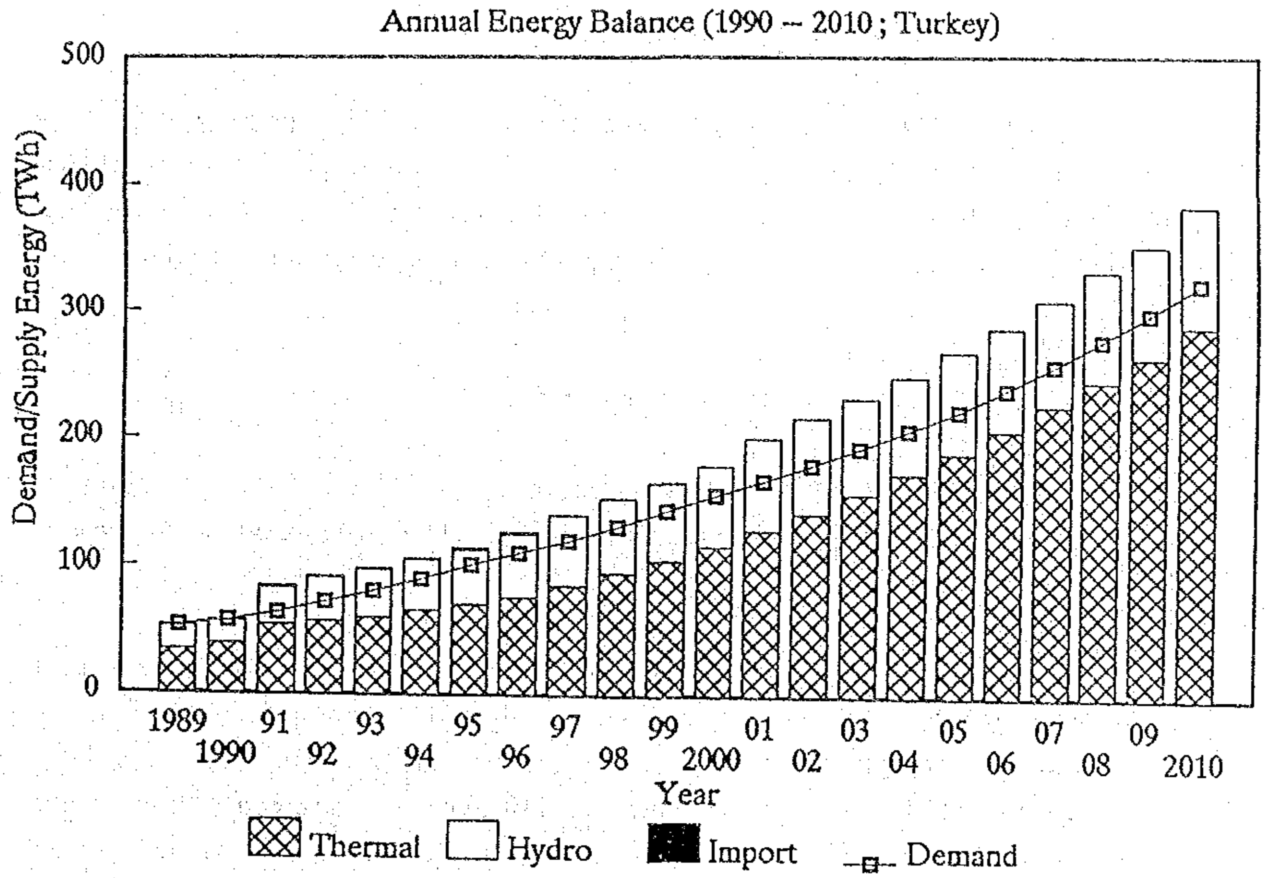

Fig. 5-2 Forecast of Demand/Supply Balance

- Annual Energy -

5.1.3 Power Demand Forecast by Macroscopic Method

To confirm TEK's long range load forecast to be reasonable, the load forecast by macroscopic method has been made. The outline of the methodology, the comment on TEK's load forecast by comparing to the load forecast by the macroscopic method are as follows:

(1) Outline of Load Forecast by Macroscopic Method

The method is a method used the relation between annual electric energy consumption per capita and economic growth as follows:

On Demand Pass Chart (Fig. 5-3) and Chart of GDP/capita and its Growth Rate (Fig. 5-4), actual past records of a country are plotted. In case of developing county, the plots will be near to the world average growth curve from lower side of the curve and reach to the curve. The contact point is called the standard year. After the standard year, the per capita demand is to be assumed growing according to the world average growth curve.

This method was proposed to IAEA by Mr. H. Aoki of EPDC for a methodology for load forecast in developing countries.

Depend on the country or social disturbances, the actual record curve will be disturbed occasionally, but in long range view the tendency of the actual curve is considered no change.

In case of Turkey, judging from the past record, the standard year was 1988, and the point in 1990 stays around the world average growth curve, along which future points are supposed to trace.

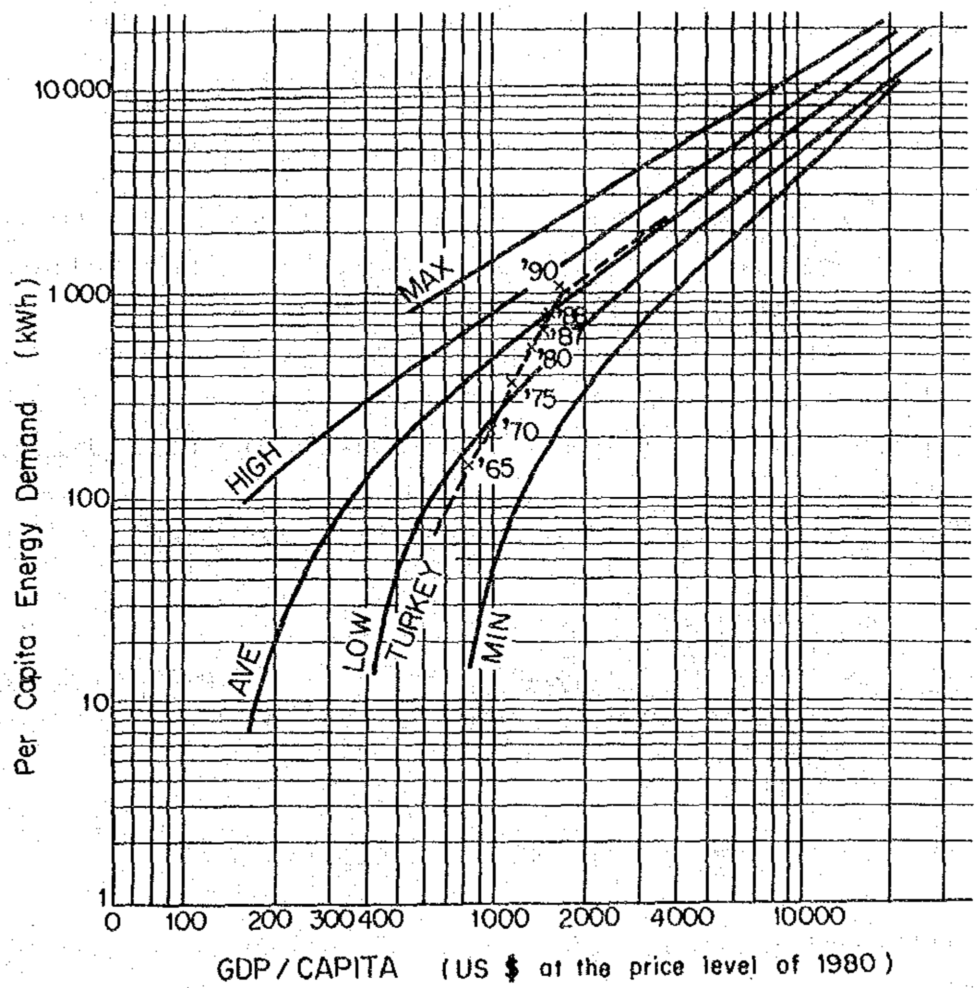

Fig. 5-3 Demand Pass Chart

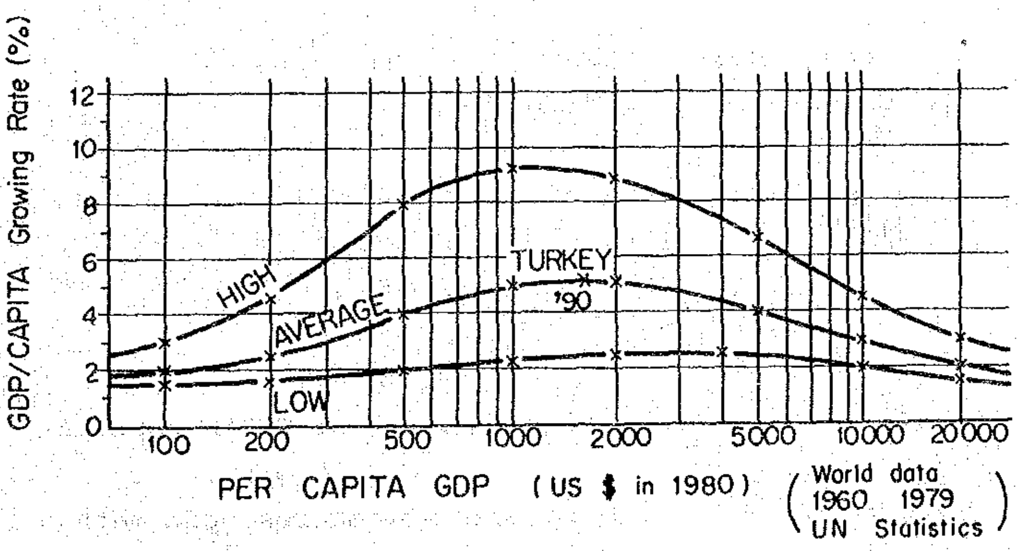

Fig. 5-4 GDP/Capita and its Growth Rate

(2) Basic Figures for Study

(a) Standard Year: 1988

The actual record curve is reached to the world average growth curve the point of 1988. For this period from 1980 to 1988, Turkey has been developed steadily without any big social disturbance, therefore, it is judged that there is big tolerance taking 1988 as the standard year into consideration.

(b) Duration of Forecast: Upto 2008 (20 years from 1988)

The completion of the hydropower plants of Oltu Project will be expected by 2006. Therefore, 20 years of load forecast is good enough for the study of the Project.

(c) Per Capita GDP in 1988 : US$1,594.-

(d) Population in 1988 : 53,715,000

(e) Per Capita Energy Consumption in 1988 : 902 kWh

(f) Annual Load Factor Calculated from Table 5-3: 67 ~ 70%

1988 ~ 1990	:	70%
1991 ~ 1995	:	69%
1996 ~ 2000	:	68%
2001 ~ 2008	:	67%

(3) Result of Load Forecast and Review of TEK's Forecast

The result of the load forecast by macroscopic method is as shown in Fig. 5-5 and Table 5-4.

The load forecast by macroscopic method is lower than TEK's forecast. For the energy in 2008, it is about 17% lower than TEK's forecast. Judging from other view point, the load forecast is only one and half years delay from the TEK's forecast and the shape of the curves are similar. Therefore, TEK's long range forecast is considered reasonable.

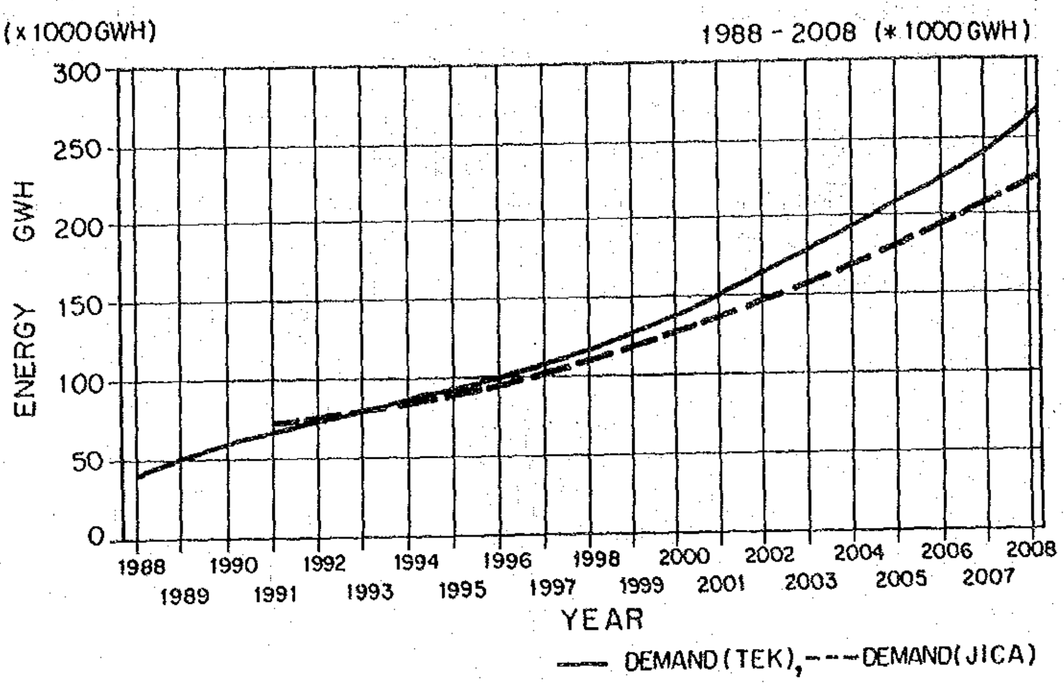

Fig. 5-5 (a) Demand Forecast of Turkey

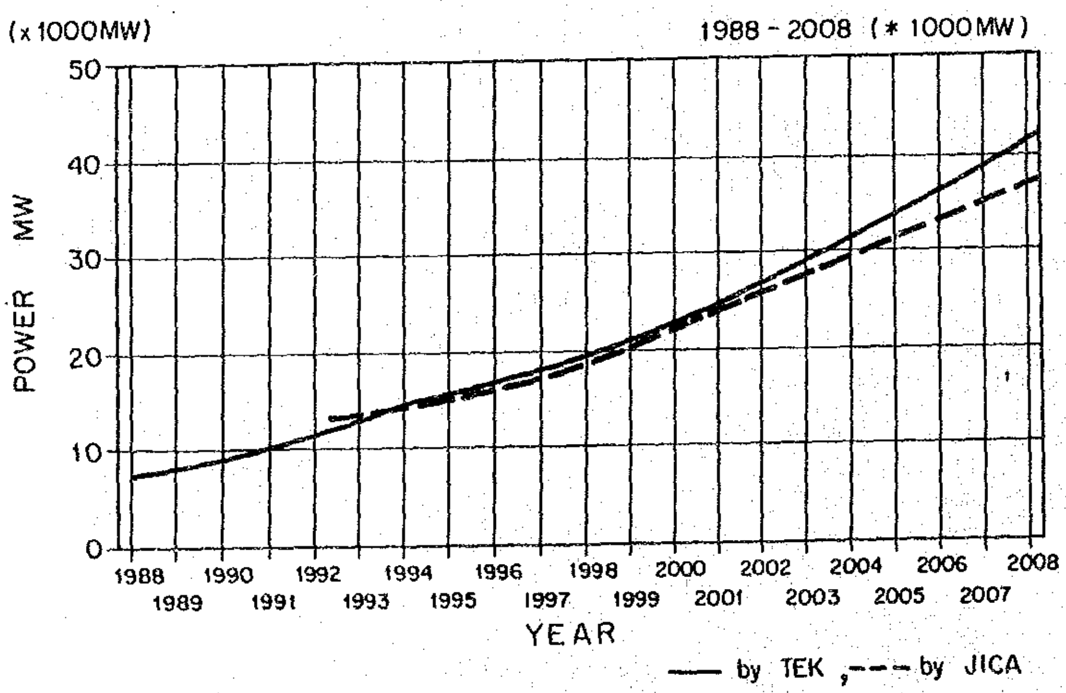

Fig. 5-5 (b) Peak Power Forecast

Table 5-4 Demand Forecast by Macro Method

(at the price level and exchange rates of 1980)

