Fig. 6-3.

Variations in annual total runoff are principal in reservoir design. Accordingly, stochastic methods are used to detect the regularity of fluctuations of hydrological data in random time series.

The distribution of periodic components in the hydrologic data series x(t) of precipitation or stream flow can be obtained by Fourier transformation as follows.

$$X(f) = \int_{-\infty}^{\infty} x(t)e^{-i2\pi ft}dt$$

$$Sx(f) = \lim_{T\to\infty} \left[\frac{1}{T} \left| X(f) \right|^2 \right]$$

The Sx(f) represents the average energy values per unit time of periodic components f and is called power spectrum.
When $X_T(t)$, the record length T of which is finite, is applied to the above equations, the estimated power spectrum is;

$$S(f) = \frac{1}{T} \left| X(f) \right|^2$$

The S(f) is usually unstable spectrum which fluctuates heavily in zig-zags and is called raw power spectrum.
The smoothed power spectrum is obtained by using the lag Weighed function W(t), which is called lag window. In this study, Hanning window is applied, which is generally used for this purpose.

Hydrologic properties over the drainage basin of Yusufeli dam site were investigated by using spectral analysis for the annual runoff at No. 2305 station (1942 - 1984) and the annual precipitation at Bayburt station (1931 - 1983). Fig. 6-4 indicates that hydrological records in the catchment basin of Yusufeli dam site such as precipitation and stream flow have the superior ingredient of approximately 5 years cycle.

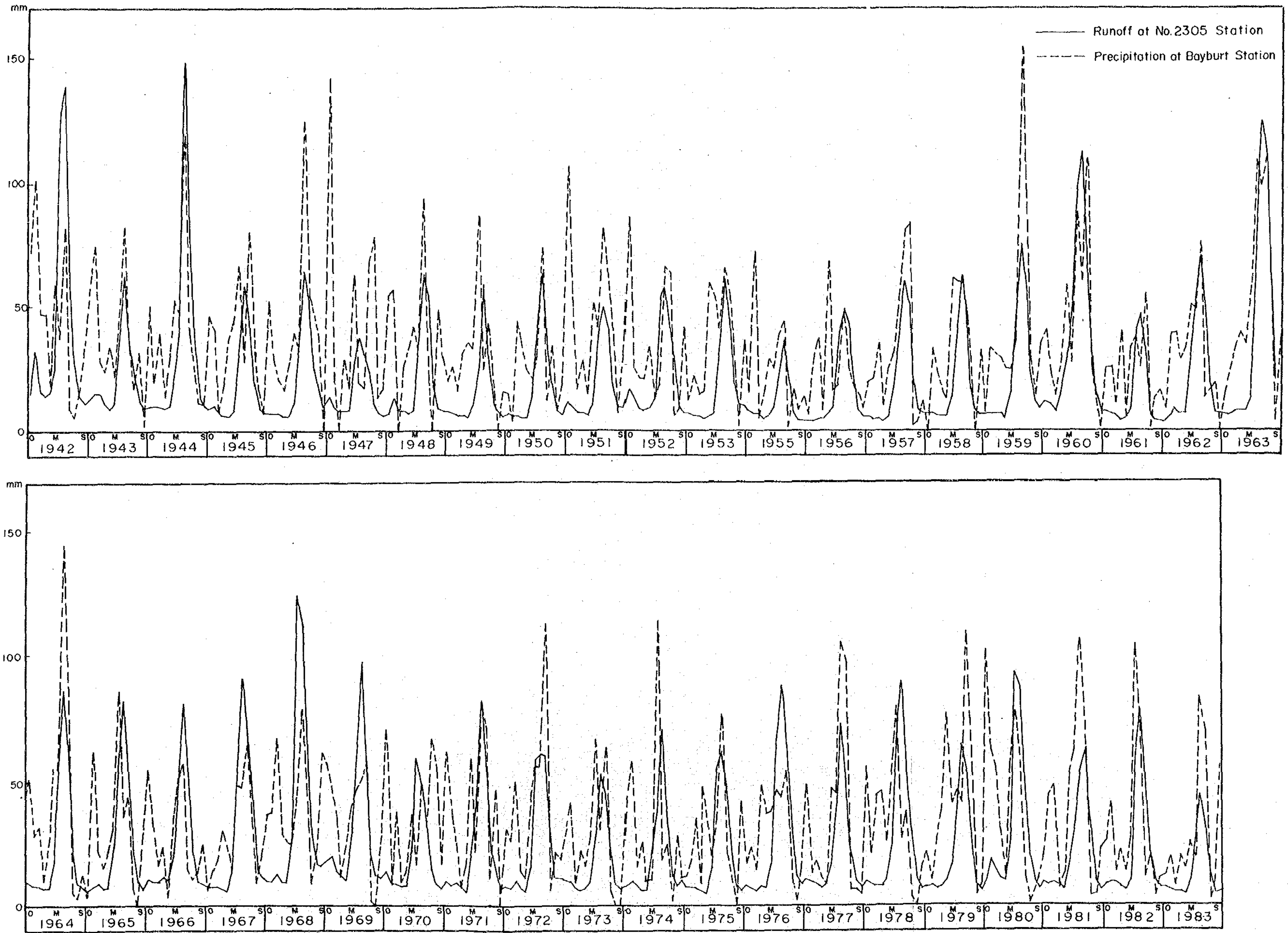

Fig. 6–3 Seasonal Variation of Precipitation and Runoff

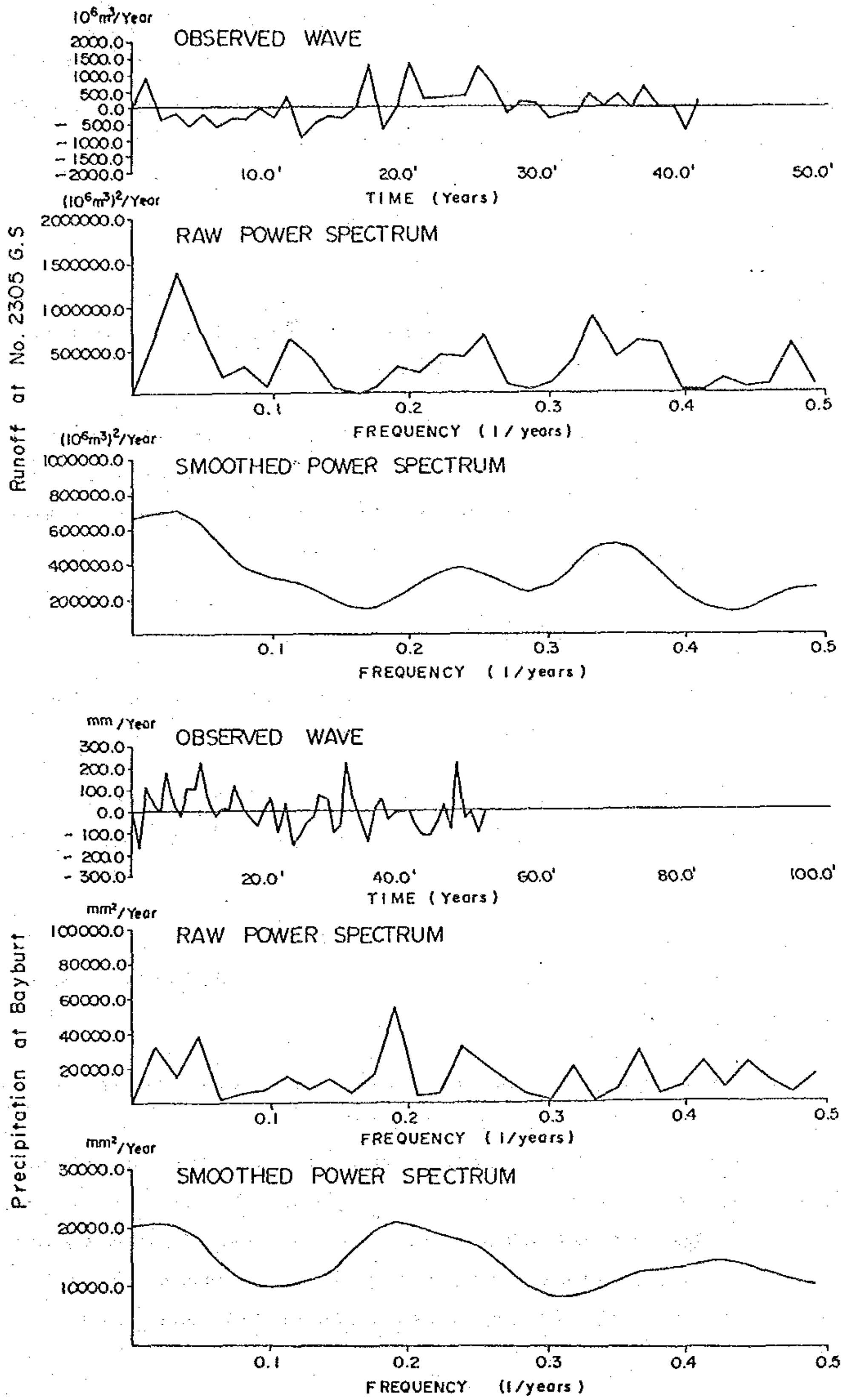

Fig. 6–4 Spectral Analysis

The correlation analyses were performed to extend monthly flow at the stream gaging stations and to estimate natural monthly flow at dam sites. The results of correlation analyses are shown in Table 6-4 and Figs. 6-5 ~ 6-10. Natural flow calculations at damsites are explicated in Table 6-5 and their results are listed in Tables 6-6 ~ 6-12.

6.3 Evaporation

The observation of monthly evaporation is being undertaken at nearby stations where the standard Weather Bureau Class A pans are used. The evaporation stations are listed in Fig. 6-11.

In reservoir design, it is necessary to estimate the monthly distribution of annual evaporation and the increased loss over the reservoir resulting from the construction of the dam, i.e., reservoir evaporation less evapotranspiration after the construction. In general the volume of water required to balance the continuity equation for a basin represents evapotranspiration.

Considering the vegetation in the reservoir, evapotranspiration in the reservoir before the construction was neglected.

Correlation analysis was made to derive a reliable relation between monthly pan evaporation and monthly average temperature at Bayburt station.

The used data are shown in Table 6-3 and 6-13.
The regression curve and equation derived from the analysis are indicated in Fig. 6-12.

Yusufeli meteorological station, where air temperatures are being observed, is located near the Yusufeli dam site. Actual monthly distribution of annual evaporation from the reservoir was estimated by using monthly average temperatures at Yusufeli and the regression equation. The pan coefficient of 0.70 was used in the estimation. The monthly evaporations from 1965 to 1984 are shown in Table 6-14. Monthly average temperatures at Yusufeli station are shown in Table 6-2.

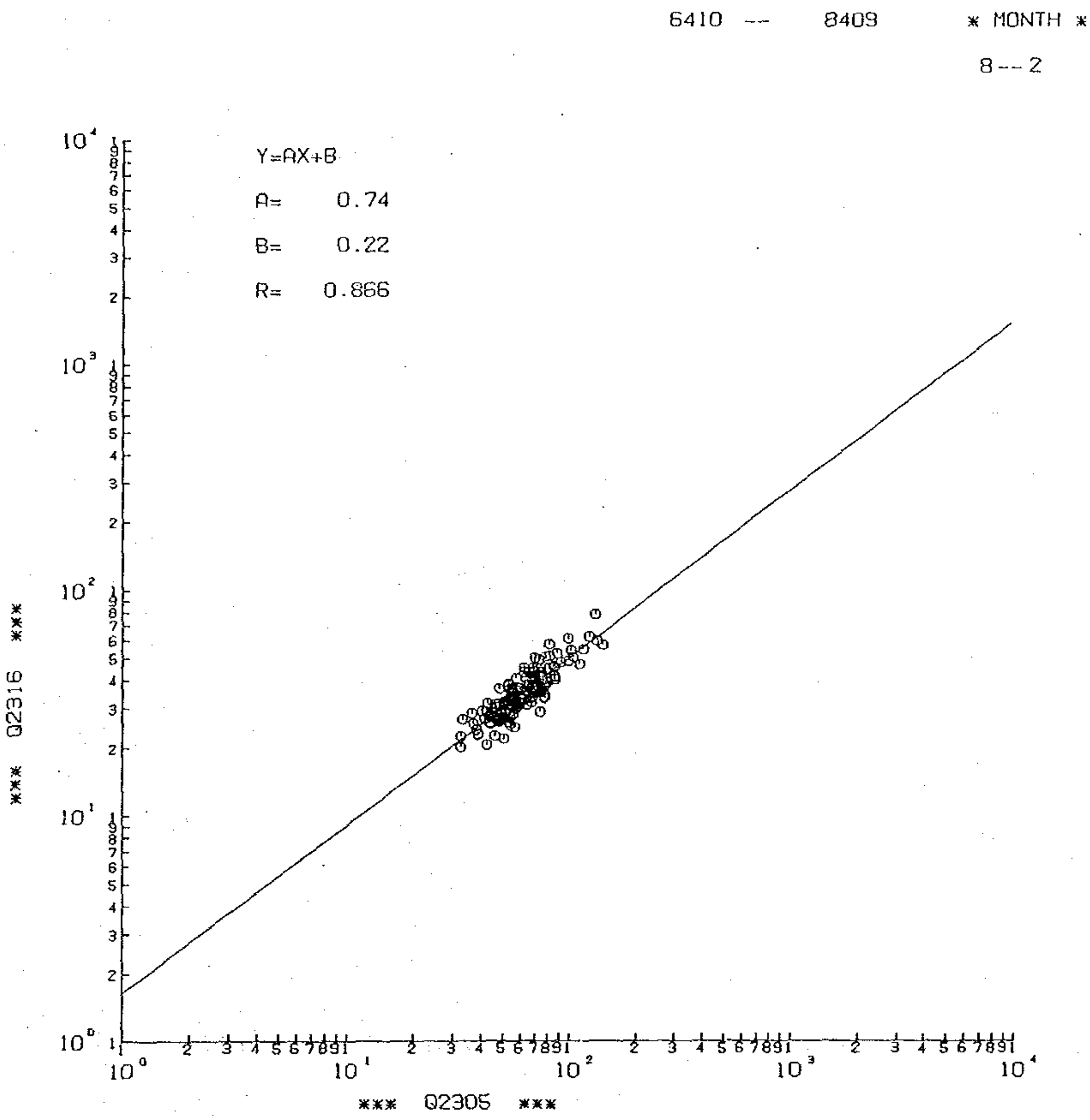

Fig. 6-5 (1) Correlation Analysis between Nos. 2316 and 2305 G.S.