Year	GDP US$		Energy Demand		Population		GDP/Capita		Energy/Capita		Power
	Billion	Rate(%)	GWh	Rate(%)	Thousand	Rate(%)	US$	Rate(%)	kWh	Rate(%)	MW
1991	101.79	7.4	62,043	8.6	57,326	2.2	1,776	5.1	1,082	6.3	10,265
1992	109.33	7.4	67,336	8.5	58,584	2.2	1,866	5.1	1,149	6.2	11,140
1993	117.40	7.4	73,011	8.4	59,869	2.2	1,961	5.1	1,220	6.1	12,079
1994	126.02	7.3	79,090	8.3	61,183	2.2	2,060	5.0	1,293	6.0	13,072
1995	135.23	7.3	85,595	8.2	62,526	2.2	2,163	5.0	1,369	5.9	14,161
1996	145.07	7.3	92,546	8.1	63,898	2.2	2,270	5.0	1,448	5.8	15,536
1997	155.55	7.2	99,968	8.0	65,300	2.2	2,382	4.9	1,531	5.7	16,782
1998	166.71	7.2	107,882	7.9	66,733	2.2	2,498	4.9	1,617	5.6	18,111
1999	178.58	7.1	116,315	7.8	68,198	2.2	2,619	4.8	1,706	5.5	19,526
2000	191.19	7.1	125,285	7.7	69,694	2.2	2,743	4.8	1,798	5.4	21,032
2001	204.51	7.0	134,783	7.6	71,204	2.2	2,872	4.7	1,893	5.3	22,964
2002	218.65	6.9	144,877	7.5	72,753	2.2	3,005	4.6	1,991	5.2	24,684
2003	233.60	6.8	155,570	7.4	74,332	2.2	3,143	4.6	2,093	5.1	26,506
2004	249.41	6.8	166,895	7.3	75,946	2.2	3,284	4.5	2,198	5.0	28,436
2005	266.10	6.7	178,874	7.2	77,595	2.2	3,429	4.4	2,305	4.9	30,477
2006	283.69	6.6	191,531	7.1	79,280	2.2	3,578	4.3	2,416	4.8	32,633
2007	302.22	6.5	204,886	7.0	81,001	2.2	3,731	4.3	2,529	4.7	34,909
2008	321.70	6.4	218,962	6.9	82,759	2.2	3,887	4.2	2,646	4.6	37,307

5.2 Power Development Program and Demand-Supply Balance

5.2.1 Study of Power Development Program in Turkey

In Turkey, the power development program was planned by WASP III since 1988. However, TEK has realized that the WASP III is not suitable for planning since Turkey has a lot of huge hydropower plants. Therefore, recently, TEK has worked out their long range program by WASP III + VALORAGUA model. The detail was not clarified but the reasons will be for compensate/adjustment of some factors to be unreasonable as follows:

(1) The major demand is located in the western area, but the hydropower plants are in the eastern regions far from the demand area.

(2) Hydro power development has required huge amount of money and the years of operation of the hydropower plants will be depend on the arrangement of the finance for them.

(3) The planning by WASP III is not taken into account of the factors of transmission lines since Turkey is a big country and has long transmission lines, therefore, it is not suitable.

5.2.2 Diversity of Power Energy Resource Development

(1) Composition of Power Generation in Turkish Power System

Ratio of the hydropower and the thermal power generations upto 2000 will be planned 1:1, but after 2000 the thermal power plants will be increased more than hydropower plants and the ratio will be nearly 1:2 in 2010 (See Fig. 5-6).

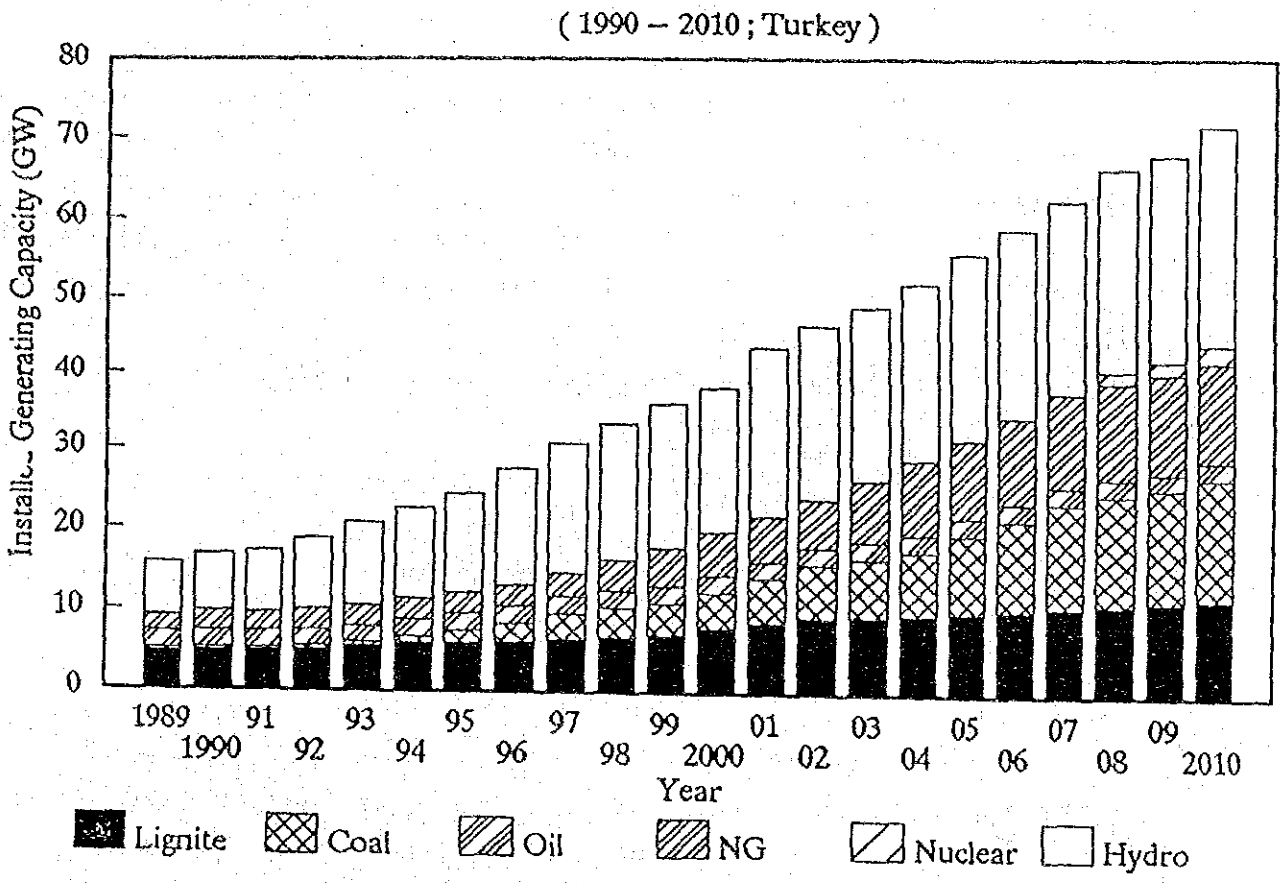

Fig. 5-6 Composition of Generating Facilities

(2) Hydropower Development

Upto year of 2000, hydropower development will be proceeded steadily. Hydropower potential to be developed economically is estimated at 34,889 MW and the energy production will be 123.5 TWh/year. The development will be at peak in 1990's, then the big hydropotential to be developed economically will be almost completed. The development plan of hydropotential is as follows:

1990	6,597 MW	24.3 TWh/Y
1995	12,179 MW	42.9 TWh/Y
2000	18,287 MW	62.2 TWh/Y
2005	24,014 MW	80.3 TWh/Y
2010	27,586 MW	93.2 TWh/Y

The above figures are an optimistic prediction of development of the hydropotential and some of the projects to be considered in planning are still at a stage of master plan, therefore, the reliability of the development after 2000 is not high enough.

(3) Development of Lignite-fired Thermal Power Plants

At this moment, annual energy production by lignite-fired thermal power plant is the largest in Turkey, however, imported coal-fired thermal power plants is to take place in 2010. A big difference between the previous development program and the latest program is that development of the lignite-fired thermal power plants is decreased and the development of natural gas-fired power plants and nuclear power plant is appeared instead of lignite-fired thermal power plants. The main reason will be that the high cost of environmental protection facilities for the lignite-fired thermal power plants makes the plants' economy bad in comparison with that of imported coal-fired thermal power plants. The development plan of lignite-fired thermal power plants is be as follows:

1990	4,898 MW	22.4 TWh/Y
1995	6,061 MW	35.5 TWh/Y
2000	7,976 MW	47.1 TWh/Y
2005	10,181 MW	60.4 TWh/Y
2010	12,078 MW	71.8 TWh/Y

(4) Development of Imported Coal-fired Thermal Power Plants

For development of the imported coal-fired thermal power plants, the first BOT project will be commissioned in the middle of 1990's and the development will be increased upto 4,088 MW in 2000 and 14,066 MW in 2010. Therefore, in the future, the base load of the power system will be supplied by imported coal-fired thermal power plants, lignite-fired thermal power plants and nuclear power plants. Development of imported coal-fired thermal power plants are considered by BOT method, therefore, the success of the development by BOT method will influence the future power development program strongly. The development plan of imported coal-fired thermal power plants will be as follows:

1990	0 MW	0 TWh/Y
1995	1,190 MW	7.7 TWh/Y
2000	4,088 MW	26.6 TWh/Y
2005	8,754 MW	56.9 TWh/Y
2010	14,066 MW	91.4 TWh/Y

(5) Development of Natural Gas-fired Thermal Power Plants

In comparison with the previous power development program, a great increase of natural gas-fired thermal power plants is one of the big differences. It is observed that the government considered to utilized natural gas as electric power energy more since the natural gas can be utilized for combined cycle generating facilities which has high efficiency in operation and the environmental protection for the natural gas-fired power plants is easy/less expensive. The development plan of natural gas-fired thermal power plants is as follows:

1990	2,033 MW	9.5 TWh/Y
1995	2,551 MW	15.3 TWh/Y
2000	5,311 MW	31.9 TWh/Y
2005	9,751 MW	56.5 TWh/Y
2010	12,751 MW	76.5 TWh/Y

(6) Development of Nuclear Power Plants

The first nuclear power plant is to be put into operation in 2008. The development of nuclear power plants is as follows:

2008	3,000 MW
2010	7,000 MW

(7) Review of Development Program

In the development program, rich hydropotential, especially big-scaled economical hydropower projects are to be developed in 1990's, in parallel reinforcement of the existing lignite-fired thermal power plants is to be made and then, toward to 2000's, development of imported coal-fired thermal power plants by BOT method is to be planned. In addition, natural gas-fired combined cycle thermal power plants which can be constructed in short period and can be easy for environmental counter measure are to be put in operation to meet the requirement of the demand.

However, it is considered slightly optimistic to obtain natural gas from Russia continuously in the future since some other European countries may plan to import natural gas from Russia and the amount of natural gas for Turkey become short because the natural gas is clean and less expensive. But for the security of natural gas, the development program is considered reasonable. After year of 2000, it is difficult to make exact story of development program since there are too many unknown factors. Because of fast technology development in these years, the discussion how Turkish demand-supply will be in the future is good enough for preparing the program. If the high growth rate of demand increase is continued, some new generation facilities like imported coal-fired thermal power plants in 1990's will be needed. For the power plants, nuclear power plant will be considered the best, but introduction of the nuclear power plant should not be hurry and it should be introduced when Turkish technology level is reached to the level of developed countries.

5.3 Timing of Commissioning Oltu Hydropower Project

5.3.1 Factors to Decide Timing of Commissioning Generating Plant

(1) Need the period necessary for the construction of power plant

(2) Need the period necessary for the construction of the related transmission lines to the demand area

(3) Need the period necessary for obtaining the finance of construction cost for the project

(4) Need the necessity of the development in view of the power demand

(5) Development of the project is more economic than that of the other project

5.3.2 Study for Timing of Commissioning Oltu Project

(1) For a hydroelectric power station to be brought to completion, after having carried out a feasibility study, periods of time for detailed designing, obtaining financing, taking tendering procedures, etc. are required besides the construction period. In Turkey, these periods required other than the construction period amount to about 6 years.

Consequently, the start of construction work for the Oltu Project will be after the year 2000, the completion of Olur Power Station being at the end of 2005 or later and that of Ayvali Power Station in the middle of 2006 or later.

(2) The electric power from the Oltu Project is to reach Yusufeli Switchyard by a 154 kV transmission line, and on stepping up voltage, be connected with the 380 kV power transmission system. Since the Yusufeli Project is planned to be completed around the year 2003, the 380 kV transmission line to Yusufeli Switchyard planned to be completed by 2003. Since the transmission line of the Oltu Project is of comparatively short distance, a long period of time will not be required for its construction. Therefore, the transmission line of the Oltu Project can be completed if after 2003.

(3) The methods of procuring construction funds for hydroelectric power development projects in Turkey consist of the following:

(a) Allocation from the government budget

(b) Procurement from the World Bank, OECF, or other international financing institution

(c) Combination of (a) and (b)

In procurement so far, what has most often been done is for financing of power station equipment such as turbines and generators to be sought from foreign sources since such equipment is not made in Turkey, while civil works costs and other costs have been covered out of government budgets. This procurement method will probably be taken for the Oltu Project also.

(4) The state of hydroelectric power development of Turkey around the year 2005 will be approximately 24,000 MW, 78% of the hydroelectric potential. The power generating facilities around this time are expected to be about 52,000 MW.

Even under such circumstances, the growth in electric power facilities is estimated will be about 8%, and of average annual development of approximately 2,400 MW, development of about 1,000 MW of hydro is expected. But in Turkey also, there will be depletion in the number of sites suitable for development and it is thought necessary to carry out positive development of the Oltu Project.

(5) As of 1992, total output of 15,500 MW has been identified for hydroelectric power development projects in various stages from feasibility study completion to construction. Accordingly, for the installed capacity of hydroelectric power stations to be made 24,000 MW by the year 2005, it will be necessary for all project sites having reached the stages of feasibility study completion to be developed.

Therefore, there is no need for further comparisons with other projects and the Oltu Project should be developed as soon as possible.

The result of economic comparison of the Oltu Project with an alternative thermal generating facility was a benefit-cost ratio of 1.54 for the Oltu Project to be overwhelmingly superior.

When domestic procurement of energy resources, diversification of energy resources, and further, the future rises in fossil fuel prices and the impact on the environment are taken into consideration, the necessity for development of the Oltu Project will be even greater.

5.3.3 Timing of Commissioning Oltu Project

The various conditions with regard to completion of the Oltu Project have been examined in the previous subsection 5.3.2. As a result, the Oltu Project should be developed at as early a stage as possible, and taking into account the period required for development, completion of Olur Hydroelectric Power Station is to be at the end of 2005, and completion of Ayvalı Hydroelectric Power Station in the middle of 2006.

Chapter 6 METEOROLOGY AND HYDROLOGY

Chapter 6

METEOROLOGY AND HYDROLOGY

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Chapter 6 METEOROLOGY AND HYDROLOGY

6.1 Outline of Meteorology and Hydrology

6.1.1 Outline of Basin

The Oltu River is a tributary of the Çoruh River in the northeast part of Turkey and joins the Çoruh River at the latter's right bank approximately 10 km downstream of the town of Yusufeli located at the midstream stretch.

The Çoruh River rises from a highland about 100 km south of Trabzon, a city on the Black Sea coast, and flows down through rugged mountainland. The head of the Çoruh River flows in a east-northeast direction, and from the vicinity of the confluence with the Oltu River at the midstream stretch, the river changes its course to the north to enter Soviet territory 20 km upstream from its mouth, and then empties into the Black Sea. The length of the river is approximately 410 km, the catchment area is 19,750 km^2, and with an average annual runoff of 5.96×10^9 m^3 (189 m^3/sec), it is the largest river in the northeastern part of Turkey.

The basin of the Oltu River (catchment area approximately 7,000 km^2) can be broadly divided into two river basins, its own and that of the Tortum River (catchment area 1,965 km^2) which merges with the Oltu at the latter's left bank 8 km upstream for the confluence with the mainstream Çoruh River. The Tortum River has a natural lake, Lake Tortum (area 6.7 km^2), created by damming up of its midstream stretch by landslides, and there is Tortum Power Station commissioned in 1971 using the water and head of the lake. The mainstream part of the Oltu River also is in the form of a ravine with no vegetation to be seen on the mountainsides, although there are hamlets and fruit orchards where river terraces are developed.

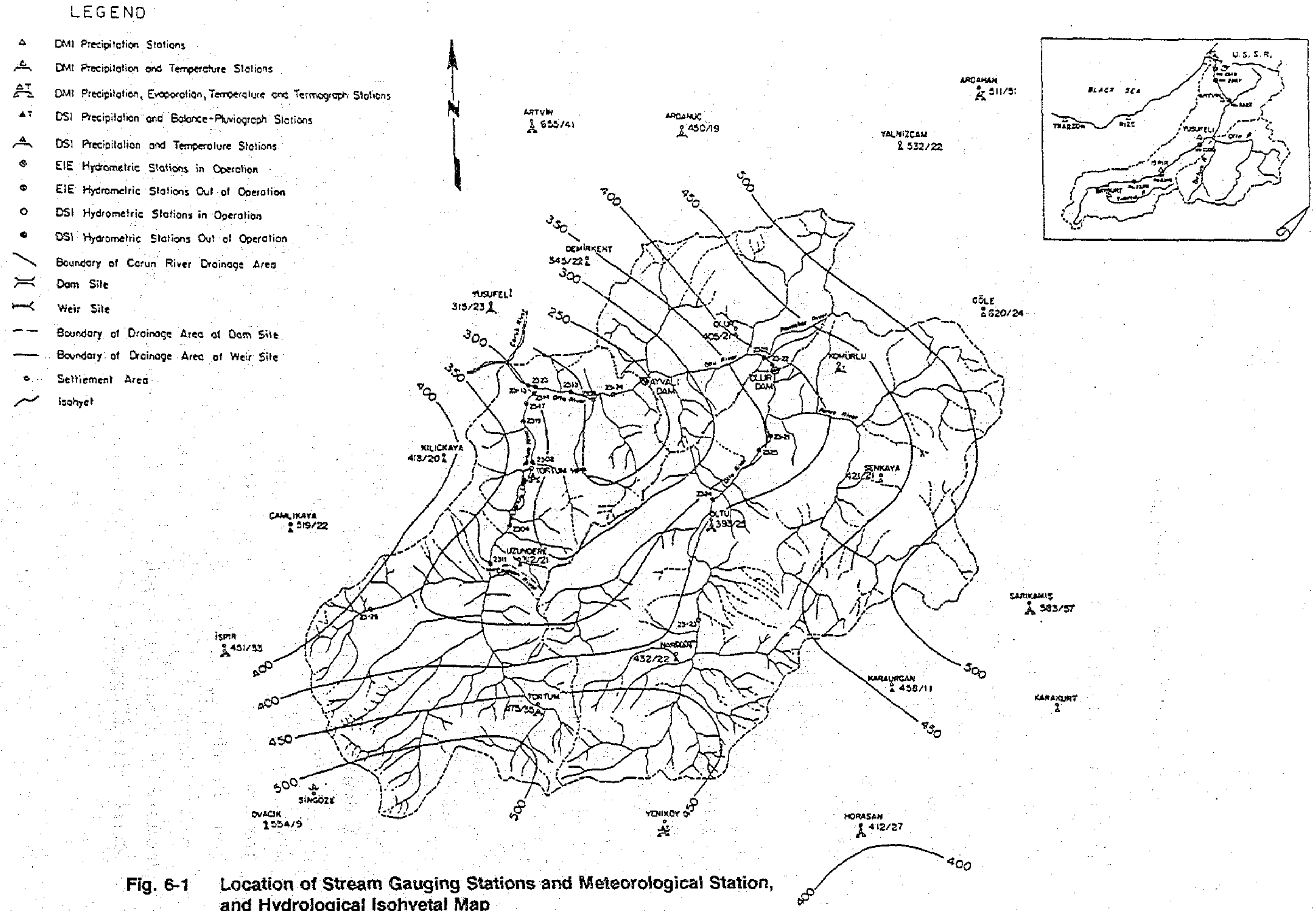


Fig. 6-1 Location of Stream Gauging Stations and Meteorological Station, and Hydrological Isohyetal Map

6.1.2 Meteorology

The downstream part of the Çoruh River Basin has precipitation of as much as 2,000 mm, and is a region having an Eastern Black Sea climate which is on the side of much rain for Turkey. The upstream and midstream parts of the basin are strongly influenced by the inland Erzurum-Kars Plateau climate of the eastern part of Anatolia, a continental climate of little rain and severe fluctuations between hot and cold.

Meteorological observation stations of the DMI and the DSI are provided in the Oltu River Basin and its surroundings as shown in Figs. 6-1 and 6-2. There are meteorological observation stations at five locations in the dam project area of the Oltu River, of which Oltu Meteorological Observation Station is at a location representative of the basin.

The average annual rainfall at Oltu Meteorological Observation Station is 400 mm, with 200 mm, 50% of the annual rainfall, occurring in the rainy season of April to July. Snowdepths occurs from November to April, with the most in February, the maximum recorded in the past having been 61 cm. Air temperatures are very high in July and August with the maximum being in August at 39°C, and the minimum becoming lower than -20°C in the winter in January and February. The mean temperature of the year is 9.8°C. The maximum wind velocity recorded is a west wind of 26 m/sec in July. These monthly records are shown in Table 6-1 and Fig. 6-3 on temperature, Table 6-2 and Fig. 6-4 on precipitation, Table 6-3 on maximum snowdepths, and Table 6-4 on maximum wind velocity. The locations of meteorological observation stations and runoff gauging stations, and an isohyetal map are shown in Fig. 6-1.

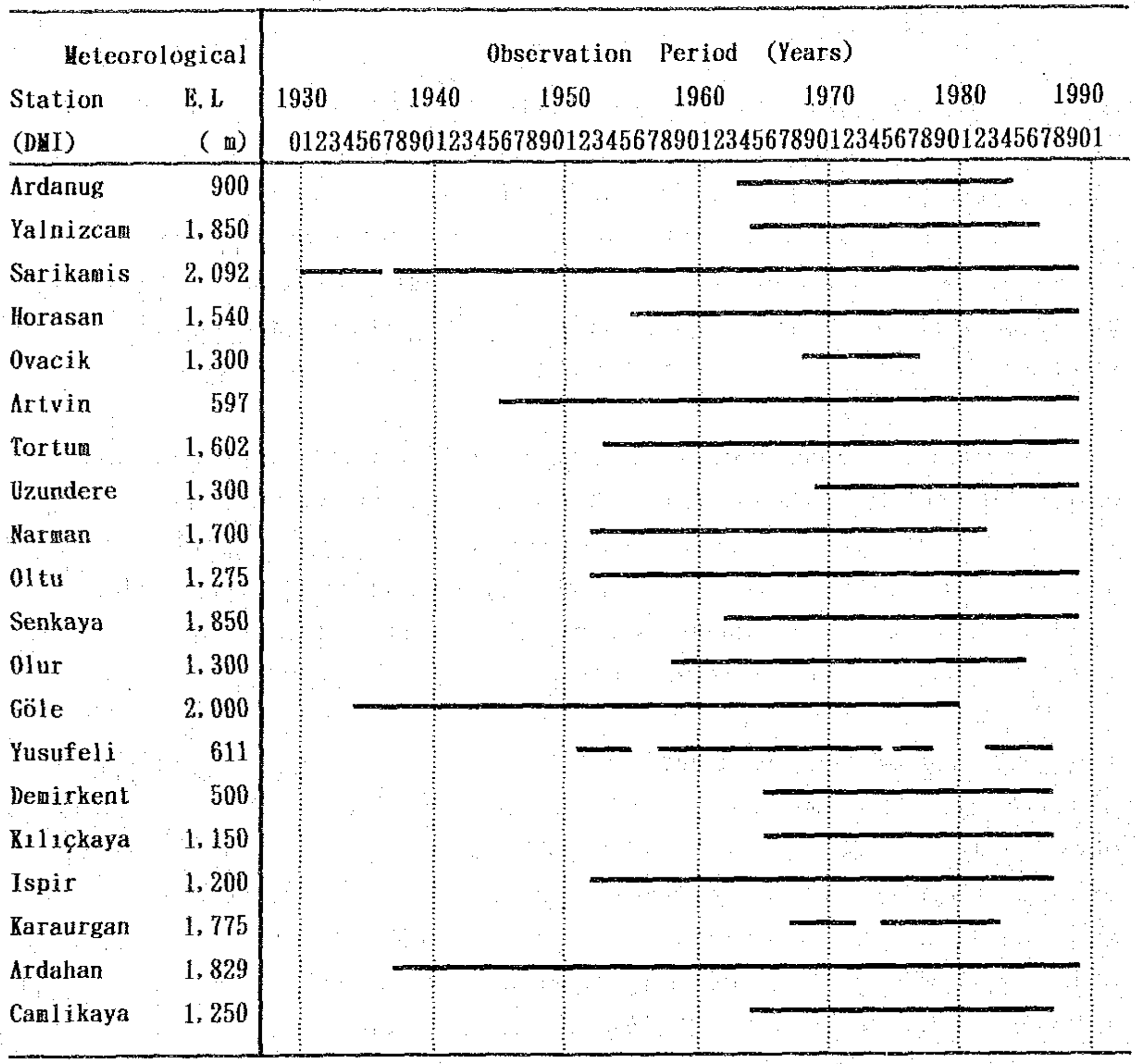


Fig. 6-2 Existing Precipitation Data

Table 6-1 Monthly Temperature at Oltu and Tortum Meteorological Station

(unit ; °C)

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Ave	-3.8	-1.7	3.6	10.1	14.1	18.0	22.4	21.9	17.8	11.3	4.6	-1.3	9.8
Oltu	Max	11.0	14.6	19.7	30.0	30.7	34.3	39.0	38.6	35.2	28.8	19.8	12.8	39.0
	Min	-24.1	-22.4	-18.4	-8.6	-3.6	1.6	7.4	5.1	1.5	-4.2	-15.2	-19.6	-24.1
	Ave	-3.3	-1.8	1.6	7.6	12.1	15.4	19.9	19.5	15.5	9.2	5.6	-1.2	8.3
Tortum	Max	14.5	13.0	18.0	25.1	28.1	32.0	35.7	36.0	32.3	26.4	20.6	12.7	36.0
	Min	-26.6	-22.8	-24.8	-12.7	-3.1	-3.3	5.5	3.9	-0.6	-8.0	-15.3	-25.0	-26.6

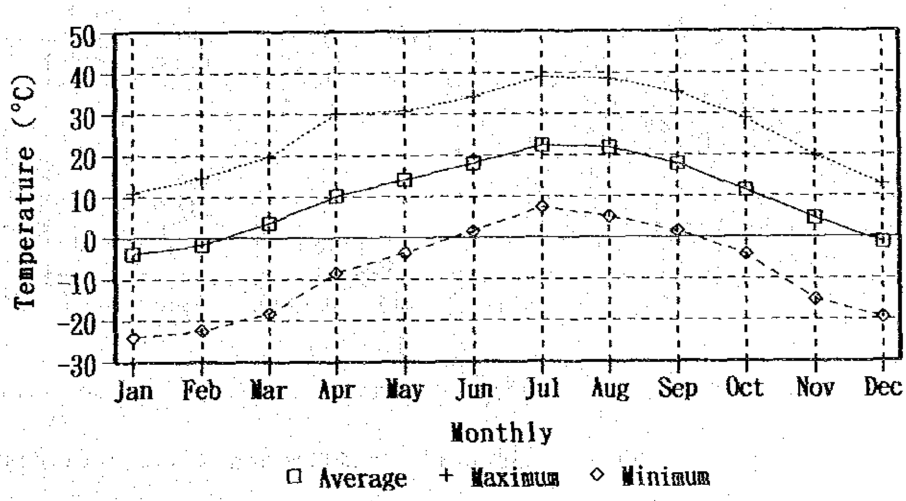


Fig. 6-3 Monthly Temperature at Oltu Meteorological Station

Table 6-2 Monthly Precipitation at Meteorological Station

(unit ; mm)