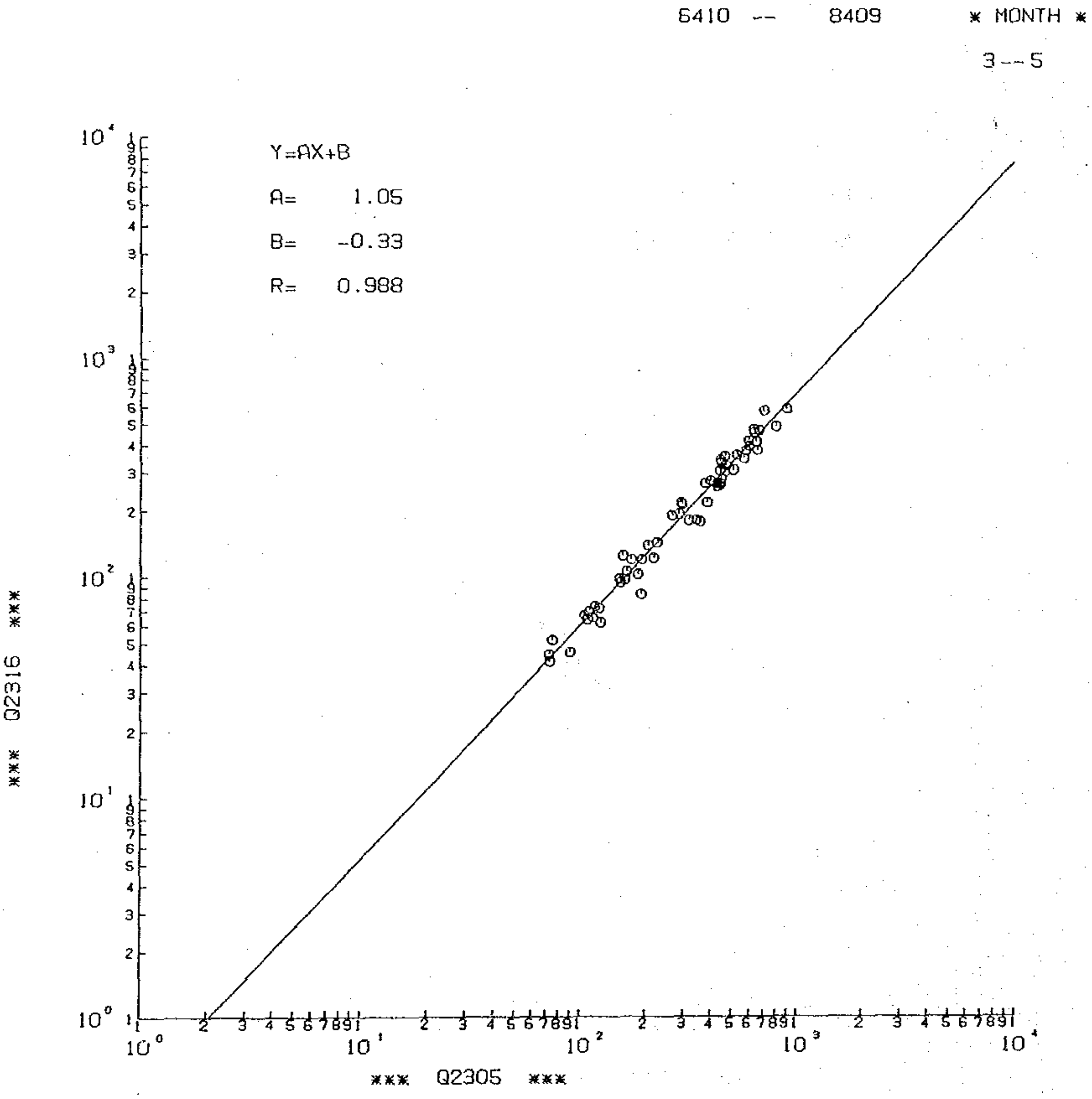

Fig. 6–5 (2) Correlation Analysis between Nos. 2316 and 2305 G.S.

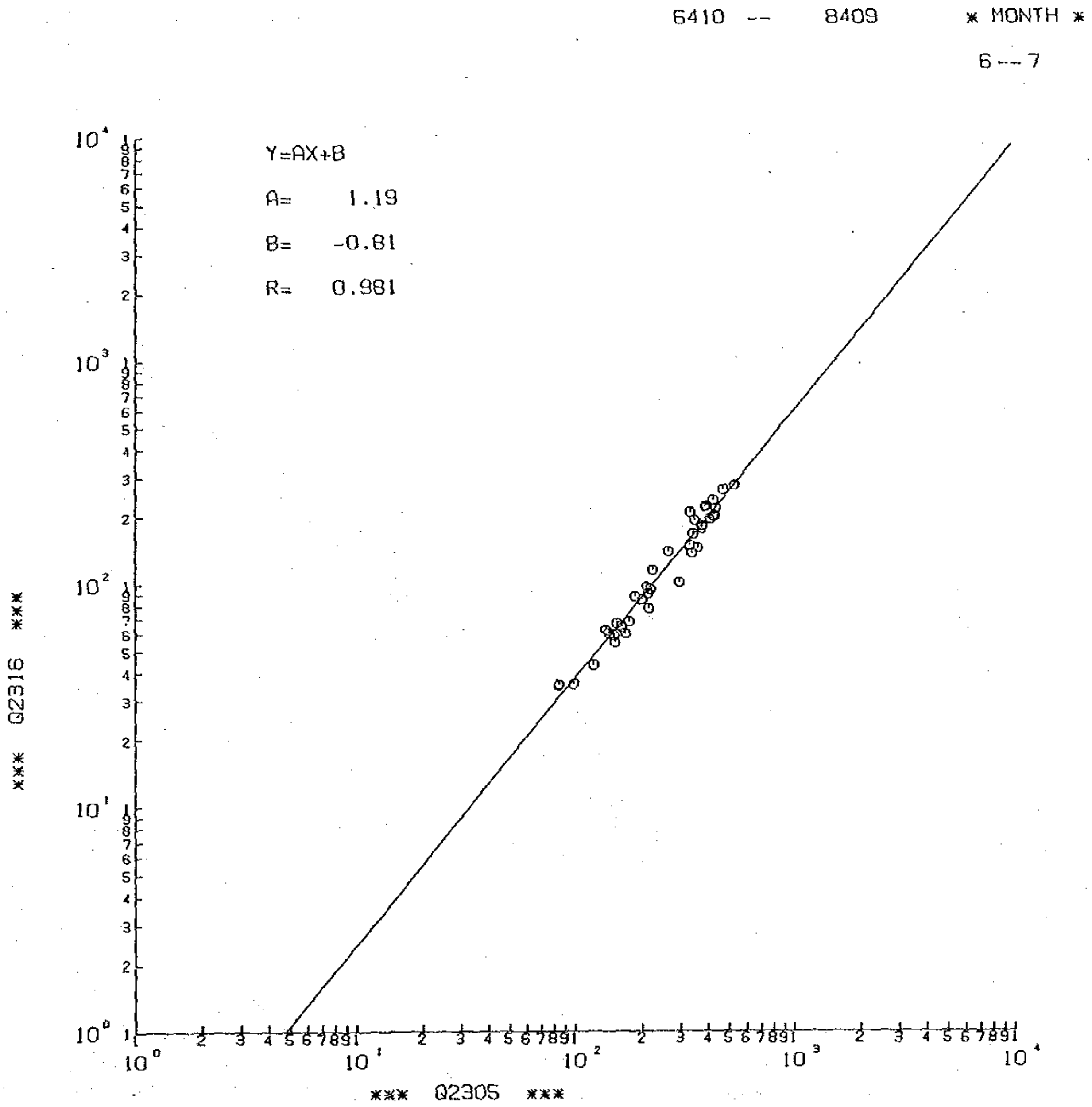

Fig. 6–5 (3) Correlation Analysis between Nos. 2316 and 2305 G.S.

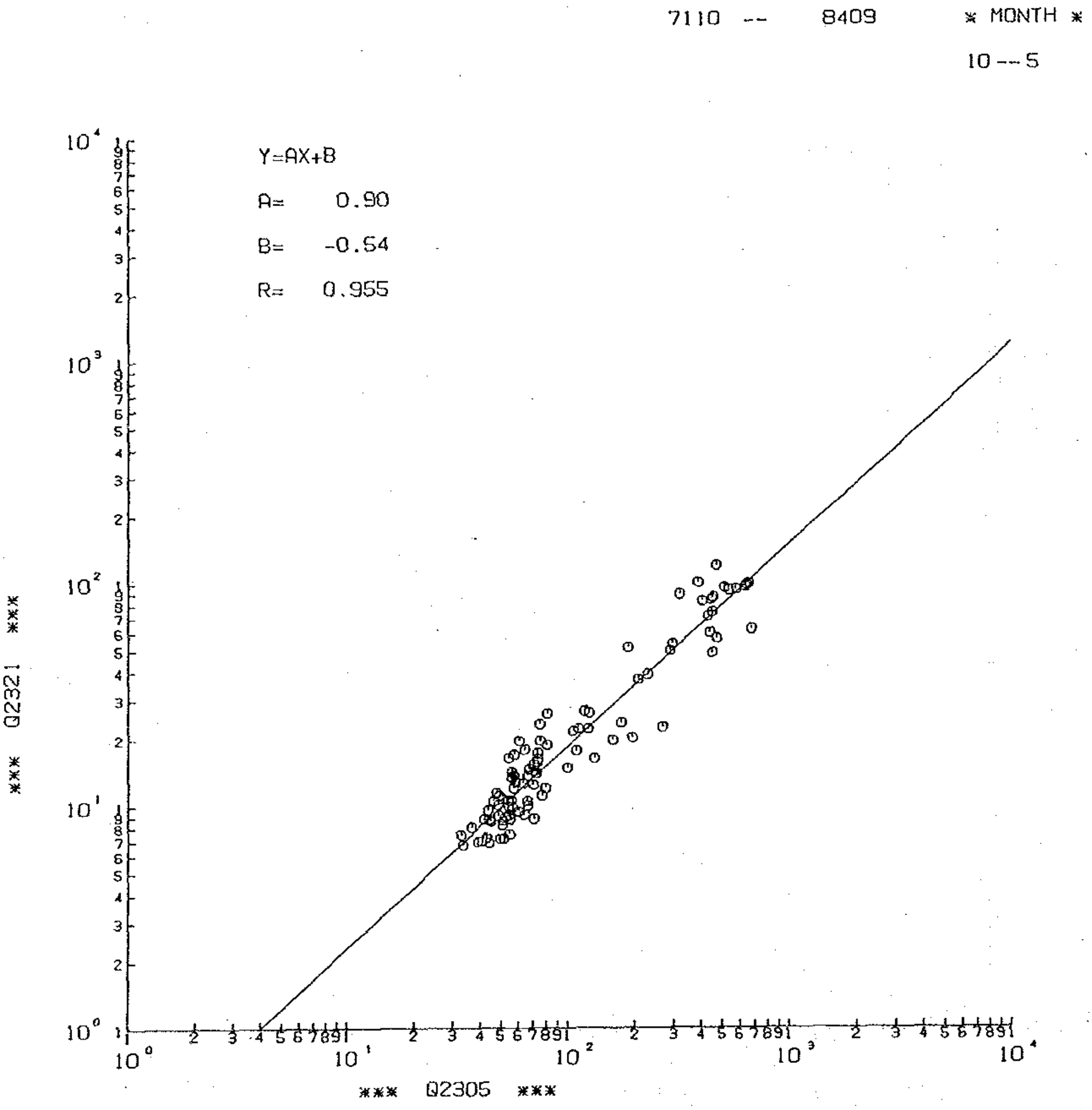

Fig. 6–6 (1) Correlation Analysis between Nos. 2321 and 2305 G.S.

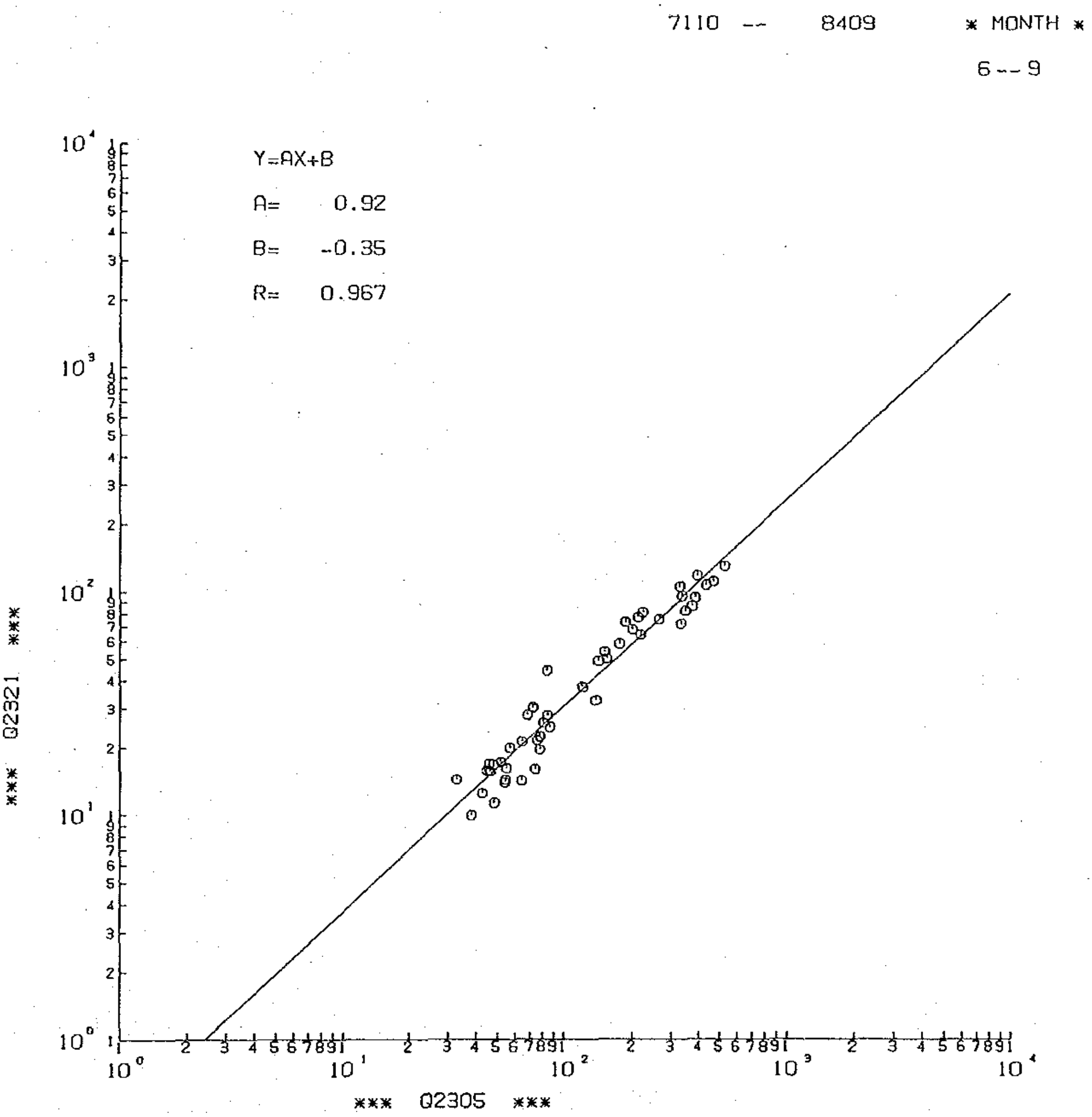

Fig. 6–6 (2) Correlation Analysis between Nos. 2321 and 2305 G.S.

7110 -- 8409 * MONTH *
1 -- 12

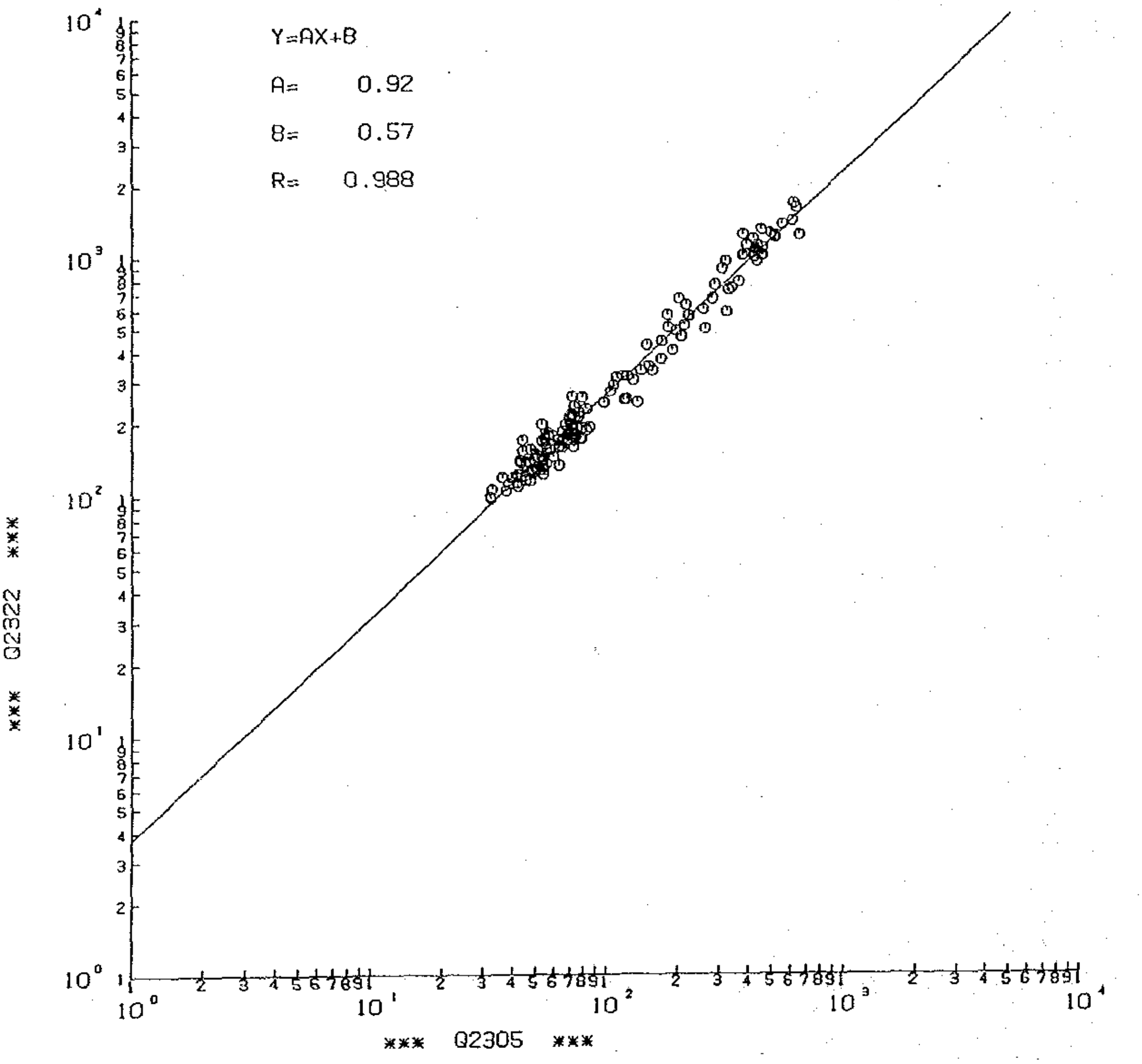

Fig. 6–7 Correlation Analysis between Nos. 2322 and 2305 G.S.

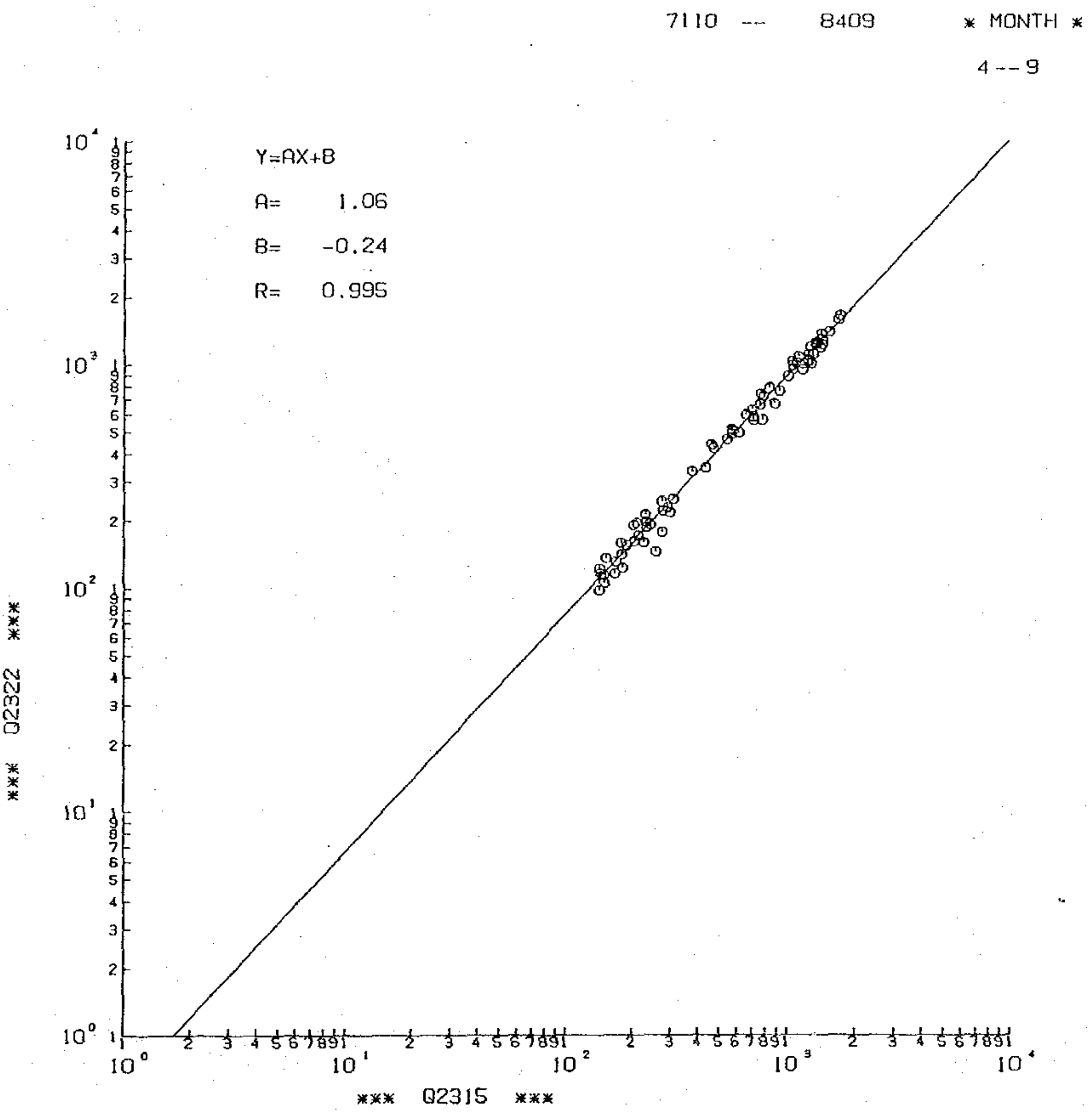

Fig. 6–8 (1) Correlation Analysis between Nos. 2322 and 2315 G.S.

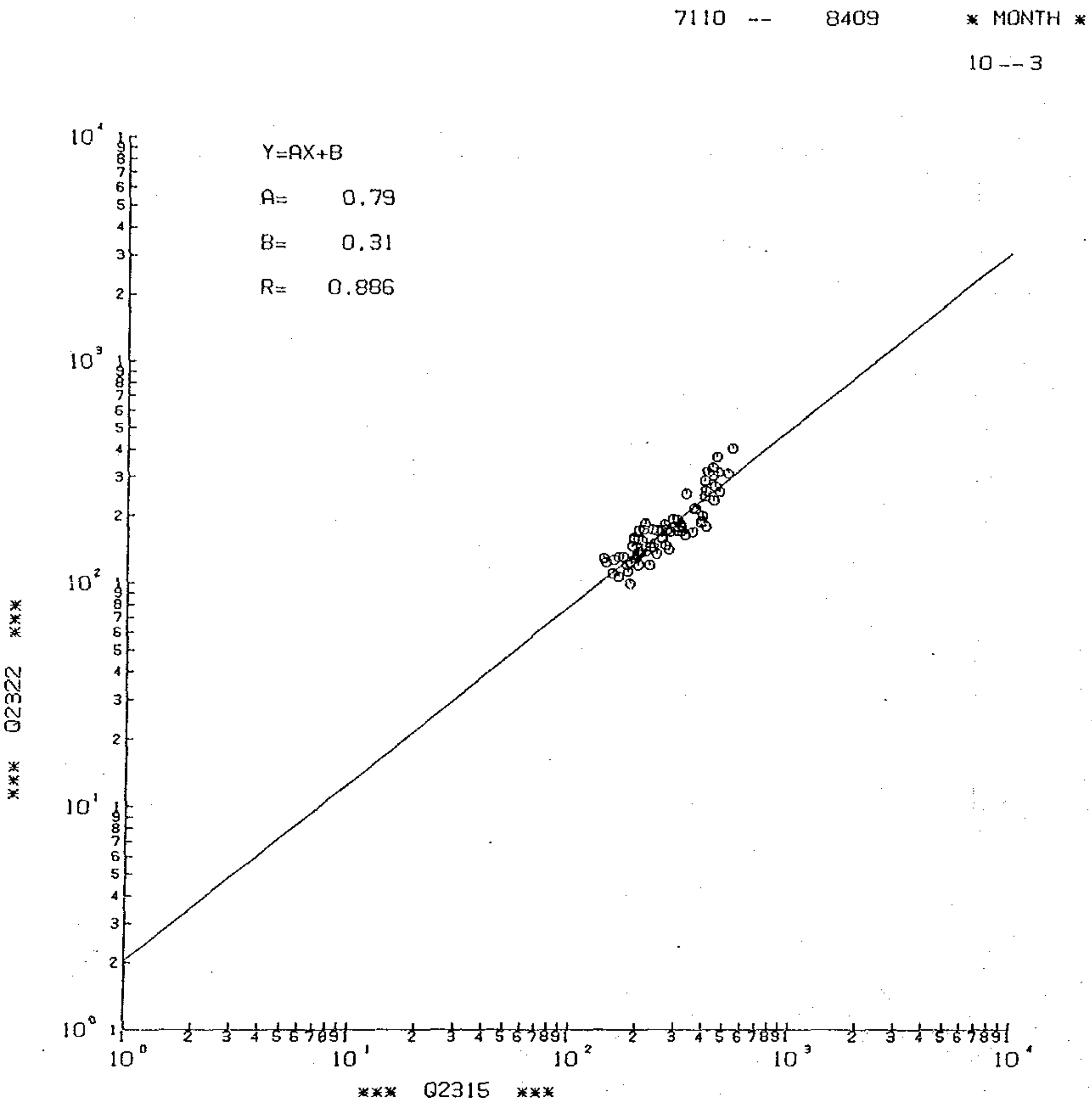

Fig. 6–8 (2) Correlation Analysis between Nos. 2322 and 2315 G.S.

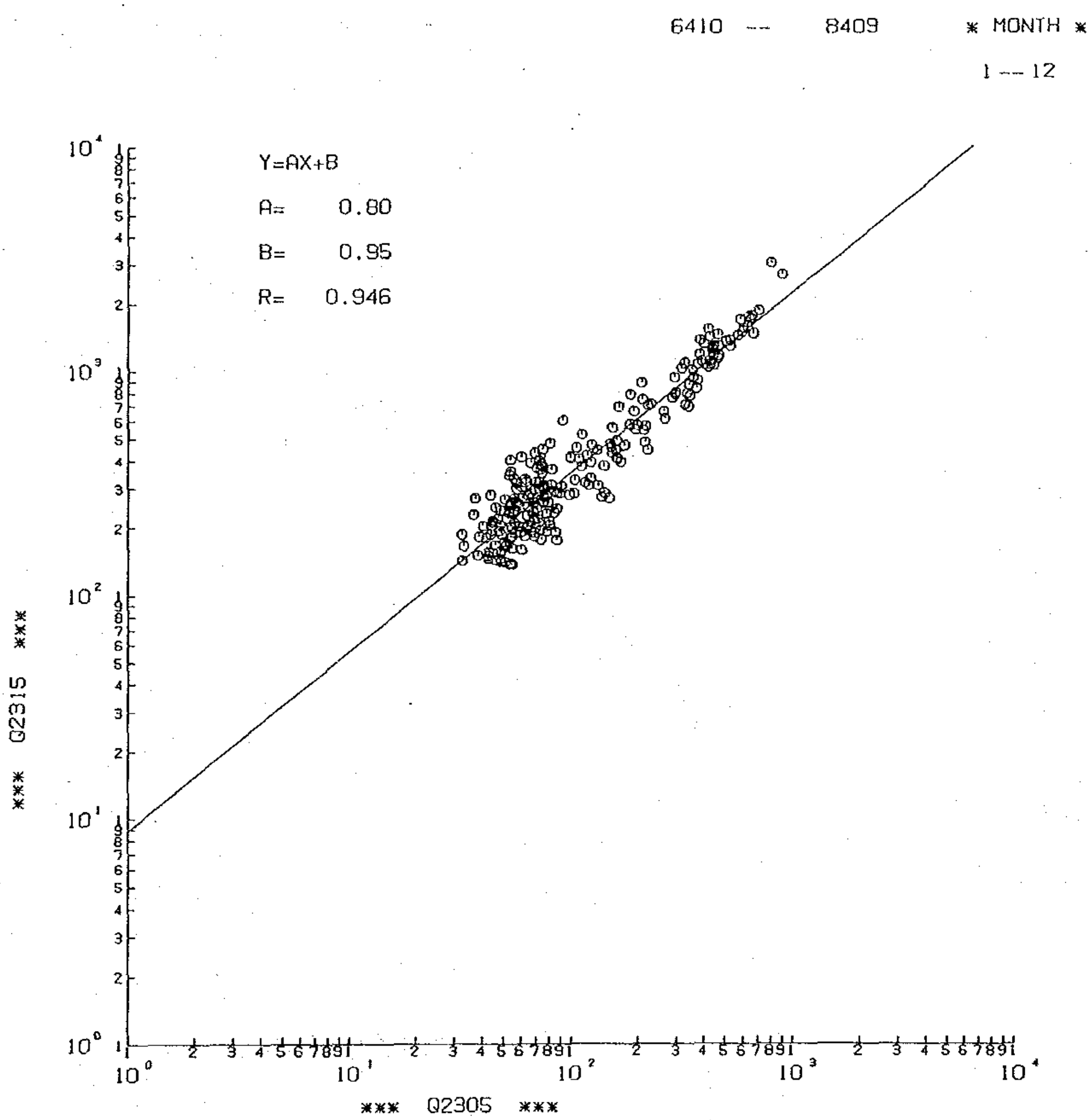

Fig. 6–9 Correlation Analysis between Nos. 2315 and 2305 G.S.