Station	Observation Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Olur	1959--'84	19.0	20.6	29.1	48.0	65.2	51.4	41.8	27.6	20.6	28.4	29.8	23.6	405.1
Senkaya	1963--'87	14.8	17.8	23.9	45.5	78.8	62.9	39.5	32.1	22.7	42.6	22.6	18.0	421.2
Oltu	1958--'89	19.1	20.8	25.2	44.5	62.6	58.3	39.6	24.9	18.1	35.1	26.0	19.0	393.2
Tortum	1954--'89	28.8	28.8	37.6	57.2	69.3	60.5	36.0	25.7	22.4	43.0	36.2	29.0	474.5
Narman	1966--'82	24.4	22.3	29.5	45.6	75.1	66.6	28.6	31.8	23.0	33.8	29.7	21.4	431.6
Uzundere	1969--'89	13.6	15.4	18.9	36.1	52.2	47.9	24.0	21.9	15.0	34.5	25.1	17.1	321.6
Ave		20.0	21.0	27.3	46.2	67.2	57.9	34.9	27.3	20.3	36.2	28.2	21.4	407.9

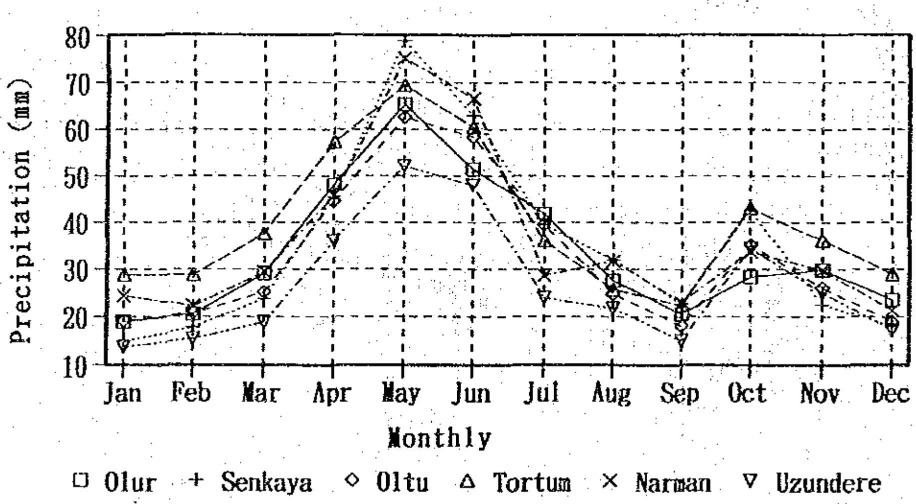


Fig. 6-4 Monthly Precipitation at Meteorological Station

Table 6-3 Monthly Maximum Snow Depths

(Unit: cm)

Station	Period	EL	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Max.
OLUR	1959-85	1,300	45	70	38	8						3	77	74	77
SENKAYA	1963-89	1,850	56	68	45	29	7					16	41	46	68
OLTU	1950-89	1,275	45	61	34	11							30	27	61
NARMAN	1959-83	1,700	28	39	34	19						5	35	30	39
UZUNDERE	1969-89	1,300	22	26	15	2							8	21	26
TORTUM	1954-89	1,602	53	95	45	21	5					11	48	32	95
Ave.			42	60	35	15	6					9	40	38	61

Table 6-4 Monthly Maximum Wind Velocity

(Unit: m/s)

Station	Period	E.L	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Max.
OLTU	1960-'89	1,275	18.9	18.9	18.9	25.0	22.6	22.5	25.7	22.0	23.0	18.9	15.7	18.9	25.7
			SW	WSW	WSW	WSW	W	WNW	W	ESE	WSW	SW	W	W	W
TORTUM	1967-'89	1,602	21.0	17.6	15.6	16.2	19.2	19.0	14.6	15.3	14.0	13.0	15.1	17.0	21.0
			S	S	S	W	SE	WNW	NW	NW	SE	SW	S	NW	S
ARTVIN	1961-'62	597	21.9	22.1	21.8	21.4	18.8	21.5	17.8	16.0	17.5	14.4	24.2	23.0	24.2
	1964-'89		SE	SSE	NW	NNW	W	SSW	NW	WNW	NW	NW	NW	SE	NW
BAYBURT	1967-'89	1,550	27.8	27.1	27.4	24.7	28.0	29.5	21.3	21.1	25.4	22.9	23.1	30.0	30.0
			SSE	W	SE	W	SSW	W	SE	SW	WSW	WSW	SE	SE	SE
Max.			27.8	27.1	27.4	25.0	28.0	29.5	25.7	22.0	25.4	22.9	24.2	30.0	30.0

6.1.3 Hydrology

(1) Runoff and Flood

Runoff; the Oltu River in the vicinity of the Project meanders through a topography which has mountains closing in at spots and parts with U shapes formed by river terraces. The river gradient is approximately 1/130 and comparatively steep so that the flow is fast. The annual runoff is less than 0.6 m^3/sec per 100 km^2, 60% of which is discharged during the 3-month period of April, May, and June, a season when rainfall and snowmelt overlap. Particularly, the outflow in May is 30% of the annual amount. The ratio of discharge between May, the month of largest discharge, and February, the month of smallest discharge, is around 10:1 (see Table 6-8).

Flood; regarding floods, there are no marks of inundation and damage to cultivated fields seen even on making a search for traces of floods. On examining meteorological records of the basin there is nothing about severe local rains in short periods of time, and it is surmised that large floods have not occurred very much.

The locations of runoff gauging stations and periods of observation are as shown in Fig. 6-5. And, the runoff gauging stations and periods of observation used in the study of this Report are as shown in Fig. 6-6. Of the gauging stations used, No. 2302 is on the Tortum River, while No. 2323 is located on the Oltu River after merging. The runoffs at these gauging stations are affected by Lake Tortum at the middle stretch of the Tortum River and Tortum Power Station (commissioned in 1971) being operated regulating the water of the lake. Therefore, these are not very desirable normally for using as runoff records of natural streams. However, since the recent correlations between No. 2323 and upstream gauging stations (No. 23-24, NO. 2329) were comparatively good as shown in Appendix Fig. A-2-1(a), (b), the runoffs in "Engineering Hydrology Reports, Aug. 1984" of EiE were used as the project site runoffs prior to 1976.

(2) Evaporation and Sedimentation

Evaporation; observation records of evaporation available on the Oltu River System are from Tortum Power Station only.

The reservoir evaporation was calculated considering the evaporation observation records at Tortum Power Station, air temperature records of Oltu Meteorological Observation Station, and the air temperature records and altitude relationships of other neighboring meteorological observation stations.

Tables 6-10 and 6-11 show that evaporation quantities are largest in July and August when air temperatures are high, and that hardly any evaporation occurs in the cold period from November to March.

Sedimentation; the Çoruh River is muddy and of a yellowish-brown color throughout the year; approximately 70% of suspended sediment consists of clay and silt. The turbidity of the Oltu River System is worse than that of the mainstream Çoruh River. It is thought this sediment outflow is supplied from areas where unconsolidated sedimentary rocks in the basin have collapsed.

The only suspended sediment observations being made on the Oltu River are at No. 2325 Runoff Gauging Station provided at the upstream end of Olur Reservoir. Since a large tributary merges with the river between No. 2325 and Olur Dam, No. 2325 represents only about 50% of the basin upstream of the dam. However, the records of observations made continuously from 1977 were used for calculation of the reservoir sedimentation of this Report.

The suspended sediment is annually 279 t/km^2, with 53% of the annual amount discharged in May, and 88% in the 3-month period of April, May, and June. (See Table A-2-8.) As for the sedimentation inside the reservoir, traction load was considered together with suspended load, and the average annual sedimentation per square kilometer for 50 years was taken to be 268 m^3.

6.2 River Runoff

6.2.1 Outline

EIE calculated the runoffs at the projected damsites from 1941 to 1982 for the "Engineering Hydrology Report," August 1984, with Runoff Gauging Station No. 2323 as the main, obtaining correlations from No. 2302, No. 23-22, and No. 23-24.

At present, among above gauging stations, the stations which have been continuing with runoff observations since 1978 are No. 2323 (from December 1963) and No. 23-24 (from October 1976).

In addition, No. 2329 was newly provided in the vicinity of No. 23-22, and No. 2325, 17.3 km upstream of No. 2329, and runoff observations have been made at these stations since December 1981 and October 1973, respectively. The runoff gauging stations and observation periods are shown in Fig. 6-5.

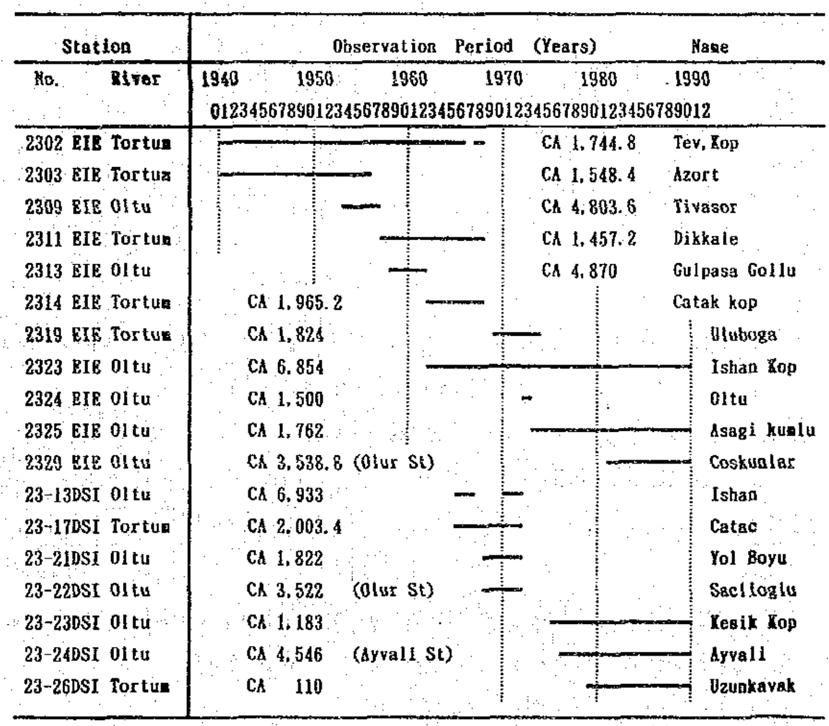


Fig. 6-5 Existing Stream Gauging Station

With regard to the location relationships of projected dam sites and runoff gauging stations, the No. 2329 (Catchment area 3,538.8 km^2) is 3.9 km downstream of the Olur dam site (Catchment area 3,509 km^2) and the No. 23-24 (Catchment area 4,546 km^2) is 5.4 km downstream of the Ayvalı dam site (Catchment area 4,517 km^2), and there is no tributary between each dam and gauging station. Therefore, the runoffs at the Olur and the Ayvalı dam sites are calculated as being the same as the No. 2329 and No. 23-24, respectively.

The methods of calculating runoffs in this report are as given in Table 6-5. The outlines of methods are as follows:

Ayvalı Dam Site Runoff

Oct. 1940 to Sept. 1976:	Conversion from No. 2329
Oct. 1976 to Sept. 1983:	Observations at No. 23-24
Oct. 1984 to Sept. 1987:	- ditto -
Oct. 1983 to Sept. 1984:	Conversion from No. 2329
Jul. 1985 to Sept. 1985:	- ditto -
May 1986:	- ditto -
Jul. 1986:	- ditto -
Nov. 1986:	- ditto -
Apr. 1987:	- ditto -
Sep. 1987:	- ditto -
Oct. 1987 to Sept. 1990:	- ditto -

Olur Dam Site Runoff

Oct. 1940 to Sept. 1976:	Data of No. 2323 multiplied by coefficient
Dec. 1981 to Sept. 1990:	Observations at No. 2329
Oct. 1976 to Nov. 1981:	Conversions from No. 23-24
Aug. 1982:	- ditto -

The relationships and runoff gauging station observation periods and runoff calculations are shown in Fig. 6-6.

In case the monthly runoff at No. 23-24 was less than that of No. 2329, modifications were made based on the runoff trends at gauging stations (No. 2323, No. 2325) along the Oltu River.