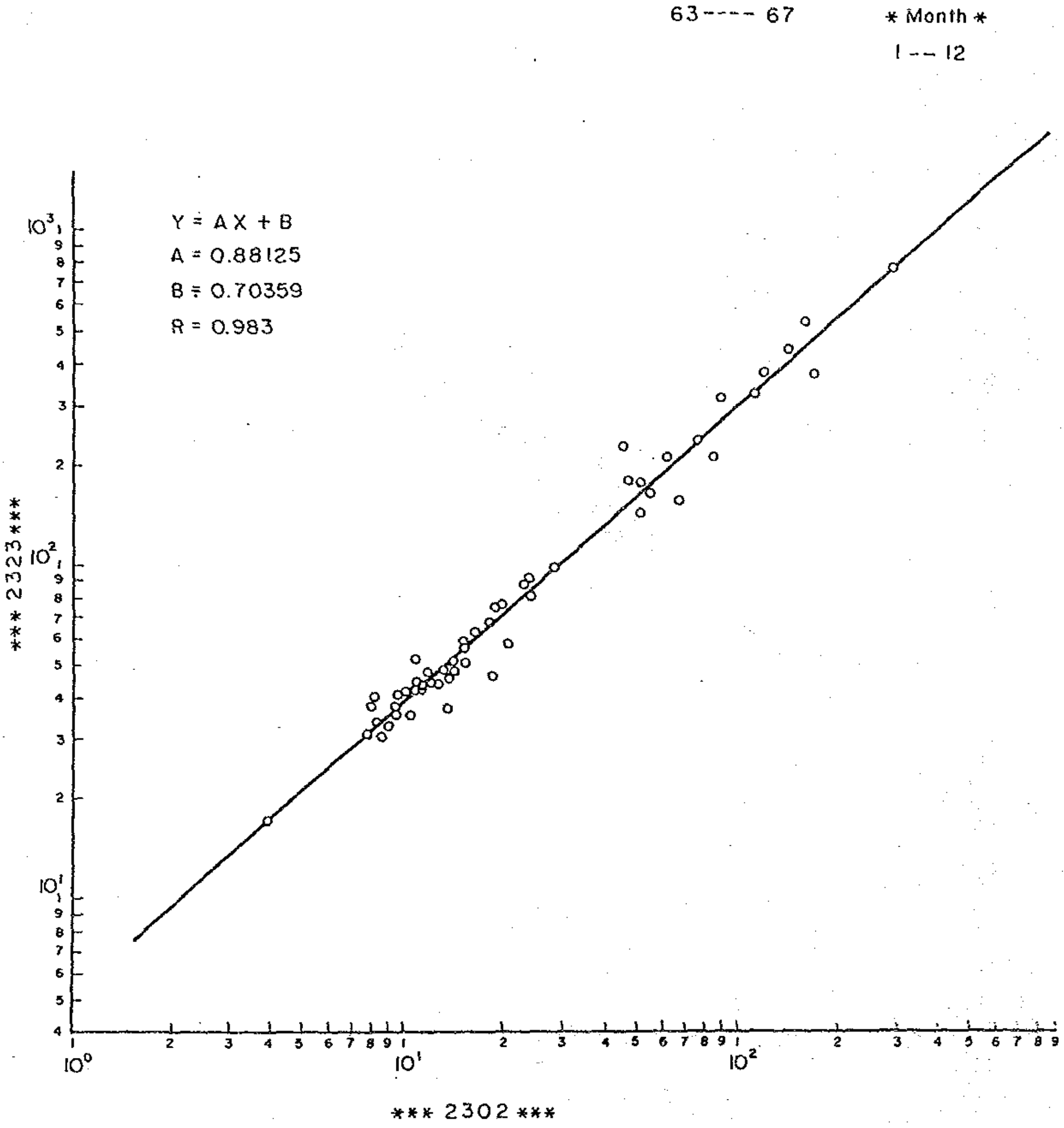

Fig. 6–10 Correlation Analysis between Nos. 2323 and 2302 G.S.

Station Name	Observation Period (1960 / 1970 / 1980 / 1990)	Remarks
Bayburt	1977 – 1984	Within the basin
Ispir	1977 – 1984	ditto
Gümüşhane	1972 – 1984	Around the basin
Erzincan	1962 – 1984	ditto

Fig. 6–11 Existing Class A Pan Evaporation Data

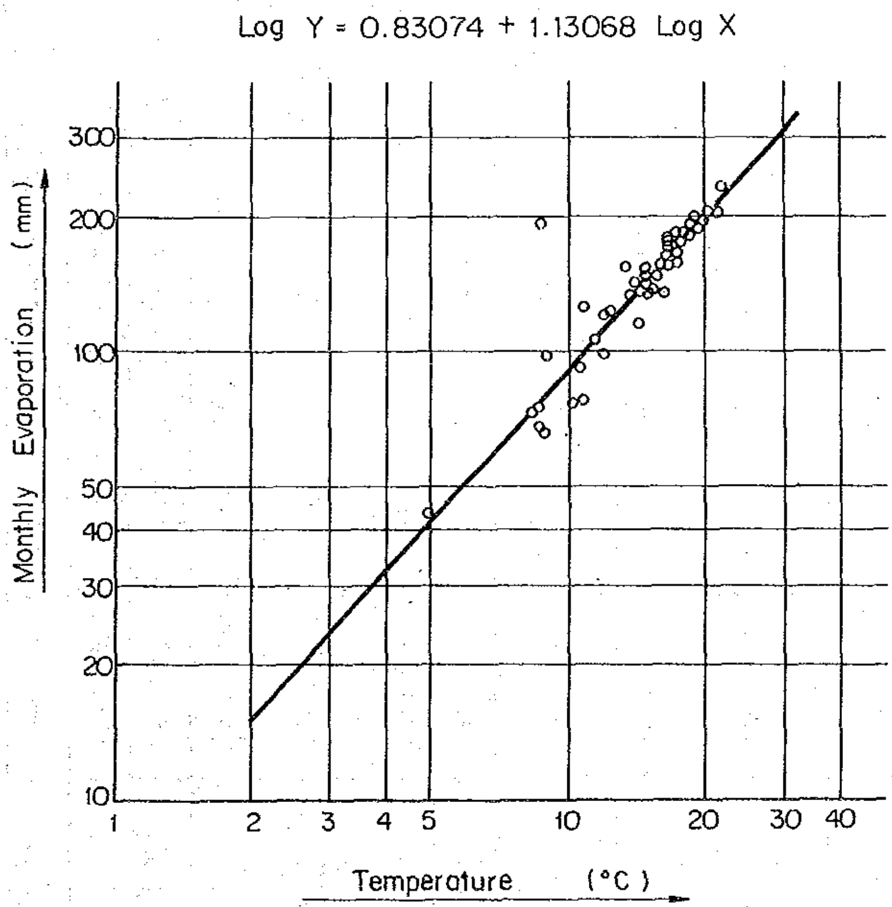

Fig. 6–12 Relation between Monthly Average Temperatures and Monthly Evaporation of Bayburt Station

Table 6–4 Correlation Analysis of Stream Gaging Station

Station	Years	Independent Variable (X)	Regression Equation	Common Observation Period	Correlation Coefficient
Ispir Koprusu (2316)	1942-1964	2305	Aug.-Feb.: logY=0.21658+0.74067 logX Mar.-May: logY=-0.33494+1.05292 logX Jun.-July: logY=-0.80677+1.19157 logX	1965-1984	0.866 0.988 0.981
	1965-1984	Observation Period			
Dutdere (2321)	1942-1971	2305	Oct.-May: logY=-0.54102+0.90431 logX Jun.-Sept.: logY=-0.34967+0.91898 logX	1972-1984	0.955 0.967
	1972-1984	Observation Period			
Altinsu (2322)	1942-1964	2305	logY=0.57244+0.92012 logX	1972-1984	0.988
	1965-1971	2315	Apr.-Sept.: logY=-0.24436+1.06124 logX Oct.-Mar.: logY=0.31064+0.79238 logX	1972-1984	0.995 0.886
	1972-1984	Observation Period			
Ishan Kop (2323)	1942-1964	2302	logY=0.70359+0.88125 logX	1963-1967	0.983
	1965-1984	Observation Period			
Karsikoy (2315)	1942-1964	2305	logY=0.94709+0.79786 logX	1965-1984	0.946
	1965-1984	Observation Period			

Table 6-5 Natural Flow Calculation at Damsites

Dam	Qi	Qj	Ai	Aj	$\frac{Adam-Ai}{Aj-Ai}$
Karakale	Q2316	Q2305	A2316	A2305	0.763
Yusufeli	Q2305	Q2322	A2305	A2322	0.149
Artvin(U)	+Q2321		+A2321		0.190
Artvin(L)	+Q2323		+A2323		0.229
Deriner	Q2322	Q2315	A2322	A2315	0.047
Borcka					0.428
Muratli	-	Q2315	-	A2315	1.005

Natural Flow at damsites is calculated as follows:

$$Qdam = Qi + (Qj - Qi) \times \frac{Adam - Ai}{Aj - Ai}$$

Where,

Qdam ; natural flow at a damsite
Qi,Qj; natural flow at a gaging station
Adam; catchment area of a damsite
Ai,Aj; catchment area of a gaging station

Table 6–6 Natural Flow at Karakale Damsite

unit: 10^6 m^3

YY	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
42	87.26	101.70	174.28	856.82	925.57	363.52	172.11	89.82	71.91	82.84	96.61	94.06	3116.50
43	71.40	59.30	80.09	277.03	417.93	241.42	123.66	76.19	58.18	63.08	67.54	66.86	1602.68
44	58.10	62.23	157.81	268.75	998.08	448.64	244.99	86.16	65.23	59.47	66.86	48.25	2564.57
45	42.79	37.39	52.58	200.84	391.18	284.35	118.40	57.32	42.96	47.74	46.09	44.87	1366.51
46	39.48	38.70	72.46	247.63	426.23	331.96	155.23	94.06	57.06	89.82	65.92	52.66	1671.31
47	51.54	52.84	168.79	248.55	197.18	142.99	67.36	44.53	38.52	48.17	81.82	53.36	1195.65
48	50.33	46.96	52.95	266.00	420.70	347.28	101.78	58.96	54.74	53.10	46.78	40.09	1539.67
49	38.52	34.07	65.01	160.55	393.03	198.69	62.78	47.04	40.96	44.01	39.48	37.13	1161.27
50	34.94	35.47	88.73	330.38	420.70	204.91	107.90	53.88	37.39	68.74	56.46	48.69	1488.19
51	45.05	40.96	68.46	256.81	327.62	257.49	102.65	59.05	59.47	108.47	81.39	60.16	1467.58
52	54.91	61.37	82.73	351.56	393.95	262.86	146.51	65.92	47.74	43.23	40.44	37.74	1588.96
53	34.50	36.51	48.42	239.37	408.70	278.08	125.41	68.40	62.57	53.10	52.41	42.01	1449.48
54	42.62	47.39	97.56	346.95	568.52	388.82	196.03	81.39	59.22	53.44	47.65	44.44	1974.03
55	35.99	36.51	59.20	139.53	235.70	124.54	42.57	29.85	28.44	29.59	29.59	33.28	824.79
56	30.47	45.40	60.93	252.22	327.62	269.12	116.65	52.58	41.75	38.26	34.54	31.70	1301.64
57	26.14	38.52	121.27	262.32	398.56	309.48	121.03	54.74	43.05	43.40	44.35	42.62	1505.48
58	37.30	37.48	87.37	268.75	409.63	278.97	104.40	49.99	48.25	46.52	44.61	45.83	1459.10
59	45.74	34.24	97.56	277.03	496.41	354.49	144.75	75.59	56.98	77.85	70.20	55.17	1786.05
60	98.31	162.30	259.57	650.91	751.95	412.35	201.36	89.82	52.23	50.94	44.27	41.22	2815.23
61	28.35	30.20	62.10	262.32	314.73	191.59	49.18	26.76	25.35	29.32	36.78	57.93	1114.61
62	42.88	46.61	200.84	356.16	469.62	276.28	110.52	48.69	46.52	47.91	48.34	49.90	1744.27
63	52.92	54.65	83.09	508.42	827.11	729.72	371.64	135.45	62.74	61.11	54.13	51.37	2992.35
64	48.34	46.00	111.23	379.20	578.70	392.43	114.02	58.79	51.02	50.10	54.00	58.86	1942.69
65	49.85	45.83	150.77	420.68	559.71	357.78	138.12	62.69	49.67	74.98	67.96	65.99	2044.03
66	80.55	76.35	145.75	351.73	537.78	328.81	139.36	63.74	59.30	50.36	49.21	53.80	1935.74
67	46.72	41.11	80.16	305.11	595.23	308.02	250.52	96.54	77.04	68.11	62.52	81.95	2013.03
68	63.92	65.48	166.94	831.80	732.51	369.65	182.90	109.25	102.11	116.41	121.94	91.40	2954.31
69	76.29	64.84	197.29	435.25	678.91	300.27	127.59	75.88	69.05	87.41	60.54	57.80	2231.12
70	50.98	54.52	139.74	387.98	414.32	182.28	83.48	59.64	46.98	60.81	54.39	58.34	1493.36
71	44.36	34.53	140.49	278.13	555.54	377.42	142.32	92.10	46.17	51.04	49.42	65.08	1876.60
72	44.52	41.42	98.28	290.64	402.66	383.07	149.41	70.86	67.55	70.69	64.43	45.17	1828.70
73	39.81	48.65	65.69	191.40	347.21	285.84	128.14	49.39	37.61	53.40	63.97	51.41	1362.52
74	39.48	40.33	150.70	248.27	460.92	234.12	72.73	49.34	64.19	43.71	43.68	44.42	1451.89
75	40.28	35.26	101.97	371.17	408.50	289.34	102.55	43.16	41.74	52.53	43.03	38.42	1567.95
76	48.23	44.12	109.99	442.31	596.66	420.15	188.55	75.86	57.45	72.39	64.13	61.10	2180.94
77	46.71	57.29	111.62	265.00	490.55	326.71	133.25	66.51	48.00	64.15	56.86	51.57	1718.22
78	49.66	68.34	160.96	418.07	597.43	347.40	172.61	67.52	47.52	52.01	49.64	48.21	2079.37
79	51.06	63.33	108.12	275.03	427.69	353.74	162.57	60.24	40.76	67.43	119.20	90.75	1819.92
80	72.42	63.75	176.98	624.26	594.93	302.36	119.86	65.20	47.35	58.77	54.83	59.31	2240.36
81	50.29	39.48	96.56	208.37	409.80	467.53	182.98	64.44	41.03	51.42	59.77	59.14	1730.81
82	46.37	37.93	66.19	394.84	519.99	310.01	122.39	56.84	43.28	47.53	42.64	34.83	1722.84
83	31.81	30.28	69.58	166.06	285.13	197.25	72.61	29.71	35.01	52.04	135.10	90.05	1194.63
AV	49.31	50.94	111.69	343.20	490.83	315.04	137.45	65.81	51.74	59.18	59.86	54.45	1789.50
MA	98.31	162.30	259.57	856.82	998.08	729.72	371.64	135.45	102.11	116.41	135.10	94.06	3116.50
MI	26.14	30.20	48.42	139.53	197.18	124.54	42.57	26.76	25.35	29.32	29.59	31.70	824.79

Table 6–7 Natural Flow at Yusufeli Damsite

unit: 10^6 m^3

YY	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
42	188.84	211.19	337.59	1379.38	1846.08	864.02	400.14	212.63	171.86	189.14	209.01	201.49	6213.37
43	159.68	135.81	172.85	515.30	870.94	529.42	286.83	176.42	132.74	142.40	154.42	149.67	3426.48
44	133.30	125.55	310.80	551.24	1854.33	910.10	509.48	206.49	160.32	146.85	160.48	121.68	5204.70
45	111.21	97.27	128.62	387.07	827.58	712.17	291.27	145.32	110.53	118.30	117.55	113.33	3160.22
46	103.32	98.84	160.45	472.68	940.40	896.43	357.92	256.96	161.81	227.18	175.07	143.15	4034.21
47	138.38	134.91	342.60	515.10	443.93	366.11	194.64	115.07	106.52	121.28	190.50	132.75	2805.79
48	123.35	114.17	125.85	512.42	924.17	895.29	265.98	158.91	152.30	137.79	124.02	110.67	3648.92
49	102.48	91.31	148.96	317.75	909.33	496.95	168.52	121.57	108.82	116.71	105.54	99.15	2787.09
50	93.56	93.03	194.45	637.52	945.44	531.48	270.16	140.20	101.87	171.64	142.96	125.77	3448.08
51	117.95	105.75	170.47	512.14	766.41	644.80	269.02	152.84	159.02	263.53	197.23	154.36	3512.52
52	140.50	150.66	188.00	723.50	919.98	674.46	365.25	179.25	134.33	119.13	114.29	111.19	3823.54
53	102.56	102.36	129.72	480.48	924.44	693.91	323.14	183.00	156.12	132.94	133.21	114.05	3475.93
54	113.15	116.34	212.62	632.76	1188.89	966.51	548.05	226.04	163.86	147.28	130.92	122.77	4571.19
55	103.14	97.93	142.70	301.86	590.15	337.88	114.76	75.04	72.29	81.73	82.84	92.87	2093.19
56	85.68	113.95	146.31	480.92	671.93	644.22	299.48	145.57	116.66	115.08	102.66	97.25	3021.75
57	85.63	104.69	255.38	530.19	815.78	689.82	298.12	139.20	117.99	120.35	125.44	116.98	3399.57
58	105.05	100.56	187.32	489.11	771.67	632.31	259.91	130.76	127.55	121.22	114.79	115.36	3155.61
59	115.73	90.99	202.32	533.18	958.03	759.96	323.93	191.40	151.28	187.35	175.40	141.50	3871.07
60	206.42	307.71	447.45	1095.51	1357.31	827.00	447.55	225.99	143.87	120.74	106.83	102.26	5388.64
61	77.82	77.52	130.98	447.03	578.01	387.54	112.76	62.37	57.91	69.74	85.15	122.56	2209.39
62	95.09	99.74	345.11	621.02	870.60	560.89	246.47	112.12	104.34	101.30	104.79	105.65	3367.12
63	112.57	112.85	162.59	922.76	1618.98	1458.70	781.12	353.58	155.74	169.91	149.90	130.11	6128.81
64	117.05	107.89	223.38	735.91	1206.05	899.68	281.65	139.03	122.65	123.38	120.01	131.10	4209.78
65	108.51	98.76	281.32	761.53	995.45	713.07	315.45	143.52	110.61	172.80	151.73	139.04	3991.79
66	159.10	151.44	245.67	667.36	1080.53	617.60	268.50	127.92	123.85	111.20	105.89	110.51	3769.57
67	98.12	88.13	152.84	518.85	1203.84	635.65	562.22	238.85	174.69	147.78	143.59	186.57	4151.13
68	149.73	144.11	309.42	1714.77	1721.72	941.26	426.02	241.14	215.17	213.25	223.88	173.52	6473.99
69	141.35	124.98	315.47	822.53	1334.51	555.16	234.54	154.10	144.89	188.05	134.16	130.61	4280.35
70	116.65	119.27	236.98	730.49	619.18	347.86	186.51	129.83	118.26	141.91	121.43	119.39	2987.76
71	100.07	86.47	238.91	481.28	1048.14	712.84	264.69	217.41	103.50	119.72	114.70	142.74	3630.47
72	103.93	99.85	188.82	757.24	818.76	771.27	327.37	153.91	159.74	158.38	151.15	113.68	2804.09
73	103.26	124.23	159.63	418.94	820.35	673.08	301.78	114.83	94.25	125.99	139.83	115.27	3191.44
74	85.05	85.80	242.46	387.16	927.97	454.35	153.06	107.34	164.57	98.47	97.00	99.93	2907.16
75	93.56	81.78	196.48	684.11	736.72	557.50	209.66	95.17	99.55	127.10	105.85	85.78	3073.26
76	99.66	96.30	227.23	752.57	1238.65	840.64	402.76	166.72	132.70	177.29	139.87	125.12	4399.51
77	99.47	109.77	206.91	513.39	991.11	634.24	282.10	148.72	114.70	139.74	124.21	106.58	3470.94
78	102.27	137.63	270.80	657.32	1221.44	716.17	360.39	154.02	106.19	121.36	119.34	122.46	4129.39
79	120.72	137.36	208.08	518.47	879.97	770.98	399.65	144.91	97.79	154.34	256.29	181.12	3869.68
80	142.13	128.30	297.08	1023.24	1086.76	509.97	221.44	128.61	98.91	131.23	126.51	127.21	4021.39
81	110.32	93.75	183.18	357.39	782.98	920.25	374.82	151.42	116.12	123.21	134.19	131.55	3519.18
82	114.74	87.68	133.44	730.64	1031.93	578.63	245.74	119.12	103.25	107.20	101.23	88.29	3441.89
83	76.96	74.15	147.89	340.32	605.38	464.90	180.34	80.66	94.07	116.53	229.10	163.83	2574.13
AV	115.76	116.12	216.88	636.11	995.76	685.60	313.81	158.74	127.74	140.97	139.12	126.64	3777.25
MA	206.42	307.71	447.45	1714.77	1854.33	1458.70	781.12	353.58	215.17	263.53	256.29	201.49	6473.99
MI	76.96	74.15	125.85	301.86	443.93	337.88	112.76	62.37	57.91	69.74	82.84	85.78	2093.19

Table 6–8 Natural Flow at Artvin (U) Damsite

unit: 10^6 m^3

YY	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
42	192.13	215.35	344.11	1410.36	1863.37	868.39	404.39	215.10	173.87	191.81	212.59	205.09	6296.56
43	162.21	137.83	175.73	525.26	879.52	535.80	290.48	178.79	134.75	144.62	156.67	152.06	3473.72
44	135.27	141.83	316.64	558.48	1876.82	921.88	517.27	208.77	161.96	148.39	162.34	122.84	5272.49
45	112.11	98.08	130.05	394.36	835.29	714.75	294.03	146.59	111.48	119.55	118.61	114.42	3189.32
46	104.14	99.76	162.94	481.30	946.52	895.59	400.17	257.85	162.25	228.95	176.09	143.88	4059.44
47	139.19	136.07	348.22	525.56	448.01	368.37	195.35	116.02	107.04	122.45	192.96	134.09	2833.33
48	124.72	115.51	127.46	521.24	930.45	896.27	271.62	159.75	152.88	138.84	124.86	111.21	3674.81
49	103.20	91.94	151.04	323.58	913.25	499.74	169.88	122.57	109.57	117.52	106.24	99.83	2808.36
50	94.20	93.77	197.38	647.63	950.70	533.35	272.59	141.25	102.45	173.22	144.23	126.79	3477.56
51	118.84	106.66	171.96	519.90	765.92	647.48	269.86	153.99	159.93	266.05	199.30	155.60	3539.49
52	141.67	152.24	190.48	731.82	923.48	676.33	371.80	179.12	134.80	119.71	114.70	111.37	3847.52
53	102.70	102.79	130.53	487.76	929.38	696.64	325.25	183.98	157.61	134.23	134.39	114.70	3499.96
54	113.93	119.54	215.78	644.98	1198.50	968.78	548.03	226.71	164.50	147.92	131.55	123.33	4603.95
55	103.46	98.58	144.32	305.91	591.65	339.16	115.90	75.85	73.03	82.18	83.23	93.31	2106.58
56	86.06	115.12	147.99	489.67	680.05	648.31	301.61	146.17	119.05	115.15	102.86	97.25	3049.29
57	85.39	105.30	259.43	537.71	824.89	696.43	300.88	140.41	118.60	120.89	125.87	117.57	3433.37
58	105.47	101.22	190.42	499.38	784.16	638.19	262.38	131.72	128.42	122.16	115.77	116.48	3195.73
59	116.82	91.66	205.99	542.26	1009.08	768.37	328.46	192.96	152.22	189.42	177.00	142.66	3916.90
60	210.35	315.25	458.69	1118.55	1378.34	838.74	453.08	227.81	144.51	122.33	108.15	103.37	5479.17
61	78.28	78.26	133.56	458.61	589.24	394.80	114.94	63.35	58.91	70.73	86.46	125.03	2252.17
62	96.79	101.74	354.44	634.85	884.93	569.90	250.39	113.80	106.10	103.40	106.79	107.82	3430.95
63	114.83	115.34	166.35	938.80	1635.17	1474.39	790.47	355.33	157.26	170.52	150.51	131.30	6200.27
64	118.45	109.40	227.75	746.73	1217.83	505.62	284.31	140.82	124.16	127.54	122.23	134.55	4259.39
65	110.78	100.74	295.25	779.60	1011.66	723.59	319.96	143.51	110.36	175.04	155.46	140.70	4056.65
66	160.16	153.45	245.41	680.07	1101.57	625.59	271.62	128.92	124.81	111.37	105.62	110.66	3819.25
67	98.34	89.23	154.64	529.59	1221.76	643.74	567.39	242.14	177.49	148.72	145.62	193.26	4211.92
68	153.35	147.45	311.30	1751.36	1773.80	961.73	436.10	245.08	217.21	212.20	221.78	173.80	6605.16
69	140.86	125.36	312.55	832.33	1350.39	556.52	233.72	153.29	145.18	190.65	135.76	132.09	4308.70
70	118.58	121.87	238.20	741.74	631.35	350.36	188.31	131.96	121.45	147.17	124.71	122.19	3037.89
71	102.84	90.67	242.23	491.10	1063.90	722.11	267.57	219.68	104.76	122.71	117.25	146.26	3691.18
72	106.42	102.48	193.51	777.27	832.33	781.59	332.72	155.67	162.29	159.05	153.14	115.40	3871.87
73	104.91	127.78	164.38	430.74	840.13	686.49	307.74	116.79	95.22	126.91	141.79	117.36	3260.24
74	90.70	86.98	246.63	352.23	943.58	461.11	154.67	108.10	167.13	99.91	98.42	101.10	2950.56
75	94.99	83.25	201.97	704.64	750.78	565.28	211.62	96.14	100.60	129.58	107.37	87.45	3133.67
76	101.23	97.94	231.36	764.84	1258.71	851.97	407.99	167.95	133.98	181.08	141.92	126.78	4465.75
77	100.96	110.95	209.06	520.44	1000.96	641.25	285.17	150.15	116.18	142.09	126.44	108.01	3511.66
78	103.52	140.24	275.54	709.40	1238.87	730.15	366.47	157.28	107.89	123.05	121.47	124.68	4198.56
79	123.71	141.00	213.14	529.81	899.47	782.68	404.54	147.45	98.67	155.10	258.52	184.14	3938.23
80	143.58	130.38	302.14	1032.59	1101.89	513.53	222.54	130.10	100.48	133.22	129.02	129.44	4068.91
81	111.96	96.00	187.42	405.42	795.85	934.82	378.93	153.55	118.75	125.64	136.67	133.38	3578.39
82	116.32	89.21	135.52	744.89	1047.64	586.10	245.85	121.17	104.80	108.99	102.83	89.79	3497.11
83	78.38	75.36	152.04	351.23	618.87	472.71	182.66	81.46	94.60	117.82	232.75	165.89	2623.77
AV	117.19	117.94	220.32	647.95	1012.95	692.58	317.21	160.22	128.98	142.57	140.72	128.26	3826.89
MA	210.35	315.25	458.69	1751.36	1876.82	1474.39	790.47	355.33	217.21	266.05	258.52	205.09	6605.16
MI	78.28	75.36	127.46	305.91	448.01	339.16	114.94	63.35	58.91	70.72	83.23	87.45	2106.58