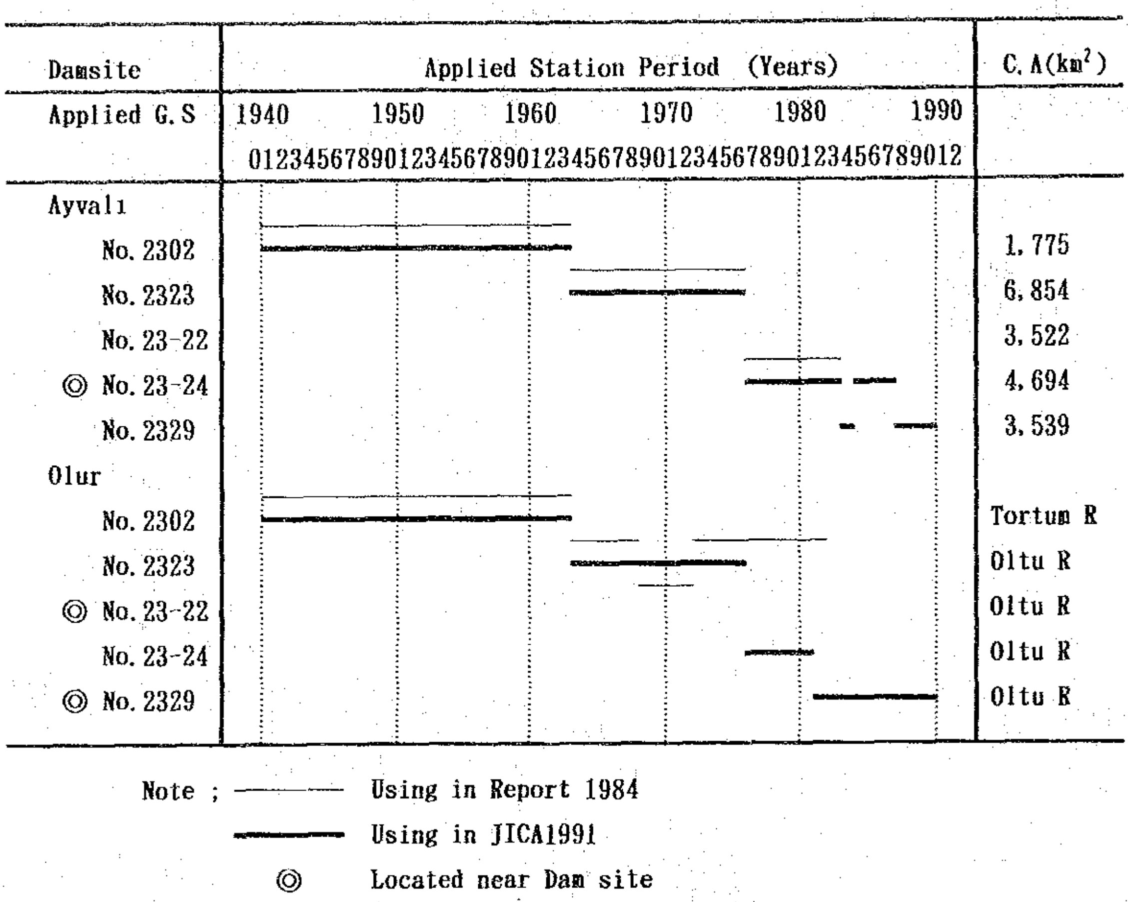


Fig. 6-6 Applied G.S for Calculation of Natural Flow at Damsites

Table 6-5 Natural Flow Calculation at Damsites

Station No.	C.A. (km^2)	Observation Period (Years)	by EIE Report 1984 (Applied G.S)		by JICA (Applied G.S)		Regression Equation (Unit: MCM)
2302	1,744.8	1940/10 ~ 1963/9					
2323	6,854.0	1962/12 ~ (1963/10 ~ 1990/9)	1940/10 ~ 1963/9	No. 2302 ; logY = 0.880 x log X(No. 2302) + 0.7036	1940/10 ~ 1963/9	No. 2302	; logY(No. 2323) = 0.880 x logX(No. 2302) + 0.7036
			1963/10 ~ 1983/9	No. 2323	1963/10 ~ 1983/9	No. 2323	
Ayvalı,Sakartepe Site							
23-24	4,693.6	1976/10 ~ (1984/10 ~ 1987/9)	1940/10 ~ 1976/9	No. 2323 ; = 0.785 x X(No. 2323) - 9.941	1940/10 ~ 1976/9	No. 2323	; Y(No. 23-24) = 0.785 x X(No. 2323) - 9.941
					1976/10 ~ 1983/9	No. 23-24	
			1976/10 ~ 1983/9	No. 23-24	1983/10 ~ 1984/9	No. 2329	; Y(No. 23-24) = 1.172 x X(No. 2329) + 1.163
					1984/10 ~ 1987/9	No. 23-24	
					1987/10 ~ 1990/9	No. 2329	; Y(No. 23-24) = 1.172 x X(No. 2329) + 1.163
					1985/7,8,9,1986/5,7, 11,1987/4,9	No. 2329	; Y(No. 23-24) = 1.172 x X(No. 2329) + 1.163
Olur Site							
23-22 2329	3,522.0 3,538.8	1968/10 ~ 1972/9 1981/12 ~ (1981/12 ~ 1990/9)	1940/10 ~ 1968/9	No. 2323 ; = 0.480 x X (No. 2323) - 5.539	1940/10 ~ 1976/9	No. 2323	; Y(No. 2329) = 0.8 x X(No. 2323) - 9.94
					1976/10 ~ 1981/11	No. 23-24	; Y(No. 2329) = 0.853 x X(No. 23-24) - 0.992
			1968/10 ~ 1972/9	No. 23-22	1981/12 ~ 1990/9	No. 2329	
			1972/10 ~ 1983/9	No. 2323	1982/8	No. 23-24	; Y(No. 2329) = 0.853 x X(No. 23-24) - 0.992
2325	1,762.0	1973/10 ~ (1973/10 ~ 1989/9)					

Note: Obserbation Period in ( ) are the data collected by JICA.

6.2.2 Calculation Method

The principle in calculating runoffs at the dam sites (Ayvalı dam site = No. 23-24 Gauging Station, Olur dam site = No. 2329 Gauging Station) is as described below.

The runoffs at No. 23-24 from October 1940 to September 1976 were converted from the records of Gauging Stations No. 2302 and No. 2323, similarly to the method in "Engineering Hydrology Report," August, 1984.

$$\log Y \text{ (No. 2323)} = 0.880 \times \log X \text{ (No. 2302)} + 0.7036;$$
1941 to 1963

$$Y \text{ (No. 23-24)} = 0.785 \times X \text{ (No. 2323)} - 9.94$$

where, Y and X are monthly runoffs ($10^6 m^3$ = MCM).

The runoffs at No. 2329 from october 1940 to September 1976 were calculated as follows by the correlation with No. 2323 as the main shown in Figs. A-2-1(a) and 6-1(b) and the recent correlation between No. 23-24 and No. 2329 (see Fig. A-2-2(a)):

$$Y \text{ (No. 2329)} = 0.8 \times X \text{ (No. 23-24)}$$

where, Y and X are monthly runoffs (MCM).

For the runoffs at No. 23-24 and No. 2329 from October 1976 to September 1990, the respective observation records were used. However, for years lacking records, the following equation was applied based on the correlation between No. 23-24 and No. 2329 in Fig. A-2-2(a).

$$Y \text{ (No. 23-24)} = 1.172 \times X \text{ (No. 2329)} + 1.163$$

From the equation:

$$X\ (\text{No. } 2329) = 0.853 \times Y\ (\text{No. } 23\text{-}24) - 0.992$$

where, Y and X are the respective monthly runoffs (MCM).

6.2.3 Calculation Results

Dam site runoffs are given in Tables 6-6 to 6-7. Gauging station records runoffs are given in Tables A-2-1 to A-2-4.

This time, the results given in Table 6-8 were obtained through studies based on the monthly runoffs in "Engineering Hydrology Report," August 1984, and additional data which had been collected.

Table 6-8 Monthly Average Natural Flow at Dam Sites

(unit: MCM)

Dam Site	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total	$m^3/s/100km^2$
Ayvali	33.98	33.34	28.91	25.95	24.06	38.06	125.13	247.70	140.82	57.68	31.14	26.22	812.99	0.55
Olur	27.48	26.84	23.31	20.67	19.20	30.58	101.69	200.60	113.31	46.11	24.91	20.95	655.65	0.59

The relationship between rainfall at Oltu Meteorological Station and runoff at No. 2329 Gauging Station is shown in Fig. 6-7.

Table 6-6(a) Natural Flow at Ayvalı Damsite (No. 23-24 G. S)

(C. A = 4, 693. 6 km^2)

(Unit: MCM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	($m^3/s/100km^2$)
1941	46.27	42.97	37.00	33.16	32.14	52.00	185.53	381.78	130.58	67.38	37.79	26.48	1073.08	0.72
1942	41.79	67.85	42.66	36.92	36.45	59.77	145.49	491.68	242.83	90.54	45.32	35.83	1337.13	0.90
1943	43.68	41.87	38.65	33.24	28.92	34.88	88.19	233.41	108.60	58.12	33.31	21.30	764.17	0.52
1944	29.47	34.02	30.64	28.37	28.13	57.02	132.15	406.90	165.90	85.05	45.40	35.67	1078.72	0.73
1945	38.89	40.61	32.06	30.41	25.46	32.14	70.13	227.92	215.36	70.13	34.26	24.76	842.13	0.57
1946	29.70	31.43	29.31	27.98	24.99	33.94	87.40	286.79	317.41	113.31	79.55	49.88	1111.69	0.75
1947	68.56	55.45	45.40	42.66	37.55	71.70	129.01	127.44	102.32	58.98	26.48	28.05	793.60	0.54
1948	31.82	46.42	34.81	30.57	27.03	29.07	99.96	278.94	294.64	75.63	44.23	44.77	1037.89	0.70
1949	39.83	36.38	33.86	28.60	24.84	33.63	59.77	300.92	140.78	42.03	28.53	26.33	795.50	0.54
1950	33.71	30.02	27.58	25.62	24.36	42.97	131.36	298.57	163.55	66.52	34.96	25.54	904.76	0.61
1951	48.15	39.67	35.20	33.31	28.05	48.70	111.74	253.82	191.81	72.49	38.49	43.52	944.95	0.64
1952	74.84	53.25	44.77	39.67	39.59	45.25	183.17	309.56	211.43	99.96	51.13	39.20	1191.82	0.81
1953	37.08	36.69	37.79	34.57	31.43	38.97	105.46	294.64	207.51	88.97	51.60	35.98	1000.69	0.68
1954	35.35	36.61	34.18	32.45	30.25	47.68	105.46	333.89	301.71	191.81	70.92	48.39	1268.70	0.86
1955	48.07	41.48	38.65	32.92	27.35	35.90	73.27	211.43	103.89	24.29	12.67	12.35	662.27	0.45
1956	22.56	23.58	27.43	24.91	29.15	36.85	88.97	166.69	174.54	80.34	41.95	34.18	751.15	0.51
1957	40.61	34.02	33.78	31.19	30.64	54.98	121.16	207.51	158.84	72.49	32.69	31.51	849.42	0.57
1958	37.95	41.24	35.98	32.76	28.37	38.26	70.92	152.56	149.42	62.36	32.37	32.14	714.33	0.48
1959	34.18	31.04	29.78	30.25	24.29	38.18	104.67	249.90	159.62	60.79	48.07	40.30	851.07	0.57
1960	49.25	49.48	40.22	37.00	37.08	48.46	143.14	256.96	140.00	91.33	57.65	40.93	991.50	0.67
1961	27.27	24.21	24.44	20.75	17.77	21.07	44.46	96.82	50.27	11.96	5.84	3.95	348.81	0.24
1962	11.88	15.18	18.71	15.42	14.24	31.43	82.69	166.69	87.40	40.69	17.22	13.45	515.00	0.35
1963	13.77	16.36	14.87	16.83	14.55	21.30	165.12	411.61	286.01	154.91	103.89	35.35	1254.57	0.85
1964	57.73	49.48	35.28	27.66	22.64	39.04	158.84	338.60	234.98	67.85	26.17	23.27	1081.54	0.73
1965	24.76	23.42	24.13	18.48	16.20	47.44	129.79	176.89	110.95	61.18	30.88	21.70	685.82	0.46
1966	42.42	29.78	28.21	28.76	26.48	34.88	132.15	244.40	75.63	26.25	15.81	19.34	704.11	0.48
1967	25.15	22.40	19.50	18.24	13.77	20.20	52.62	282.87	106.24	118.02	53.57	29.86	762.44	0.52
1968	33.16	32.14	31.43	27.50	23.89	49.80	410.82	461.85	248.33	83.48	41.48	33.47	1477.35	1.00
1969	36.30	40.30	29.70	22.40	18.48	42.66	178.46	346.45	78.77	24.68	23.74	21.70	863.64	0.58
1970	37.79	27.03	27.74	22.79	19.26	31.19	140.78	115.66	38.49	30.33	15.34	18.32	524.72	0.35
1971	21.93	19.34	15.42	15.02	10.86	24.99	66.36	217.71	101.53	18.95	46.66	13.69	572.46	0.39
1972	20.83	22.25	22.17	18.56	19.18	25.70	135.29	186.31	140.78	48.86	22.25	31.51	693.69	0.47
1973	34.88	32.14	26.25	24.99	26.80	31.74	93.68	195.73	140.00	49.41	14.16	17.85	687.63	0.46
1974	31.51	29.39	20.44	16.04	14.63	28.37	52.47	200.44	61.34	17.54	16.20	31.59	519.96	0.35
1975	16.12	16.83	20.83	19.50	14.00	23.58	88.97	108.60	66.60	24.68	10.86	15.73	426.30	0.29

Table 6-6(b) Natural Flow at Ayvalı Damsite (No. 23-24 G. S)

(Unit: MCM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	($m^3/s/100km^2$)
1976	24.29	22.48	12.90	15.18	14.55	38.26	132.93	326.04	162.76	70.13	30.10	29.00	878.62	0.59
1977	39.90	35.70	34.00	25.20	26.50	37.60	118.00	246.00	87.90	32.20	17.50	24.60	725.10	0.49
1978	29.60	27.00	23.90	23.70	28.50	46.80	121.00	318.00	108.00	23.40	13.40	16.60	779.90	0.53
1979	23.40	24.80	24.40	23.40	24.10	32.30	117.00	193.00	140.00	57.90	17.20	15.90	693.40	0.47
1980	38.60	53.20	38.00	31.30	27.50	47.20	207.00	185.00	31.70	11.60	17.80	15.40	704.30	0.48
1981	21.80	20.80	20.20	18.90	17.50	24.80	78.30	156.00	211.00	27.90	18.90	17.90	634.00	0.43
1982	22.30	26.30	23.00	21.00	18.00	23.80	161.00	229.00	59.10	17.50	9.42	18.40	628.82	0.42
1983	21.00	18.80	17.80	16.80	16.70	22.80	44.80	90.40	47.80	8.50	4.80	13.10	323.30	0.22
1984	24.72	41.25	27.06	23.67	19.92	34.57	146.49	301.20	83.20	36.32	43.24	29.88	811.52	0.55
1985	27.10	30.20	25.50	26.70	24.50	33.70	157.00	118.00	28.20	17.92	9.32	19.21	517.35	0.35
1986	26.70	24.20	24.50	23.00	25.00	40.10	161.00	176.96	130.00	30.69	10.40	18.00	690.55	0.47
1987	33.70	38.55	26.00	26.20	31.60	34.50	153.52	416.00	103.00	35.30	15.50	21.90	935.77	0.63
1988	25.12	28.45	22.92	21.47	24.10	37.07	153.91	283.11	249.87	120.70	36.25	34.21	1037.18	0.70
1989	44.42	33.89	28.25	23.38	19.02	50.57	156.43	51.08	14.29	8.04	7.09	11.92	448.38	0.30
1990	29.03	26.89	28.00	18.24	16.70	45.08	178.70	273.16	76.19	34.53	14.88	16.87	758.27	0.51
Ave	33.98	33.34	28.91	25.95	24.06	38.06	125.13	247.70	140.82	57.68	31.14	26.22	812.99	0.55

Note ; (1) 1940/10---1976/ 9 : Y = 0.785 * X(No. 2323) - 9.94
(2) 1976/10---1983/ 9 : No. 23-24
(3) 1983/10---1984/ 9 : Y = 1.172 * X(No. 2329) + 1.163
(4) 1984/10---1987/ 9 : No. 23-24
(5) 1987/10---1990/ 9 : Y = 1.172 * X(No. 2329) + 1.163
(6) 1985/ 7, 8, 9, 1986/ 5, 7, 11, 1987/ 4, 9 : Y = 1.172 * X(No. 2329) + 1.16