Table 6–9 Natural Flow at Artvin (L) Damsite

unit: 10^6 m^3

YY	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
42	155.19	219.23	350.20	1435.28	1877.64	872.47	408.34	217.41	175.74	194.30	215.93	208.44	6374.17
43	164.57	139.71	178.41	534.55	887.52	541.77	293.89	181.01	136.62	146.70	158.78	154.29	3517.82
44	137.11	143.93	322.09	565.24	1897.81	932.88	524.53	210.89	163.50	149.79	164.08	123.92	5335.77
45	112.95	98.84	131.39	401.16	842.48	717.15	296.60	147.79	112.37	120.72	119.59	115.43	3216.47
46	104.89	100.61	165.27	485.34	952.22	894.80	402.28	258.68	162.66	230.59	171.05	144.56	4082.95
47	139.94	137.15	353.46	531.59	451.81	370.47	156.01	116.91	107.53	123.54	195.25	135.34	2859.00
48	126.00	116.76	128.97	529.47	936.32	897.19	273.14	160.54	153.42	139.83	125.64	111.72	3699.00
49	103.87	92.52	152.98	329.02	916.91	502.35	171.14	123.49	110.28	118.26	106.90	100.47	2828.19
50	94.80	94.46	200.12	657.06	955.60	535.10	274.85	142.22	103.00	174.70	145.42	127.74	3505.07
51	119.67	107.50	173.34	527.15	773.19	649.98	271.59	155.07	160.78	268.41	201.24	156.75	3564.67
52	142.77	153.72	192.79	739.58	926.76	678.08	374.17	179.93	135.24	120.24	115.09	111.54	3869.91
53	102.83	103.20	131.29	494.54	933.99	699.18	327.21	184.89	158.99	135.43	135.49	115.31	3522.35
54	114.66	120.66	218.74	656.39	1207.47	570.90	548.01	227.33	165.09	148.51	132.13	123.86	4633.75
55	103.76	99.19	145.83	309.68	593.04	340.35	116.97	76.61	73.73	82.60	83.60	93.71	2119.07
56	86.42	116.17	149.55	497.84	687.62	652.13	303.60	146.73	119.41	115.21	103.04	97.24	3074.96
57	85.16	105.87	263.22	544.73	833.38	702.61	303.46	141.55	119.16	121.39	126.27	118.12	3464.92
58	105.85	101.84	193.32	508.97	795.82	643.60	264.68	132.62	129.24	123.03	116.69	117.53	3233.19
59	117.84	92.28	209.41	550.73	1019.40	776.22	332.69	194.42	153.09	191.36	178.49	143.75	3959.68
60	214.02	322.28	469.18	1140.06	1397.97	849.71	458.25	229.51	145.10	123.80	109.39	104.41	5563.68
61	78.71	78.95	135.96	469.42	599.71	401.58	116.97	64.27	59.83	71.66	87.69	127.34	2292.09
62	98.37	103.60	363.15	647.77	898.29	578.30	254.05	115.38	107.75	105.37	108.65	109.85	3490.53
63	116.94	117.66	169.86	953.78	1650.28	1489.04	799.19	356.95	158.69	171.09	151.08	132.41	6266.97
64	119.75	110.82	231.82	756.84	1226.95	511.16	286.79	142.49	125.56	131.42	124.30	137.78	4305.68
65	112.91	102.59	288.92	796.46	1026.79	733.41	324.17	143.51	110.13	177.14	158.55	142.26	4117.24
66	161.14	155.32	245.17	691.93	1121.21	633.04	274.53	129.85	125.70	111.52	105.36	110.79	3865.56
67	98.54	90.25	156.32	539.62	1238.48	651.29	572.21	245.20	180.10	149.60	147.51	199.51	4268.63
68	156.73	150.56	313.06	1785.51	1822.40	580.84	445.51	248.75	219.11	211.22	219.81	174.06	6727.56
69	140.40	125.72	309.83	841.49	1365.21	557.78	232.94	152.54	145.46	193.07	137.26	133.46	4335.16
70	120.38	124.30	239.34	752.25	642.71	352.69	190.00	133.95	124.42	152.07	127.77	124.80	3084.68
71	105.42	94.59	245.32	500.27	1078.61	730.77	270.25	221.79	105.93	125.50	119.82	149.55	3747.82
72	108.75	104.90	197.89	795.97	845.00	791.28	237.71	157.31	164.67	159.67	155.00	117.01	3935.16
73	106.44	131.09	168.81	441.76	858.59	699.00	313.30	118.61	96.12	127.78	143.61	119.30	3324.41
74	92.25	88.08	250.53	396.95	958.14	467.42	156.17	108.82	169.51	101.25	99.74	102.20	2991.06
75	96.33	84.63	207.09	723.79	763.90	572.54	213.46	97.04	101.57	131.90	108.79	89.01	2190.05
76	102.71	99.47	235.22	776.28	1277.43	862.55	412.87	169.10	135.18	184.62	143.84	128.32	4527.59
77	102.35	112.05	211.07	527.03	1010.14	647.80	288.03	151.48	117.56	144.29	128.53	109.35	3549.68
78	104.70	142.67	279.96	720.67	1255.15	743.21	372.14	160.33	109.47	124.62	123.45	126.76	4263.13
79	126.50	144.39	217.87	540.39	917.68	793.61	409.11	149.82	99.50	155.82	260.60	186.96	4002.25
80	144.94	132.32	306.87	1041.32	1116.01	516.86	223.57	131.48	101.94	135.07	131.36	131.53	4113.27
81	113.50	98.11	191.37	412.91	807.87	948.42	382.76	155.53	121.20	127.90	138.98	135.08	3623.63
82	117.78	90.63	137.46	758.20	1062.29	593.09	253.68	123.07	106.25	110.67	104.32	91.19	3548.63
83	79.70	76.49	155.51	361.41	631.46	480.00	184.83	82.20	55.10	119.03	236.16	167.81	2670.10
AV	118.51	119.65	223.53	659.01	1025.27	699.11	320.37	161.60	130.14	144.06	142.21	129.77	3873.23
MA	214.02	322.28	469.18	1785.51	1897.81	1489.04	799.19	356.95	219.11	268.41	260.60	208.44	6727.56
MI	78.71	76.49	128.97	309.68	451.81	340.35	116.97	64.27	59.83	71.66	83.60	89.01	2119.07

Table 6–10 Natural Flow at Deriner Damsite

unit: 10^6 m^3

YY	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
42	260.51	301.04	476.84	2017.32	2163.42	959.79	492.69	267.70	216.93	247.99	286.80	279.66	7970.69
43	215.46	180.71	235.91	725.46	1052.80	666.38	366.72	229.11	177.48	191.62	204.44	202.47	4448.56
44	177.22	189.14	435.86	705.82	2316.43	1157.57	675.17	257.39	197.79	181.21	202.47	148.60	6644.67
45	132.57	116.59	161.22	542.19	991.59	771.11	352.74	174.99	133.07	147.08	142.26	138.70	3804.11
46	122.79	120.47	215.46	655.39	1071.72	885.21	449.56	279.66	174.24	267.70	199.76	161.47	4603.43
47	158.20	161.97	463.22	657.59	533.22	417.53	213.02	137.67	119.95	148.35	245.10	163.48	3419.30
48	154.67	144.80	162.22	659.26	1059.11	921.50	308.13	179.72	167.48	162.72	144.29	124.60	4228.50
49	119.95	106.70	195.32	442.71	995.82	560.09	200.00	145.06	127.17	136.14	122.79	115.82	3267.57
50	109.31	110.87	258.83	850.91	1059.11	575.70	324.63	164.99	116.59	207.87	172.49	149.87	4101.17
51	139.20	127.17	204.68	677.36	844.47	705.82	310.50	179.96	181.21	319.93	243.89	183.20	4117.39
52	167.59	186.67	242.92	900.17	997.93	718.52	426.70	199.76	147.08	133.84	125.63	117.63	4365.24
53	108.00	114.00	149.61	635.56	1031.73	755.92	371.36	206.89	190.13	162.72	160.72	130.26	4016.90
54	132.05	146.07	282.03	889.48	1351.22	1019.07	553.38	243.85	180.46	163.73	146.83	137.42	5285.63
55	112.44	114.00	179.47	389.89	626.72	369.04	141.24	94.08	89.83	93.28	93.28	104.35	2407.62
56	95.93	140.23	184.19	666.38	844.47	734.18	348.07	161.22	129.48	119.18	109.21	99.61	3632.25
57	82.89	115.55	343.40	650.51	1008.51	831.57	359.74	167.48	133.33	134.35	137.17	132.05	4140.95
58	116.33	116.85	255.22	715.82	1033.83	758.09	315.22	153.66	148.60	143.53	137.93	141.49	4026.57
59	141.24	107.22	282.03	725.46	1230.37	938.53	422.12	227.41	173.99	233.96	212.04	168.74	4863.11
60	291.55	467.76	683.94	1572.66	1792.27	1073.83	566.78	267.70	160.21	156.44	136.90	127.94	7297.98
61	89.56	95.13	187.41	650.51	814.34	542.19	160.72	84.76	80.48	92.48	114.77	176.73	3129.08
62	132.82	143.78	542.15	910.84	1170.07	751.57	231.69	149.87	143.53	147.59	148.85	153.41	4726.21
63	162.22	167.24	243.89	1257.31	1953.84	1784.26	978.88	394.50	190.63	185.93	165.73	157.69	7642.12
64	148.85	142.01	317.58	964.03	1413.76	1027.51	341.06	179.22	156.69	215.08	169.82	207.96	5283.57
65	159.03	142.51	377.31	1139.15	1335.57	935.29	411.82	145.31	106.98	225.67	235.64	177.81	5352.09
66	185.71	198.21	248.46	934.36	1520.23	787.18	335.79	150.35	145.31	116.82	101.97	115.66	4840.06
67	104.38	112.72	195.10	744.86	1579.50	807.46	673.43	309.46	234.74	171.42	190.42	336.75	5460.24
68	231.16	219.13	362.56	2414.73	2799.61	1368.79	637.86	325.24	255.81	197.17	185.71	184.14	5245.91
69	134.08	135.77	264.51	1030.40	1668.65	587.89	220.11	139.44	152.88	249.44	171.42	164.98	4919.57
70	160.12	177.28	271.25	567.87	874.95	402.55	226.12	175.71	185.91	258.22	194.07	181.51	4075.96
71	160.66	177.28	318.82	688.05	1375.24	909.27	327.00	266.75	131.07	185.13	173.22	221.97	4938.46
72	156.80	155.70	290.69	1179.81	1104.69	987.65	438.14	190.66	212.50	173.99	196.74	153.27	5241.04
73	140.18	206.54	264.26	671.44	1232.64	953.88	426.23	156.57	115.66	147.13	186.55	162.79	4663.87
74	124.04	112.13	333.50	456.74	1252.89	595.99	188.28	125.75	220.84	128.62	127.47	126.99	3833.24
75	125.59	115.32	318.96	1115.20	1026.47	720.27	252.75	116.42	122.04	183.60	140.89	122.85	4360.76
76	135.37	132.04	319.31	1017.43	1653.56	1075.85	512.70	194.42	162.18	265.39	183.71	160.61	5812.57
77	131.66	137.08	254.89	662.60	1197.36	780.66	349.13	182.65	150.31	197.87	177.02	139.42	4360.65
78	131.32	156.50	372.51	556.01	1584.36	1011.49	489.03	223.66	142.80	158.18	170.88	176.87	5613.61
79	188.31	219.54	317.08	759.54	1287.69	1015.36	503.42	198.71	118.42	176.40	308.64	250.73	5343.84
80	176.17	174.46	407.83	1226.10	1404.50	588.69	245.38	159.85	132.80	173.47	189.10	177.70	5056.05
81	149.08	146.59	278.63	568.88	1056.35	1225.83	463.03	195.71	172.13	175.89	194.68	174.41	4800.21
82	152.74	122.98	182.74	1033.48	1357.75	733.66	332.23	163.09	135.81	147.56	139.31	124.17	4625.52
83	108.80	103.13	243.10	573.96	888.40	628.46	230.99	99.13	107.13	147.46	309.55	211.12	3651.23
AV	148.25	157.27	293.45	866.03	1276.22	834.33	387.47	192.04	155.86	177.91	176.20	163.97	4849.00
MA	291.55	467.76	683.94	2474.73	2799.61	1784.26	978.88	394.50	259.81	319.93	309.55	336.75	9245.91
MI	82.89	95.13	149.61	389.89	533.22	369.04	141.24	84.76	80.48	92.48	93.28	99.61	2407.62