Table 6-7(a) Natural Flow at Olur Damsite (No. 2329 G. S)

(C. A = 3,538.8 km^2)

(Unit: MCM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	($m^3/s/100km^2$)
1941	37.02	34.38	29.60	26.53	25.71	41.60	148.42	305.42	104.46	53.90	30.23	21.18	858.45	0.77
1942	33.43	54.28	34.13	29.54	29.16	47.82	116.39	393.34	194.26	72.43	36.26	28.66	1069.70	0.96
1943	34.94	33.50	30.92	26.59	23.14	27.90	70.55	186.73	86.88	46.50	26.65	17.04	611.34	0.55
1944	23.58	27.22	24.51	22.70	22.50	45.62	105.72	325.52	132.72	68.04	36.32	28.54	862.99	0.77
1945	31.11	32.49	25.65	24.33	20.37	25.71	56.10	182.34	172.29	56.10	27.41	19.81	673.71	0.60
1946	23.76	25.14	23.45	22.38	19.99	27.15	69.92	229.43	253.93	90.65	63.64	39.90	889.34	0.80
1947	54.85	44.36	36.32	34.13	30.04	57.36	103.21	101.95	81.86	47.18	21.18	22.44	634.88	0.57
1948	25.46	37.14	27.85	24.46	21.62	23.26	79.97	223.15	235.71	60.50	35.38	35.82	830.32	0.74
1949	31.86	29.10	27.09	22.88	19.87	26.90	47.82	240.74	112.62	33.62	22.82	21.06	636.38	0.57
1950	26.97	24.02	22.06	20.50	19.49	34.38	105.09	238.86	130.84	53.22	27.97	20.43	723.83	0.65
1951	38.52	31.74	28.16	26.65	22.44	38.96	89.39	203.06	153.45	57.99	30.79	34.82	755.97	0.68
1952	59.87	42.60	35.82	31.74	31.67	36.20	146.54	247.65	169.14	79.97	40.90	31.36	953.46	0.85
1953	29.66	29.35	30.23	27.66	25.14	31.18	84.37	235.71	166.01	71.18	41.28	28.78	800.55	0.72
1954	28.28	29.29	27.34	25.96	24.20	38.14	84.37	267.11	241.37	153.45	56.74	38.71	1014.96	0.91
1955	38.46	33.18	30.92	26.34	21.88	28.72	58.62	169.14	83.11	19.43	10.14	9.88	529.82	0.47
1956	18.05	18.86	21.94	19.93	23.32	29.48	71.18	133.35	139.63	64.27	33.56	27.34	600.91	0.54
1957	32.49	27.22	27.02	24.95	24.51	43.98	96.93	166.01	127.07	57.99	26.15	25.21	679.53	0.61
1958	30.36	32.99	28.78	26.21	22.70	30.61	56.74	122.05	119.54	49.89	25.90	25.71	571.48	0.51
1959	27.34	24.83	23.82	24.20	19.43	30.54	83.74	199.92	127.70	48.63	38.46	32.24	680.85	0.61
1960	39.40	39.58	32.18	29.60	29.66	38.77	114.51	205.57	112.00	73.06	46.12	32.74	793.19	0.71
1961	21.82	19.37	19.55	16.60	14.22	16.86	35.57	77.46	40.22	9.57	4.67	3.16	279.07	0.25
1962	9.50	12.14	14.97	12.34	11.39	25.14	66.15	133.35	69.92	32.55	13.78	10.76	411.99	0.37
1963	11.02	13.09	11.90	13.46	11.64	17.04	132.10	329.29	228.81	123.93	83.11	28.28	1003.67	0.90
1964	46.18	39.58	28.22	22.13	18.11	31.23	127.07	270.88	187.98	54.28	20.94	18.62	865.22	0.78
1965	19.81	18.74	19.30	14.78	12.96	37.95	103.83	141.51	88.76	48.94	24.70	17.36	548.64	0.49
1966	33.94	23.82	22.57	23.01	21.18	27.90	105.72	195.52	60.50	21.00	12.65	15.47	563.28	0.50
1967	20.12	17.92	15.60	14.59	11.02	16.16	42.10	226.30	84.99	94.42	42.86	23.89	609.97	0.55
1968	26.53	25.71	25.14	22.00	19.11	39.84	328.66	359.48	198.66	66.78	33.18	26.78	1181.87	1.06
1969	29.04	32.24	23.76	17.92	14.78	34.13	142.77	277.16	63.02	19.74	18.99	17.36	690.91	0.62
1970	30.23	21.62	22.19	18.23	15.41	24.95	112.62	92.53	30.79	24.26	12.27	14.66	419.76	0.38
1971	17.54	15.47	12.34	12.02	8.69	19.99	53.09	174.17	81.22	15.16	37.33	10.95	457.97	0.41
1972	16.66	17.80	17.74	14.85	15.34	20.56	108.23	149.05	112.62	39.09	17.80	25.21	554.95	0.50
1973	27.90	25.71	21.00	19.99	21.44	25.39	74.94	156.58	112.00	39.53	11.33	14.28	550.09	0.49
1974	25.21	23.51	16.35	12.83	11.70	22.70	41.96	160.35	49.07	14.03	12.96	25.27	415.96	0.37
1975	12.90	13.46	16.66	15.60	11.20	18.86	71.18	86.88	53.28	19.74	8.69	12.58	341.03	0.31

Table 6-7(b) Natural Flow at Olur Damsite

(No. 2329 G. S)

(Unit: MCM)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	($m^3/s/100km^2$)
1976	19.43	17.98	10.32	12.14	11.64	30.61	106.34	260.83	130.21	56.10	24.08	23.20	702.88	0.63
1977	33.04	29.46	28.01	20.50	21.61	31.08	99.66	208.85	73.99	26.47	13.94	19.99	606.60	0.54
1978	24.26	22.04	19.39	19.22	23.32	38.93	102.22	270.26	91.13	18.97	10.44	13.17	653.35	0.59
1979	18.97	20.16	19.82	18.97	19.57	26.56	98.81	163.64	118.43	48.40	13.68	12.57	579.58	0.52
1980	31.93	44.39	31.42	25.71	22.47	39.27	175.58	156.81	26.05	8.90	14.19	12.14	588.86	0.53
1981	17.60	16.75	16.24	15.13	13.94	20.16	65.80	132.08	178.99	22.81	15.13	14.28	528.91	0.47
1982	18.03	21.44	19.50	15.20	12.40	17.60	119.00	152.00	26.50	8.96	7.05	13.70	431.38	0.39
1983	16.40	15.10	14.80	13.40	12.10	16.50	32.30	81.70	38.20	7.72	4.01	6.47	258.70	0.23
1984	20.10	34.20	22.10	19.20	16.00	28.50	124.00	256.00	70.00	30.00	35.90	24.50	680.50	0.61
1985	23.00	25.10	22.00	19.10	19.00	26.10	139.00	116.00	26.00	14.30	6.96	15.40	451.96	0.40
1986	24.70	18.90	20.80	18.00	18.80	34.50	142.00	150.00	113.00	25.20	5.16	17.10	588.16	0.53
1987	31.80	31.90	21.50	18.50	25.80	26.10	130.00	349.00	79.30	20.10	15.00	17.70	766.70	0.69
1988	20.44	23.28	18.56	17.33	19.57	30.64	130.33	240.57	212.21	101.99	29.94	28.20	873.06	0.78
1989	36.91	27.92	23.11	18.96	15.24	42.16	132.48	42.59	11.20	5.87	5.06	9.18	370.68	0.33
1990	23.78	21.95	22.90	14.57	13.26	37.47	151.48	232.08	64.02	28.47	11.70	13.40	635.08	0.57
Ave	27.48	26.84	23.31	20.67	19.20	30.58	101.69	200.60	113.31	46.11	24.91	20.95	655.65	0.59

Note : (1) 1940/10---1976/ 9 : Y = 0.8 * (0.785 * X(No. 2323) - 9.94)
(2) 1976/10---1981/11 : Y = 0.853 * X(No. 23-24) - 0.99
(3) 1981/12---1990/ 9 : No. 2329
(4) 1982/ 8 : Y = 0.853 * X(No. 23-24) - 0.99

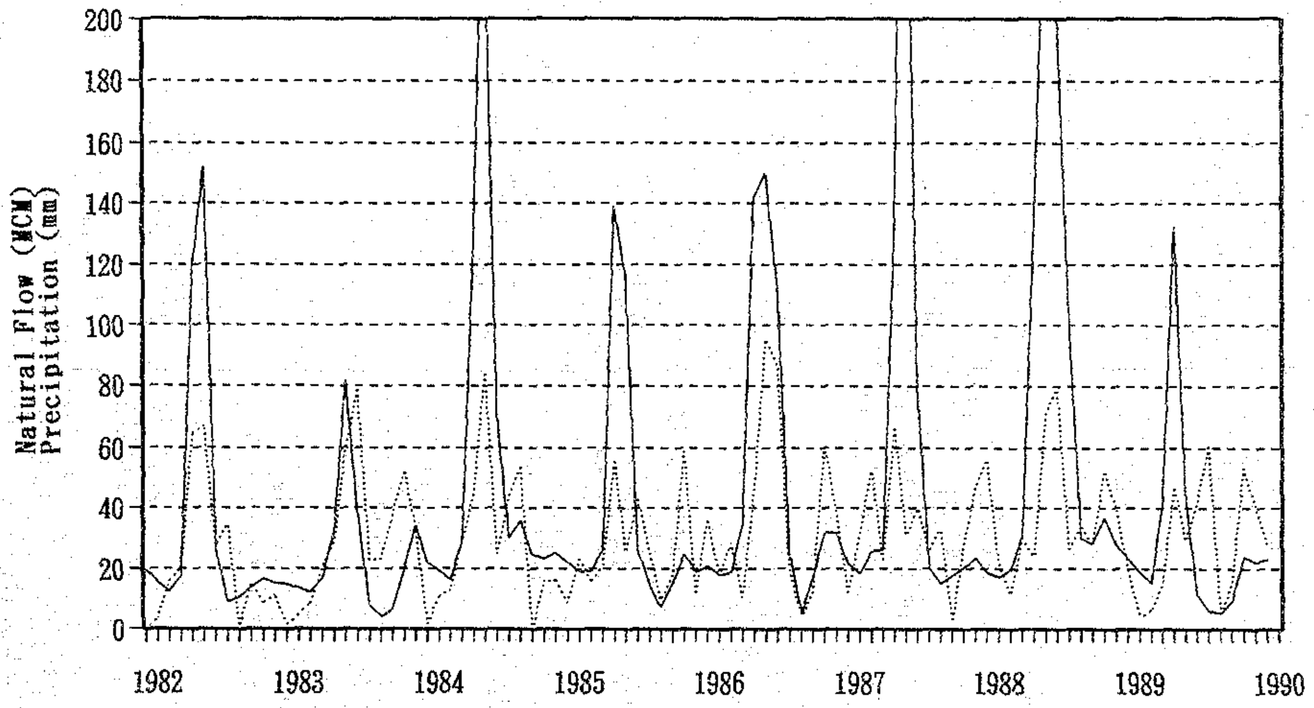


Fig. 6-7 Seasonal Variation of Precipitation at Oltu Station and Natural Flow at No.2329 Station

6.3 Evaporation

There is no meteorological station which observes both evaporation and air temperature in the Oltu river basin.

Observation periods of meteorological stations in the upstream of Çoruh river basin and Tortum power station (evaporation only) are shown in Fig. 6-8.

The evaporation from the reservoirs was calculated by the evaporation of the Tortum power station in the Memorandum dated on 3rd May, 1991 which partly compensated by the air temperature data of the Oltu meteorological station.

Station			Observation Period (1970 – 1975 – 1980 – 1985 – 1990)
Name	No.	E. L (m)	
Bayburt	625	1,550	77————
Ispir	762	1,200	77————
Erzurum	096	1,869	72—————
Tortum P/S		1,070	(Oltu River) 77————

Note ;Air Temperature has not been observed at Tortum P/S.

Fig. 6-8 Existing Evaporation Data

The observed evaporation data of the Tortum power station are shown in Table 6-9 the air temperature data of the Oltu meteorological station are shown in Table A-2-5.

The air temperature of the Tortum power station calculated by the data of Tortum meteorological station are shown in Table A-2-6.

In this calculation the air temperature of some months of the Oltu meteorological station where there are no observation data, are compensated by the correlation of air temperature between the Oltu station and the Tortum station.

The correlation between evaporation and air temperature at the Tortum power station was obtained based on Fig. A-2-3 using the following equation:

$$Y = 12.448 \times X - 46.05$$

where, Y: evaporation (mm)
X: air temperature (°C)

The following take into account the calculation of evaporation from the reservoirs.

- Standard Weather Bureau Class A pans were used for evaporation measurements and 0.7 of pan coefficient was adopted.

- Evaporanspirations in the vicinities of projected reservoir sites in the Oltu River Basin, when taking into account the states of vegetation and geology before and after the construction of dams, are not thought to be different.

- The air temperatures of the Olur reservoir and the Ayvalı reservoir are estimated from the data of the Oltu meteorological station by considering the altitude of EL. 1,105 m and EL. 930 m of these reservoirs.

The 22 years (1968 to 1989) monthly evaporation from the reservoir is shown in Tables 6-10 and 6-11.

The average annual evaporation from the Olur reservoir and the Ayvalı reservoir is 843 mm and 885 mm, respectively.