Table 6–11 Natural Flow at Borcka Damsite

unit: 10^6 m^3

YY	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
42	294.78	337.77	521.01	2038.23	2177.97	1008.68	537.32	302.44	248.14	281.44	322.70	315.13	8385.61
43	246.57	208.99	268.51	774.22	1100.90	714.53	406.76	261.23	205.48	220.83	234.69	232.56	4875.27
44	205.20	218.14	478.68	754.40	2323.85	1204.29	723.42	291.46	227.51	209.53	232.56	173.91	7042.95
45	156.22	138.49	187.74	588.12	1040.26	820.16	392.14	207.77	156.79	172.24	166.93	163.00	4184.86
46	145.40	142.81	246.57	703.39	1115.61	934.41	492.85	315.13	201.95	302.44	225.64	188.01	5022.21
47	184.43	188.56	506.96	705.62	578.94	459.67	243.94	161.87	142.24	173.63	278.35	190.21	3814.42
48	180.57	169.73	188.84	747.78	1107.14	970.59	345.26	207.92	194.59	189.38	169.16	147.40	4618.36
49	142.24	127.44	224.84	485.77	1044.46	606.42	229.90	170.01	150.26	160.18	145.40	137.63	3624.55
50	130.36	132.11	293.00	900.15	1107.14	622.36	362.63	191.86	138.49	238.39	200.05	175.30	4491.84
51	163.56	150.26	234.95	725.64	892.71	754.40	347.75	208.18	209.53	357.69	277.05	211.69	4534.41
52	195.14	215.46	276.02	949.34	1046.56	767.62	469.19	229.64	172.24	157.64	148.54	139.65	4767.04
53	128.90	135.60	175.02	683.28	1080.05	804.89	411.61	237.33	219.22	189.38	187.19	153.67	4406.14
54	155.66	171.12	317.65	938.68	1433.25	1067.51	595.57	277.05	208.72	190.49	171.96	161.59	5693.25
55	133.85	135.60	207.64	430.94	674.31	409.19	165.80	113.25	108.45	112.35	112.35	124.80	2728.53
56	115.33	164.68	212.77	714.53	893.71	783.00	387.24	187.74	152.81	141.38	130.36	119.49	4003.04
57	100.58	142.24	382.35	738.93	1057.04	880.80	399.46	194.59	157.07	158.20	161.31	155.66	4528.23
58	138.20	138.78	289.15	754.40	1082.13	807.07	352.72	179.46	173.91	168.32	162.15	166.08	4412.37
59	165.80	128.02	317.65	774.22	1275.86	987.55	464.44	259.41	201.68	266.43	242.88	195.96	5279.90
60	327.73	511.65	732.29	1609.72	1821.99	1121.69	613.26	302.44	186.64	182.51	161.02	151.11	7722.05
61	108.15	114.44	216.27	728.93	863.54	588.12	187.19	102.71	97.83	111.45	136.46	204.66	3469.75
62	156.51	168.60	588.12	959.97	1216.60	800.52	370.05	175.30	168.32	172.79	174.18	179.19	5130.15
63	188.84	194.32	277.05	1302.28	1977.35	1814.27	1027.65	435.75	219.76	214.66	192.68	183.88	8028.49
64	174.18	166.65	355.21	1012.90	1455.23	1075.87	379.89	207.37	182.78	266.25	204.29	256.37	5736.99
65	189.82	167.91	501.19	1196.29	1397.34	986.77	443.09	160.38	118.99	281.00	294.98	215.09	5952.85
66	225.83	242.92	313.07	985.81	1565.74	833.91	363.07	165.81	160.38	134.50	115.58	133.00	5259.62
67	118.63	129.23	238.66	790.12	1646.10	854.88	716.06	335.28	256.05	206.45	232.25	440.85	5964.56
68	288.70	271.88	479.14	2552.44	2879.37	1431.27	675.11	351.95	282.68	241.50	225.83	223.69	9907.56
69	156.85	159.06	335.91	1084.64	1736.79	627.13	240.47	154.06	168.53	314.46	206.45	197.79	5382.14
70	191.27	214.37	345.55	1020.32	924.57	433.77	246.87	193.02	203.94	326.92	237.24	220.10	4557.95
71	192.00	214.37	414.49	731.23	1441.94	559.96	353.80	290.05	145.04	218.28	207.13	277.98	5446.27
72	171.28	177.42	336.42	1274.69	1166.41	1016.99	447.28	196.00	220.14	190.00	234.85	187.56	5619.04
73	165.71	283.12	322.55	755.26	1285.98	1001.13	444.14	169.14	129.00	164.28	239.13	201.27	5160.71
74	132.43	129.28	377.70	542.84	1292.13	619.99	206.57	147.85	251.71	133.57	139.28	150.99	4124.34
75	149.99	141.99	398.98	1197.12	1038.28	746.56	274.85	127.85	130.43	228.56	172.13	145.71	4752.45
76	162.42	148.42	377.98	1125.26	1682.13	1098.71	534.42	213.85	187.71	348.83	197.42	173.57	6250.72
77	145.00	161.85	286.13	699.56	1232.42	801.99	382.28	219.99	192.99	277.12	233.41	166.85	4799.59
78	157.99	240.70	408.70	1044.40	1627.42	1079.70	521.42	244.99	157.28	175.71	234.13	248.12	6140.56
79	238.99	280.13	357.85	828.12	1349.41	1050.42	530.85	212.42	137.85	227.84	361.98	312.84	5888.70
80	209.70	202.28	462.70	1315.26	1464.70	634.42	256.43	166.71	147.28	185.28	278.26	215.42	5538.44
81	180.85	199.56	347.98	624.13	1131.41	1280.70	495.42	201.43	189.28	199.14	272.41	217.84	5340.15
82	198.84	154.99	236.84	1117.69	1387.85	747.00	350.14	179.85	142.28	176.13	181.99	165.70	5039.30
83	131.28	136.28	324.26	653.98	939.84	656.28	254.59	116.28	124.28	183.28	354.13	252.27	4127.15
AV	174.90	187.08	342.01	942.16	1323.37	877.74	420.27	215.76	177.86	210.73	210.96	196.99	5279.83
MA	327.73	511.65	732.29	2552.44	2879.37	1814.27	1027.65	435.75	282.68	357.69	361.98	440.85	9907.56
MI	100.58	114.44	175.02	430.94	578.94	409.19	165.80	102.71	97.83	111.45	112.35	119.49	2728.53

Table 6–12 Natural Flow at Muratli Damsite

unit: $10^6\ m^3$

YY	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
42	347.85	394.73	590.07	2079.48	2210.32	1087.21	607.17	356.24	296.38	333.20	378.35	370.10	9051.10
43	294.63	252.62	318.94	851.40	1178.66	790.51	469.05	310.89	248.66	265.91	281.40	279.03	5541.70
44	248.35	262.90	545.50	831.23	2346.15	1280.46	799.61	344.20	273.38	253.23	279.03	212.88	7676.92
45	192.63	172.16	228.61	660.15	1118.59	898.00	453.40	245.60	193.28	210.97	204.91	200.40	4778.70
46	180.16	177.16	294.63	779.11	1197.15	1013.04	560.46	370.10	244.68	356.24	275.76	228.92	5677.41
47	224.86	229.54	575.31	781.39	650.61	525.39	291.71	199.12	176.50	212.56	329.79	231.41	4428.19
48	220.47	208.11	229.85	824.48	1184.83	1049.22	402.86	251.41	236.38	230.48	207.47	182.47	5228.03
49	176.50	159.31	270.40	552.99	1122.76	679.15	276.06	208.42	185.76	197.18	180.16	171.15	4179.84
50	162.71	164.74	345.89	578.68	1184.83	695.67	421.65	233.28	172.16	285.53	242.53	214.47	5102.14
51	201.05	185.76	281.69	801.88	972.21	831.23	405.55	251.71	253.23	416.30	328.36	255.66	5184.63
52	236.99	259.89	327.23	1027.98	1124.84	844.69	535.47	275.76	210.97	194.25	183.78	173.50	5395.35
53	161.01	168.80	214.15	758.47	1158.04	882.54	474.25	284.35	264.11	230.48	227.99	189.69	5013.88
54	191.58	209.70	372.85	1017.31	1503.44	1145.62	672.05	328.36	252.31	231.72	210.65	198.80	6334.79
55	166.77	168.80	251.10	494.87	749.25	471.66	203.62	142.68	137.03	141.62	141.62	156.22	3225.24
56	145.13	202.33	256.86	750.51	972.21	860.33	448.14	228.61	186.71	175.51	162.71	150.01	4581.06
57	127.72	176.50	442.88	815.45	1135.24	959.22	461.24	236.38	193.61	194.91	198.46	191.98	5133.59
58	171.83	172.45	341.67	821.23	1160.10	884.76	410.94	219.20	212.88	206.50	199.44	203.94	5014.98
59	203.62	159.59	372.85	851.40	1350.51	1066.14	530.44	308.87	244.37	316.65	290.53	237.91	5933.28
60	383.83	580.24	808.67	1673.26	1875.50	1199.20	686.25	356.24	227.36	222.67	198.14	186.75	8398.11
61	136.67	144.09	260.79	815.45	941.83	660.15	227.99	130.24	124.45	140.57	169.81	247.74	3999.78
62	192.56	206.82	660.15	1038.61	1252.53	878.11	429.65	214.47	206.50	211.61	213.19	218.89	5763.49
63	229.85	236.06	328.36	1376.29	2022.25	1868.18	1106.06	499.99	264.71	258.98	234.20	224.24	8649.17
64	213.19	204.58	413.62	1091.41	1524.69	1153.90	440.24	250.79	222.98	344.64	257.22	330.57	6447.83
65	237.13	206.99	690.29	1288.13	1497.13	1069.09	492.34	183.88	137.66	365.74	385.84	272.30	6826.52
66	287.37	311.48	411.96	1068.08	1692.05	908.32	405.53	189.90	183.88	161.77	136.65	159.76	5917.15
67	140.67	154.74	305.45	862.10	1754.35	930.43	783.73	375.79	289.38	260.24	296.41	599.86	6753.15
68	376.79	352.68	657.13	2681.77	3013.34	1532.29	744.54	393.87	318.52	309.47	287.37	284.35	10952.12
69	191.91	194.53	445.12	1171.58	1847.80	689.28	272.30	176.84	192.92	413.97	260.24	248.18	6105.07
70	239.14	271.29	459.19	1104.26	1003.78	482.30	279.33	220.05	232.10	432.06	303.44	279.33	5306.27
71	240.14	271.29	560.67	799.81	1543.35	1040.95	395.88	326.55	166.79	269.28	259.23	363.73	6237.67
72	193.92	211.00	406.94	1423.78	1265.02	1066.07	463.20	204.98	232.10	215.02	293.40	240.14	6215.57
73	204.98	399.90	411.96	885.21	1372.53	1077.13	473.25	188.90	149.71	190.91	319.52	260.24	5934.24
74	145.69	155.74	446.12	614.93	1357.46	659.14	235.12	181.87	299.43	141.61	157.75	187.89	4582.81
75	186.89	182.87	521.48	1326.31	1361.05	789.76	309.47	145.69	143.68	297.42	220.05	180.86	5365.53
76	203.97	173.83	468.23	1293.16	1733.25	1138.42	569.71	244.16	227.08	476.27	219.04	193.92	6941.04
77	165.79	199.95	334.59	758.61	1251.15	837.99	434.07	277.32	258.23	397.89	319.52	208.99	5484.10
78	198.95	308.47	465.21	1182.63	1700.09	1187.65	572.73	278.32	179.86	202.97	330.57	356.70	6964.15
79	316.51	372.77	421.00	935.45	1448.90	1108.28	574.74	234.11	167.80	306.46	444.11	407.94	6738.07
80	261.24	245.17	547.61	1455.53	1562.44	706.36	274.31	177.85	169.81	203.97	413.97	273.30	6291.96
81	231.10	280.33	454.16	710.38	1249.95	1369.52	546.60	211.00	216.03	235.12	390.86	284.35	6179.40
82	269.28	203.97	319.52	1249.95	1439.85	770.67	378.80	205.98	152.73	220.05	247.18	229.09	5687.07
83	165.79	186.85	448.13	777.70	1021.86	701.34	252.39	142.68	150.72	238.13	423.01	315.50	4864.14
AV	215.91	232.90	416.83	1031.26	1400.76	947.37	471.72	252.54	211.88	261.15	264.37	247.69	5954.42
MA	383.83	580.24	808.67	2681.77	3013.34	1868.18	1106.06	499.99	318.52	476.27	444.11	599.86	10952.12
MI	127.72	144.09	214.15	494.87	650.61	471.66	203.62	130.24	124.45	140.57	136.65	150.01	3225.24

Table 6–13 Observed Monthly Class A Pan Evaporations of Bayburt Meteorological Station

(unit: mm)

Month / Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
1977	–	–	–	–	–	133.0	178.4	192.2	137.2	43.5	D	D	–
1978	D	D	D	D	127.2	158.5	206.1	183.0	156.8	77.1	D	D	908.7
1979	D	D	D	D	121.4	140.3	176.0	201.2	158.6	66.2	D	D	863.7
1980	D	D	D	D	121.2	178.2	230.2	185.1	144.4	75.3	D	D	934.4
1981	D	D	D	D	98.0	136.6	197.6	182.6	135.0	78.0	D	D	827.8
1982	D	D	D	D	105.1	152.4	159.6	168.2	116.7	73.1	D	D	775.1
1983	D	D	D	D	99.0	148.1	190.9	176.2	131.6	68.2	D	D	814.0
1984	D	D	D	D	92.2	138.0	198.1	148.1	152.8	196.9	D	D	926.1

1) D; unmeasurable due to frost
2) –; no data available

Table 6–14 Actual Monthly Evaporations from Yusufeli Reservoir

(unit: mm)

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual Total
1965	11.6	15.2	59.7	83.2	136.3	161.8	182.1	191.2	158.6	80.2	46.3	24.6	1,150.8
66	39.3	52.6	68.4	108.2	130.	164.2	202.7	201.	152.2	122.2	78.7	38.	1,357.4
67	8.1	2.7	46.3	86.9	120.6	145.	161.	172.3	144.2	109.8	52.6	10.4	1,059.8
68	D	6.4	44.9	109.8	141.8	151.4	187.	179.7	151.4	112.	69.9	17.	1,171.2
69	9.8	16.5	61.2	84.7	141.1	179.7	176.4	198.5	151.4	94.4	48.3	34.	1,195.9
1970	25.3	41.4	67.7	122.9	132.4	164.2	192.8	174.8	152.2	96.7	68.4	16.5	1,255.3
71	12.7	25.3	60.4	98.3	137.9	147.4	196.1	177.3	180.5	98.3	54.7	6.4	1,190.4
72	D	4.8	47.7	112.1	126.1	159.4	196.9	203.5	157.8	123.7	44.9	7.5	1,184.2
73	D	34.6	49.1	92.3	130.	141.8	183.8	178.1	165.4	114.4	31.9	9.8	1,121.
74	D	18.3	66.2	72.1	140.2	175.6	180.5	182.9	141.1	135.5	64.1	24.6	1,201.1
75	9.8	8.6	48.4	122.9	133.9	177.2	195.2	188.7	151.4	135.3	58.3	0.35	1,230.1
76	D	D	41.4	95.2	127.6	149.8	177.2	185.4	151.4	106.7	56.8	26.6	1,118.3
77	4.8	37.3	54.0	99.	126.8	145.	179.7	187.	149.8	81.7	51.9	11.	1,128.1
78	3.7	29.3	65.5	78.7	127.6	124.5	179.7	172.3	151.4	112.	36.0	11.	1,091.7
79	4.8	27.3	65.5	98.3	141.8	158.6	177.9	203.5	162.6	104.4	64.8	15.2	1,228.3
1980	3.7	11.0	58.3	90.	132.4	169.9	198.5	178.9	141.8	94.4	61.9	32.6	1,173.3
81	25.3	38.6	63.4	82.5	112.8	165.1	199.4	188.7	165.1	116.7	47.7	40.	1,245.2
82	-	-	-	-	-	-	-	-	157.0	105.1	42.8	10.7	-
83	D	17.7	48.4	109.0	138.7	158.6	192.0	174.8	153.0	101.3	58.3	19.5	1,171.3
84	24.0	25.3	64.8	93.7	122.9	161.8	182.9	162.6	171.5	107.4	61.2	5.8	1,183.9
Ave.	9.6	21.7	56.9	96.8	131.6	157.9	186.4	184.3	155.5	107.6	55.0	18.1	1,181.4

6.4 Sedimentation

Suspended sediment samplings are being carried out by EIE at 85 stations. Suspended sediment samples collected usually at an interval of one month are used to develop the sediment rating curve for each station.

In the Coruh river basin suspended sediment samples are collected at the following stations in Table 6-15.

Table 6-15 Existing Suspended Sediment Data

Station Name	No.	Period	Number of Samples
Karsikoy	2315	June 1967 - Oct. 1984	182
Ispir Koprusu	2316	Sept. 1969 - Oct. 1984	167
Laleli	2320	July 1971 - Nov. 1983	88
Asagi Kumlu	2325	June 1977 - Oct. 1984	84

The data series measured at No. 2315 and No. 2316 stations have the considerable variability of sediment load and river discharge as are shown in Table 6-16.

Table 6-16 Characteristics of Sediment Data

Station No.	Suspended Sediment (PPM)			River Discharge (m^3/sec)		
	Max.	Min.	Ave.	Max.	Min.	Ave.
2315	6,170	12	469	868	37.6	146.3
2316	3,000	13	167	327	7.5	24.6

Two sediment rating curves relating suspended sediment discharge and river water discharge at Nos. 2315 and 2316 stations were constructed to estimate daily sediment load. The curves are given in Fig. 6-13 and 6-14. The regression equations were derived as follows.

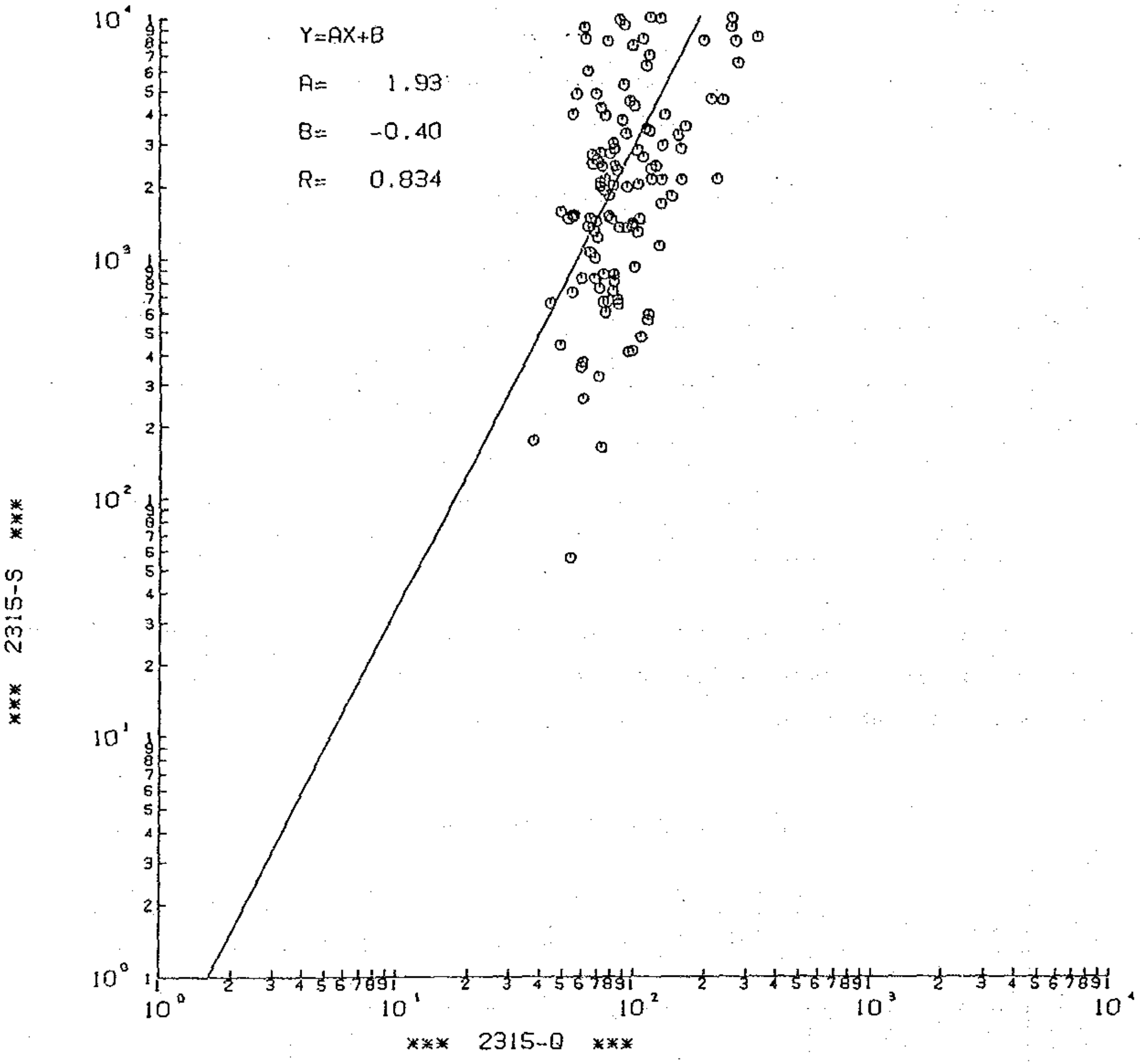

Fig. 6–13 Sediment Rating Curve at No. 2315 Station

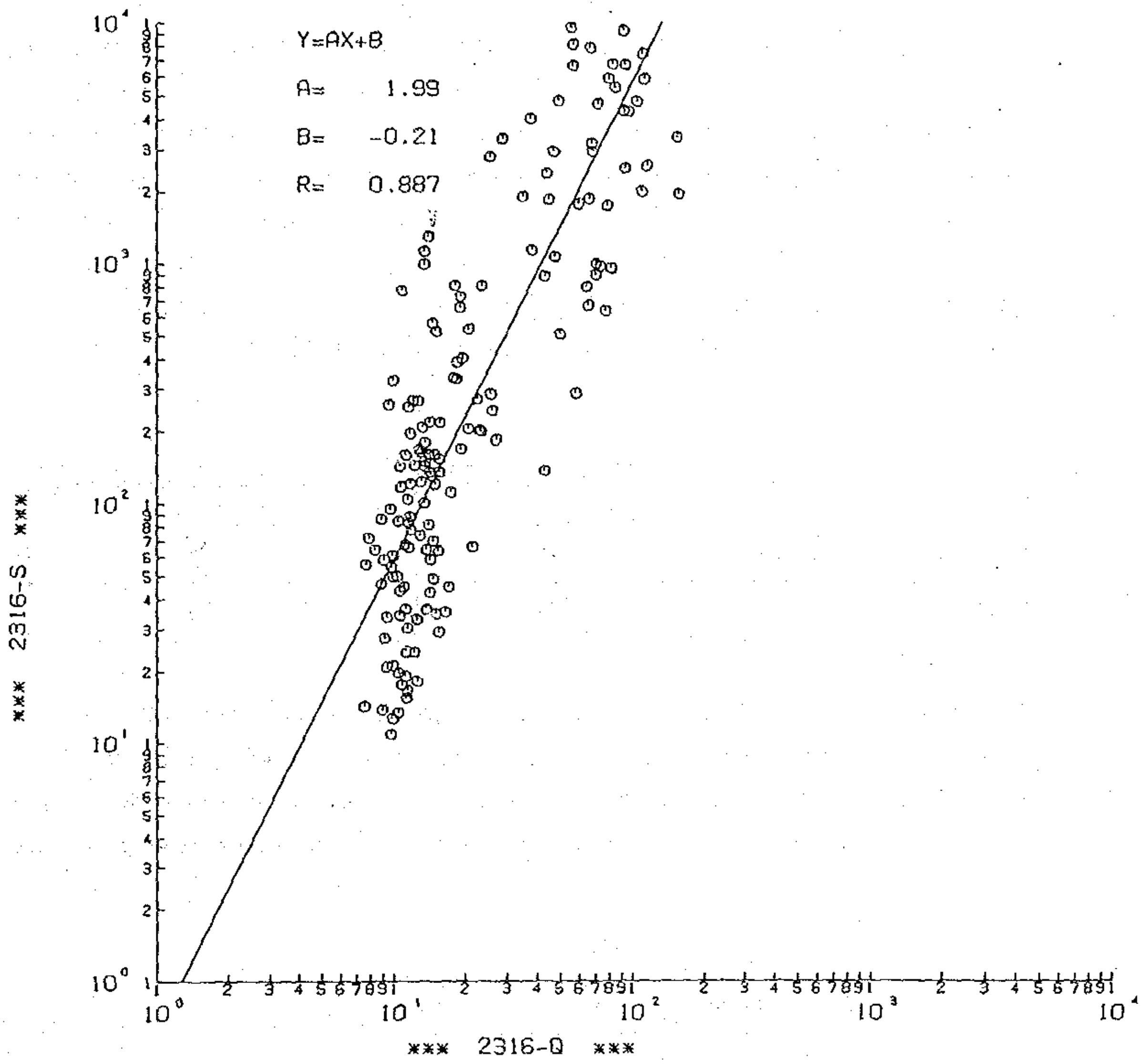

Fig. 6–14 Sediment Rating Curve at No. 2316 Station

No. 2315: $\log S = -0.40123 + 1.92772 \log Q$

No. 2316: $\log S = -0.21199 + 1.98650 \log Q$

where,

S; suspended sediment discharge in tons per day

Q; river water discharge in cubic meters per second

The sediment rating curves should be generally used with caution. However, as they were used to estimate mean annual sediment yield, the erros in estimating the sediment rating curves were considered to tend to compensate. The mean annual sediment yields in tons per square kilometer at Nos. 2315 and 2316 stations were respectively estimated by using the sediment rating curves and daily discharge data recorded at Nos. 2315 and 2316 stream gaging stations from October 1964 to September 1983. Calculation results are shown below.

Station No.	Catchment Area (km^2)	Calculation Period (years)	Mean Annual Sediment Yield ($tons/km^2$)
2315	19,654	19	360
2316	5,505	19	138

The sediment volume in the reservoir depends on the specific density of the deposited material. The specific density varies with the kind of sediment and the age of the deposits. The kinds of suspended sediment and their contents are found below by the gradation analysis made by EIE.

Sand	Silt	Clay
33%	37%	30%

The dry specific density W_t at time t were found by Lane and Koelzer to be defined by $W_t = W_1 + K \log t$, where W_1 is the initial specific density and K is a consolidation coefficient. The average density of the total sediment accumlation at time t can be found by integrating from year 1 to year t.

The average specific density after 50 years of the deposits in the Yusufeli reservoir was estimated to be 1.195 ton/m^3.

The average annual sediment yields at Nos. 2315 and 2316 stations were estimated by adding 12% of the suspended sediment load as the bed load transport to the suspended sediment load.

No. 2315: 337 m^3/km^2
No. 2316: 129 m^3/km^2

Fleming utilized data from over 250 catchment basins in the world to derive mean annual suspended load Qs in tons as a function of mean annual discharge Q in cubic feet per second for various vegetal covers: $Qs = aQ^n$, where a and n are coefficients for various vegetal cover types. The Qs was calculated for No. 2315 station in order to check the mean annual suspended sediment yield of 360 ton/km^2 estimated. The Qs was found 280 ton/km^2 taking into consideration the vegetal cover over the Coruh river basin. The value of 360 ton/km^2 is considered to be reasonably satisfactory in view of an order of estimation.

6.5 Probable Flood

The observation of flood peak discharges is being made by EIE at some stream gaging stations located on the Coruh river and its tributaries. The list of the stations together with the measured flood peaks is given in Table 6-17.

The three gaging stations, Nos. 2305, 2323 and 2321, were selected to find probable flood for various return periods at Yusefeli and Artvin damsites.

In the flood frequency analysis, the Gumbel distribution and the log-Pearson Type III distribution were applied. Flood peaks recorded at the three stations are listed in Tables 6-18 6-20. Maximum historical flood peaks are 798 m^3/sec, 469 m^3/sec and 89 m^3/sec for Nos. 2305, 2323 and 2321 stations respectively.
Probable floods for various return periods at the damsites were estimated by summing up the three probable floods at the above stations

Table 6–17 List of Measured Flood Peaks

Station		River	Catchment Area (km²)	Observation Period	Historical Max. Flood	
No.	Name				Discharge (m^3/s)	Date
2302	Tev Koprusu	Tortum	1,744	1941 - 68	227	-
2304	Bayburt	Coruh	1,734	1942 - 84	216	Apr.11
2305	Peterek	Coruh	7,272	1942 - 84	798	May 4
2306	Aralik	Aralik	70	1945 - 56	33	-
2307	Deviskel	Deviskel	193	1945 - 59	21	-
2308	Borcka	Coruh	19,443	1956 - 65	1,169	May 26
2310	Kan	Coruh	4,405	1954 - 63	509	May 7
2311	Dikkale	Tortum	1,457	1965 - 67	74	Jul.5
2314	Catakkopru	Tortum	1,965	1964 - 67	85	May 22
2315	Karsikoy	Coruh	19,654	1965 - 84	2,431	Apr.18
2316	Ispir Kopru	Coruh	5,505	1965 - 84	449	Apr.18
2319	Uluboga	Tortum	1,824	1970 - 74	70	May 11
2320	Laleli	Coruh	4,760	1971 - 84	328	Apr.12
2321	Dutdere	Barhal	586	1972 - 84	89	May 23
2322	Altinsu	Coruh	18,326	1972 - 84	1,018	May 20
2323	Ishan Kopru	Oltu	6,854	1965 - 84	469	May 20

Table 6–18 Flood Peak Discharges at No. 2305 Station

Date	Discharge (m^3/sec)	Date	Discharge (m^3/sec)
16 Apr. 1942	754	22 May 1964	480
7 May 1943	239	28 Apr. 1965	350
4 May 1944	798	1 May 1966	337
10 May 1945	194	13 May 1967	332
13 June 1946	219	18 Apr. 1968	679
5 Apr. 1947	139	14 May 1969	395
30 May 1948	246	15 Apr. 1970	276
13 May 1949	219	9 May 1971	310
8 May 1950	226	1 May 1972	256
3 May 1951	166	12 May 1973	238
7 Apr. 1952	239	12 May 1974	310
20 May 1953	226	13 Apr. 1975	241
6 May 1954	317	21 May 1976	369
24 May 1955	144	15 May 1977	402
26 Apr. 1956	206	10 Apr. 1978	412
17 June 1957	232	6 June 1979	247
16 May 1958	213	11 Apr. 1980	580
20 May 1959	401	4 June 1981	267
11 May 1960	578	23 Apr. 1982	390
16 May 1961	191	1 June 1983	205
10 Apr. 1962	261	27 May 1984	281
2 June 1963	489		

Table 6-19 Flood Peak Discharges at No. 2323 Station

Date	Discharge (m^3/sec)	Date	Discharge (m^3/sec)
18 May 1965	154		
2 May 1966	191		
13 May 1967	249		
18 Apr. 1968	422		
30 Apr. 1969	378		
15 Apr. 1970	146		
17 May 1971	165		
1 May 1972	174		
12 May 1973	205		
13 May 1974	231		
15 May 1975	99.8		
21 May 1976	227		
14 May 1977	220		
18 May 1978	295		
14 June 1979	230		
11 Apr. 1980	263		
5 June 1981	196		
19 May 1982	224		
18 May 1983	97.8		
20 May 1984	469		

Table 6–20 Flood Peak Discharges at No. 2321 Station

Date	Discharge (m^3/sec)	Date	Discharge (m^3/sec)
1 June 1972	70.1		
23 May 1973	89.0		
3 Sept. 1974	80.6		
13 Apr. 1975	69.8		
29 June 1976	86.0		
15 May 1977	62.0		
18 June 1978	64.4		
27 June 1979	80.1		
10 Apr. 1980	66.1		
23 June 1981	77.9		
12 May 1982	60.3		
6 June 1983	54.8		
17 June 1984	52.6		