Table 6-9 Observed Monthly Evaporations of Tortum Power Station

(unit ; mm)

Year	Jan	Fev	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977						175.2	253.4	249.6	173.4				851.6
1978						192.9	274.8	246.2	200.2	101.6			1,015.7
1979				88.7	151.5	180.9	229.4	255.5	197.0				1,103.0
1980						230.0	292.4	222.5	175.0	75.9			995.8
1981					130.0	214.6	179.0	248.5	183.5	97.2			1,052.8
1982					141.7	226.7	248.5	236.2	182.1	99.1			1,134.3
1983					159.9	199.1	265.4	238.6	175.5				1,038.5
1984						209.3	227.5	194.2	181.0				812.0
1985						235.3	270.0	258.0	183.0	76.1			1,022.4
1986					112.7	191.4	271.9	262.9	172.1	80.9			1,091.9
1987					166.4	191.4	252.4	220.6	179.0	90.1			1,099.9
1988					48.9	73.6	236.1	220.6	164.5	75.3			819.0
1989					180.9	225.4	237.8	229.5	151.0	74.6			1,099.2
1990					133.6	214.2	229.6		174.0	83.6			835.0
Ave				88.7	136.2	197.1	247.7	237.1	178.0	85.4			997.9

Table 6-10 Estimated Monthly Evaporations of Olur Reservoir

(Unit ; mm)

Year	Jan	Fev	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1968			0.0	72.8	106.3	118.1	171.5	155.2	133.4	80.9	29.3		867.5
1969			4.9	37.5	111.7	152.5	159.7	179.6	117.1	57.4	13.0		833.4
1970			23.0	85.5	99.9	138.0	169.7	155.2	120.8	61.0	34.8		887.9
1971			13.0	54.7	102.7	120.8	189.6	147.9	153.4	55.6	8.5		846.2
1972			0.0	71.9	80.9	125.3	174.2	176.0	127.1	91.8	0.0		847.2
1973			0.0	48.3	98.1	113.5	165.1	172.4	134.3	78.2	0.0		809.9
1974			1.3	24.8	109.9	155.2	168.8	157.0	110.8	108.1	16.7		852.6
1975			0.0	81.8	95.4	148.8	182.3	179.6	123.5	59.2	4.0		874.6
1976			0.0	46.5	91.8	130.7	157.0	178.7	119.9	72.8	23.0		820.4
1977			4.9	58.3	95.4	117.1	157.9	166.9	131.6	38.4	23.9		794.4
1978			21.2	43.8	92.7	120.8	185.0	162.4	144.3	80.9	0.0		851.1
1979			12.1	55.6	98.1	122.6	156.1	189.6	144.3	67.4	25.7		871.5
1980			3.1	46.5	105.4	148.8	189.6	160.6	120.8	61.0	27.5		863.3
1981			15.7	41.1	71.9	131.6	179.6	168.8	140.7	84.6	3.1		837.1
1982			0.0	65.5	99.9	136.2	155.2	160.6	126.2	61.9	0.0		805.5
1983			8.5	63.7	99.0	127.1	174.2	166.0	120.8	61.9	23.0		844.2
1984			16.7	50.2	79.1	135.3	170.6	143.4	139.8	65.5	13.0		813.6
1985			0.0	67.4	117.1	146.1	157.9	187.8	129.8	53.8	26.6		886.5
1986			0.0	71.9	70.1	121.7	183.2	188.7	140.7	67.4	0.0		843.7
1987			0.0	38.4	112.6	133.4	173.3	157.0	114.4	54.7	0.0		783.8
1988			0.0	58.3	90.0	122.6	162.4	153.4	118.1	62.8	0.0		767.6
1989			22.1	87.3	104.5	143.4	178.7	189.6	131.6	64.6	14.8		936.6
Ave			6.7	57.8	96.9	132.3	171.0	168.0	129.2	67.7	13.0		842.7

Note; Y(Evap) = C * (12.448 *1.039 * X(Oltu °C) - 46.05)
C = 0.7

Table 6-11 Estimated Monthly Evaporations of Ayvali Reservoir

(Unit ; mm)

Year	Jan	Fev	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1968			0.0	76.8	111.6	123.8	179.3	162.4	139.8	85.3	31.7		910.7
1969			6.3	40.2	117.3	159.6	167.1	187.8	122.9	60.8	14.8		876.8
1970			25.1	90.0	105.0	144.5	177.4	162.4	126.7	64.6	37.3		933.0
1971			14.8	58.0	107.9	126.7	198.1	154.9	160.5	59.0	10.1		890.0
1972			0.0	75.9	85.3	131.4	182.1	184.0	133.2	96.6	0.0		888.5
1973			0.0	51.4	103.2	119.1	172.7	180.2	140.8	82.5	0.0		849.9
1974			2.6	27.0	115.4	162.4	176.5	164.3	116.3	113.5	18.5		896.5
1975			0.0	86.2	100.3	155.8	190.6	187.8	129.5	62.7	5.4		918.3
1976			0.0	49.6	96.6	137.0	164.3	186.8	125.7	76.8	25.1		861.9
1977			6.3	61.8	100.3	122.9	165.2	174.6	137.9	41.1	26.1		836.2
1978			23.2	46.7	97.5	126.7	193.4	169.9	151.1	85.3	0.0		893.8
1979			13.8	59.0	103.2	128.5	163.3	198.1	151.1	71.2	27.9		916.1
1980			4.4	49.6	110.7	155.8	198.1	168.0	126.7	64.6	29.8		907.7
1981			17.6	43.9	75.9	137.9	187.8	176.5	147.3	89.1	4.4		880.4
1982			0.0	69.3	105.0	142.6	162.4	168.0	132.3	65.5	0.0		845.1
1983			10.1	67.4	104.1	133.2	182.1	173.7	126.7	65.5	25.1		887.9
1984			18.5	53.3	83.4	141.7	178.4	150.2	146.4	69.3	14.8		856.0
1985			0.0	71.2	122.9	153.0	165.2	196.2	136.1	57.1	28.9		930.6
1986			0.0	75.9	74.0	127.6	191.5	197.2	147.3	71.2	0.0		884.7
1987			0.0	41.1	118.2	139.8	181.2	164.3	120.1	58.0	0.0		822.7
1988			0.0	61.8	94.7	128.5	169.9	160.5	123.8	66.5	0.0		805.7
1989			24.2	91.9	109.7	150.2	186.8	198.1	137.9	68.4	0.0		967.2
Ave			7.6	61.3	101.9	138.6	178.8	175.7	135.5	71.6	13.6		884.5

Note ;Y(Evap) = C * (12.448 * 1.079 * X(Oltu ℃) − 46.05)
C = 0.7

6.4 Sedimentation

6.4.1 Outline

The observation stations for suspended sediment and the periods of observation are shown in Fig. 6-9. Suspended sediment in the Oltu River is being observed at only one location, the Asağı Kumlu Station, No. 2325, upstream of the Olur Reservoir.

No	Station Name	River	C.A (km^2)	Observation Period (1965 – 1970 – 1975 – 1980 – 1985 – 1990)
2325	Asagi kumlu	Oltu	1,762	77
2320	Laleli	Coruh	5,188	71
2316	Ispir Kop	"	5,514	69
2322	Altinsu	"	18,326	80
2315	Karsikoy	"	19,654	67

Fig. 6-9 Existing Suspended Sediment Data

According to observations on site of the conditions of the river, turbidity of the Oltu River is severer than in the upstream part of the Çoruh River, and the degree of turbidity is not lessened even when clear weather prevails.

It is considered that the source of supply for the suspended sediment is the discharge from the landslide area of semiconsolidated rocks of the Oltu Formation.

It is desirable, hereafter, for the suspended sediment per unit catchment area to be checked by suspended sediment observation records of the No. 2329 site proposed in 1.3(2) of the "Memorandum," 3 May 1991.

6.4.2 Sediment Yield

(1) Calculations for 16-Year Period (Oct. 1973 to Sep. 1990)

On seeking a correlation between No. 2325 and No. 2316 at Ispir on the upstream part of the Çoruh River regarding discharge and suspended sediments by Figs. 6-10(a) and 6-10(b), the following equations were obtained:

No. 2316 $Y = 0.611 \times X^{1.95}$: N = 240

No. 2325 $Y = 8.851 \times X^{1.94}$: N = 149

where, Y: suspended sediment (ton/day)
X: discharge (m^3/sec)
N: number of observations

The 16-year suspended sediments at No. 2325 according to the daily discharges from October 1973 to September 1990 are as given in Table A-2-7, and an annual average suspended sediment quantity per square kilometer of 245 tons was calculated.

On seeking a correlation between the 16-year monthly suspended sediments and discharge at No. 2325 by Fig. 6-11, the following equation was obtained:

long $Y = 1.928 \times \log X + 1.689$: N = 192

where, Y: suspended sediment (ton/month)
X: discharge (MCM)
N: number of data

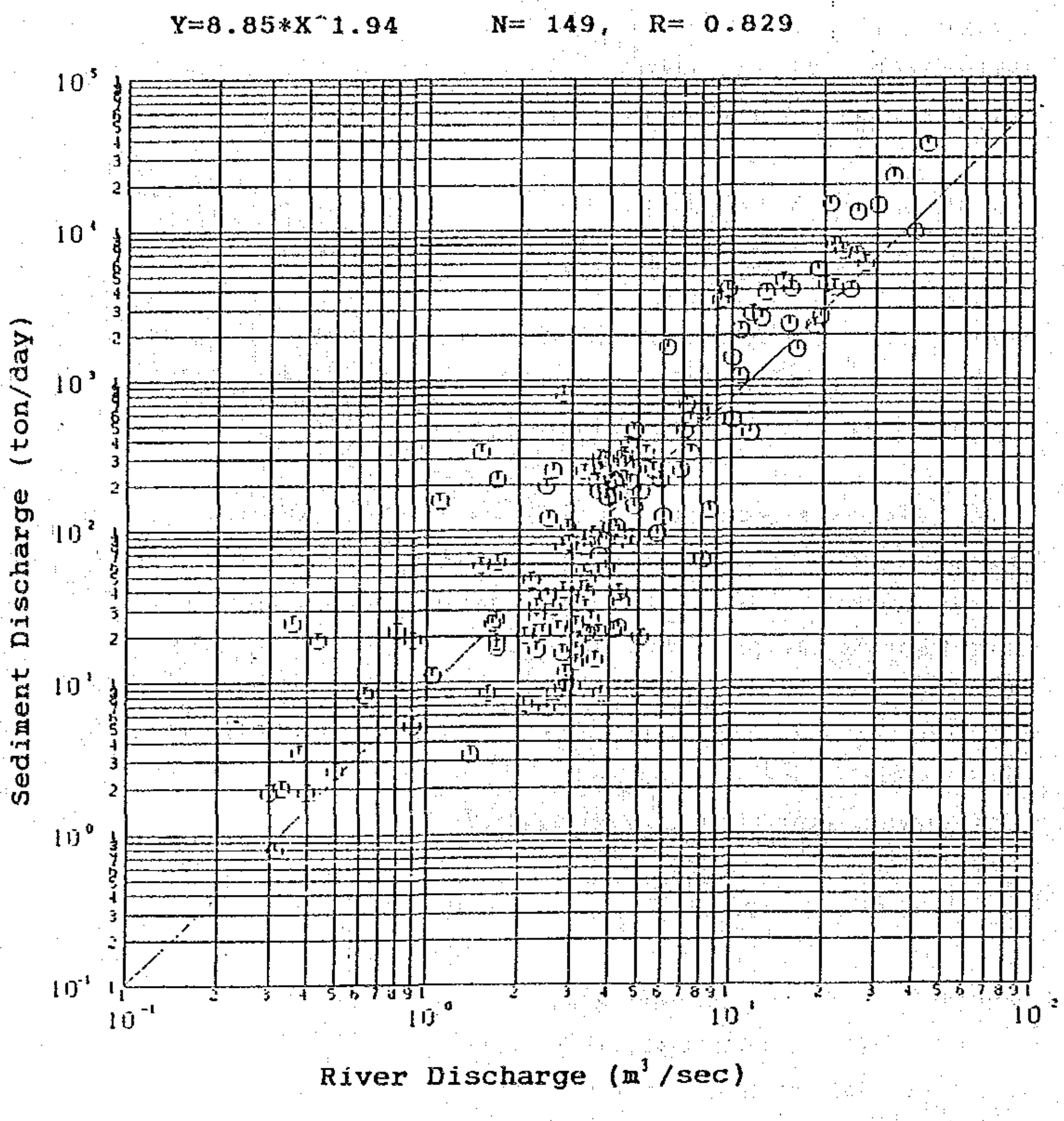


Fig. 6-10(a) Sediment Rating Curve at No.2325 Station

Y=0.611*X^1.95 N= 240, R= 0.791

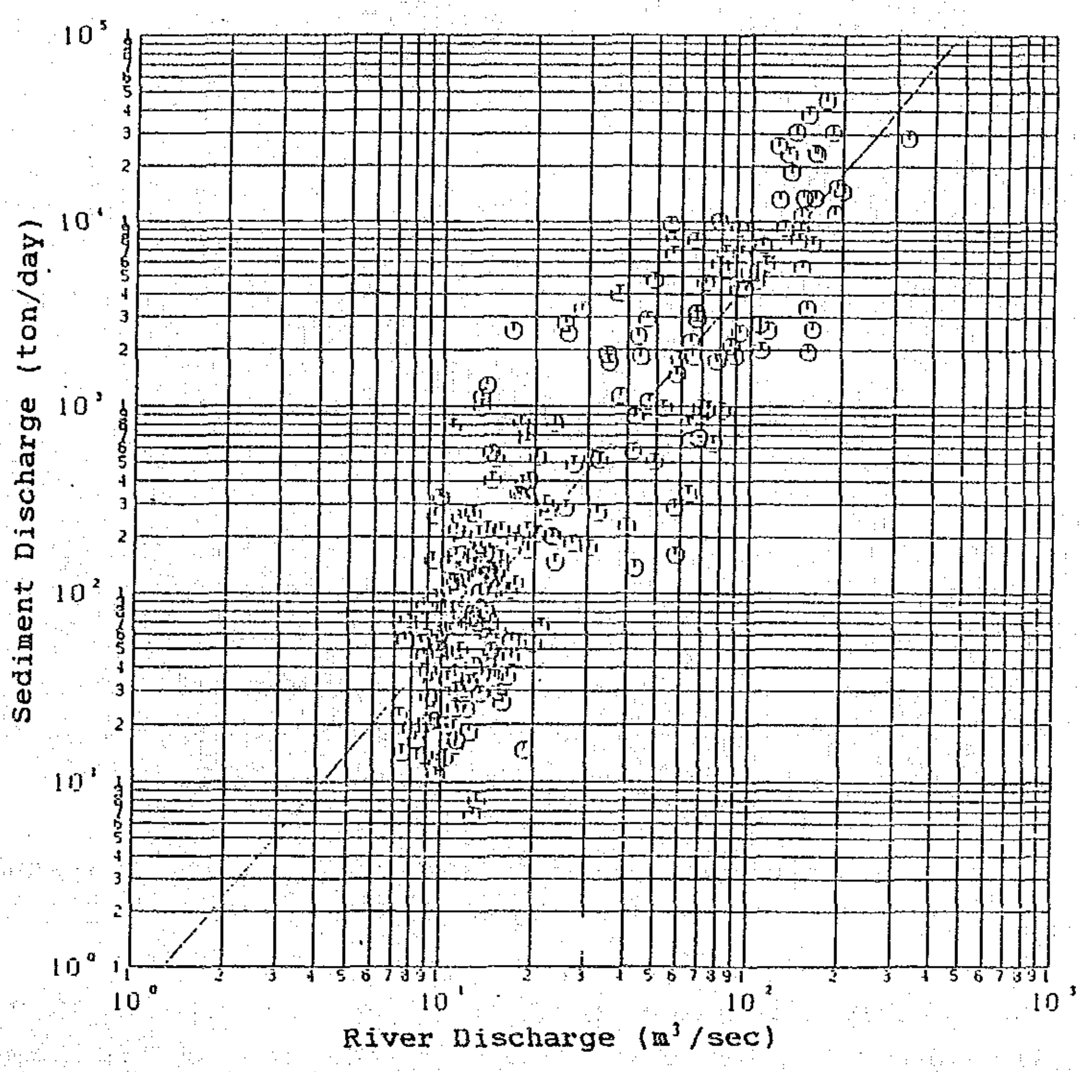


Fig. 6-10(b) Sediment Rating Curve at No.2316 Station

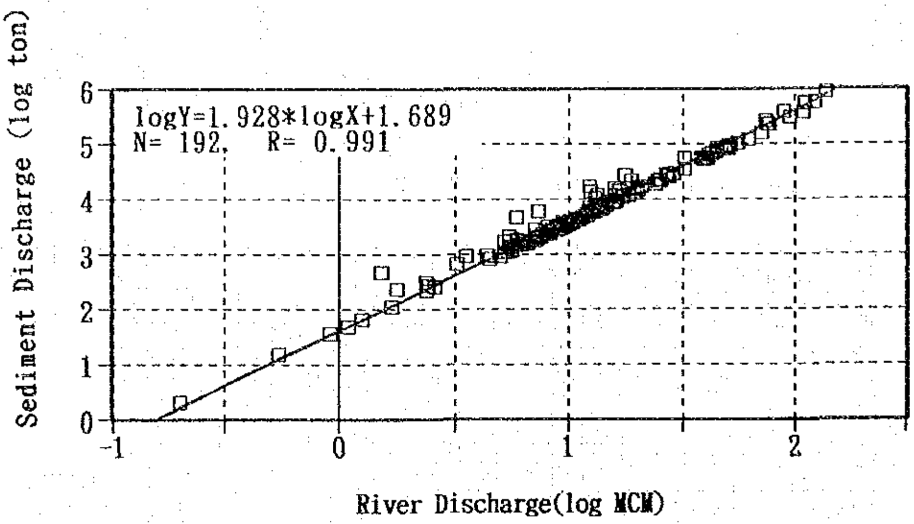


Fig. 6-11 Sediment Monthly Rating Curve at No. 2325 Station

(2) Calculations for 50-Year Period (Oct. 1940 to Sep. 1990)

The suspended sediment quantities at No. 2325 during the 50-year period from October 1940 to September 1990 from the correlation between the abovementioned monthly suspended sediment and discharge are given in Table A-2-8.

As a result, the annual average suspended sediment per square kilometer for the 50-year period is 279 ton/km^2.

The monthly discharges of No. 2325 during October 1940 to September 1973 were obtained applying the relationship between No. 2329 and No. 2325 of Fig. A-2-2(c) to the discharges of Olur Damsite, Table 6-7.

6.4.3 Sediment Accumulation

The density of deposition in the reservoir differs according to the sediment components and the number of years of sedimentation. According to gradation analyses by EIE, the composition of the suspended sediment and component ratios are as follows:

Sand	Silt	Clay
33%	37%	30%

The average density Wt of deposition after passage of t years in time has been defined by Lane and Koelzer using the following equation:

$$Wt = W_1 + K \times \log t$$

where, W_1: initial density (ton/m^3)

K : consolidation factor

The average density 50 years later is calculated as 1.165 ton/m^3 from $W_{50} = W_1 + 1.298 \times K$.

Further, the sediment deposited in the reservoir was calculated assuming the ratio of bed load to suspended load as 12% and aggregating as follows:

Annual average suspended load
per unit catchment area: 279 ton/km^2

Sedimentation in reservoir
per unit catchment area: 268 m^3/km^2

In the Olur Reservoir

50-year sedimentation:	47,020,000 m^3/ 50 yr
100-year sedimentation:	94,040,000 m^3/100 yr

In the Ayvalı Reservoir (without Olur dam)

50-year sedimentation:	60,530,000 m^3/ 50 yr
100-year sedimentation:	121,060,000 m^3/100 yr

where, the catchment areas at the dam sites are 3,509 km^2 for the Olur site, and 4,517 km^2 for the Ayvalı site.

6.5 Probable Flood

6.5.1 Outline

In calculation of probable flood, analyses were made by Gumbel distribution and logarithmic Pearson Type III distribution widely used as probable distribution functions in conformity with flood records. Flood discharge observations are not being made at runoff gauging stations on the Oltu River.

However, in the chronological table on discharge, annual peak discharge is given besides daily maximum discharges and, therefore, for probable flood discharge analysis, the annual peak discharge was used.

Data for probable flood analysis were those of 50 years from October 1940 to September 1990 for No. 23-24 (Ayvalı dam site) and No. 2329 (Olur dam site).

As for measurements missing for annual peak discharge records, supplementation was done by the method below using the records of the No. 2323 and No. 2325 gauging stations.

6.5.2 Annual Peak Discharge

When annual peak discharge measurement is lacking but maximum daily discharges are available, the former was determined by the correlation between maximum daily discharge and annual peak discharge records.

In case of measurements missing for both maximum daily discharges and annual peak discharges at No. 23-24 and No. 2329 Gauging Stations, the relationship for calculating the annual peak discharge at No. 2323 was obtained from Fig. A-2-4 as follows:

$$Qp = Y \times Qp \text{ (No. 2323)}$$
$$Y = 1.255 \times \log X \text{ (C.A)} = 3.81$$

where, Qp: annual peak discharge at any site (m^3/sec)

Y: coefficient for annual peak discharge of No. 2323 at any site

Y (No. 2323) = 1.000
Y (No. 23-24) = 0.798
Y (No. 2329) = 0.644
Y (No. 2325) = 0.264

X: catchment area of any site (km^2)

The gauging station records and calculated discharges mentioned above are given in Table A-2-9.

6.5.3 Analysis Results

Flood discharge plotted on probability paper is as shown in Figs. 6-12(a) and 6-12(b). Probable annual flood discharge is as shown in Table 6-12 below.

Maximum peak discharges at Gauging Stations in Turkey are shown in Fig. 6-12.

Table 6-12 Probable Floods

Gumbel Distribution

Return Period (Years)	No. 23-24 (Ayvali Dam Site)		No. 2329 (Olur Dam Site)	
	(m^3/sec)	($m^3/s/100km^2$)	(m^3/sec)	($m^3/s/100km^2$)
200	530	12	470	13
100	480	11	420	12
50	430	9.5	380	11
25	380	8.4	340	9.7
10	310	6.9	280	8.0
5	260	5.8	230	6.6
2	180	4.0	160	4.6

Log Pearson Type III

Return Period (Years)	No. 23-24 (Ayvali Dam Site)		No. 2329 (Olur Dam Site)	
	(m^3/sec)	($m^3/s/100km^2$)	(m^3/sec)	($m^3/s/100km^2$)
200	510	11	450	13
100	460	10	400	11
50	410	9.1	360	10
25	360	8.0	320	9.1
10	300	6.6	260	7.4
5	250	5.5	220	6.3
2	180	4.0	150	4.3

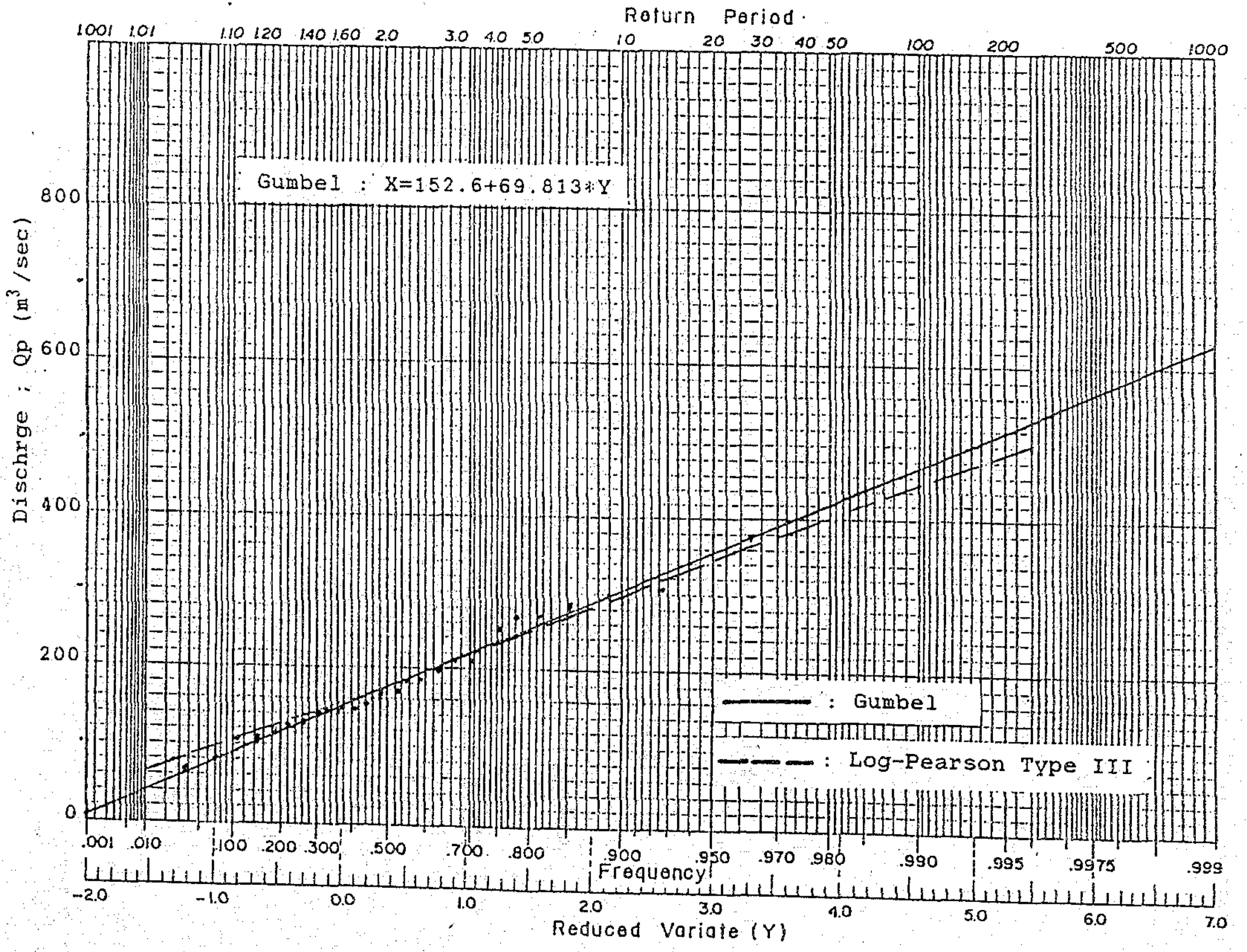


Fig. 6-12(a) Flood Frequency at No.23-24 Station

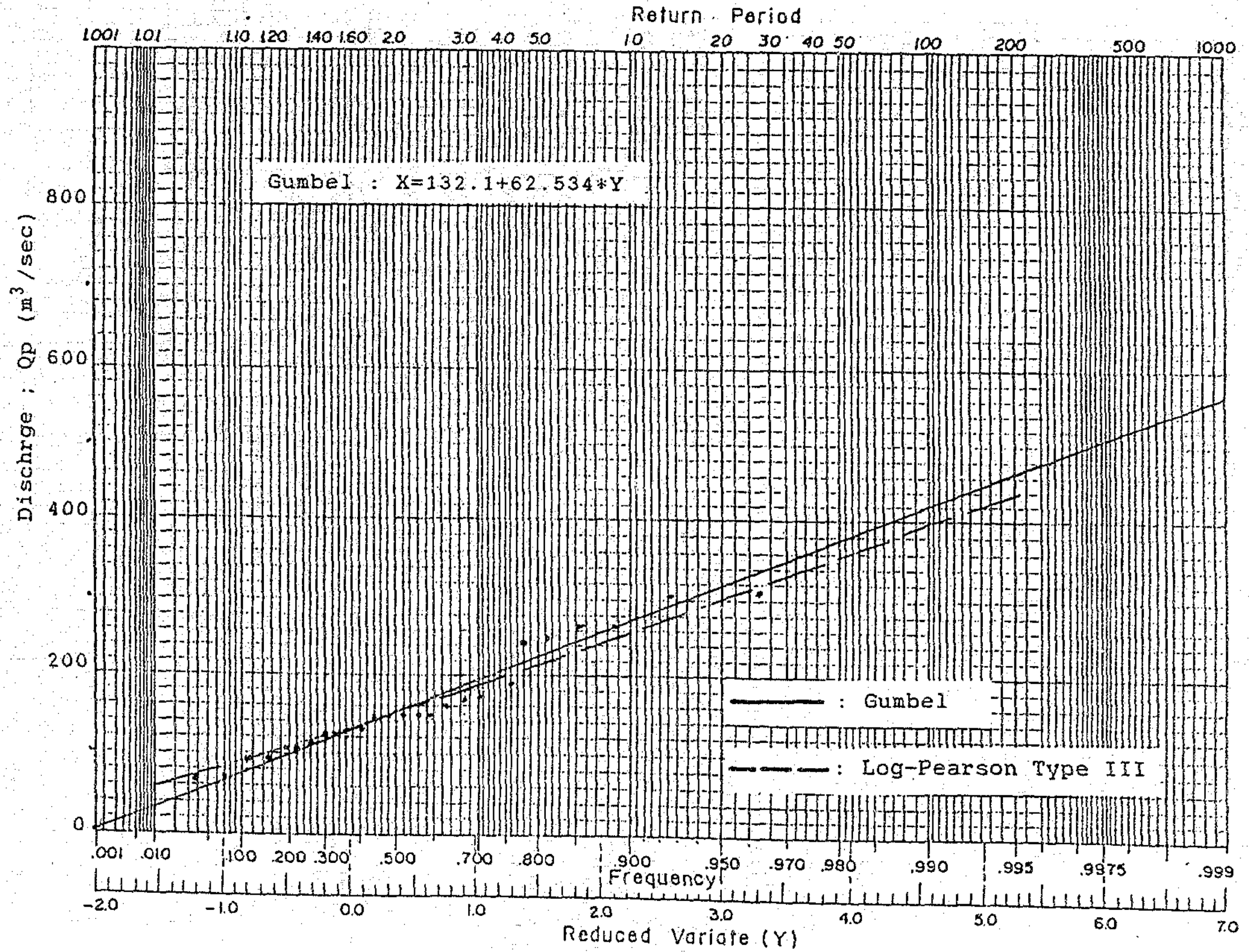


Fig. 6-12(b) Flood Frequency at No.2329 Station

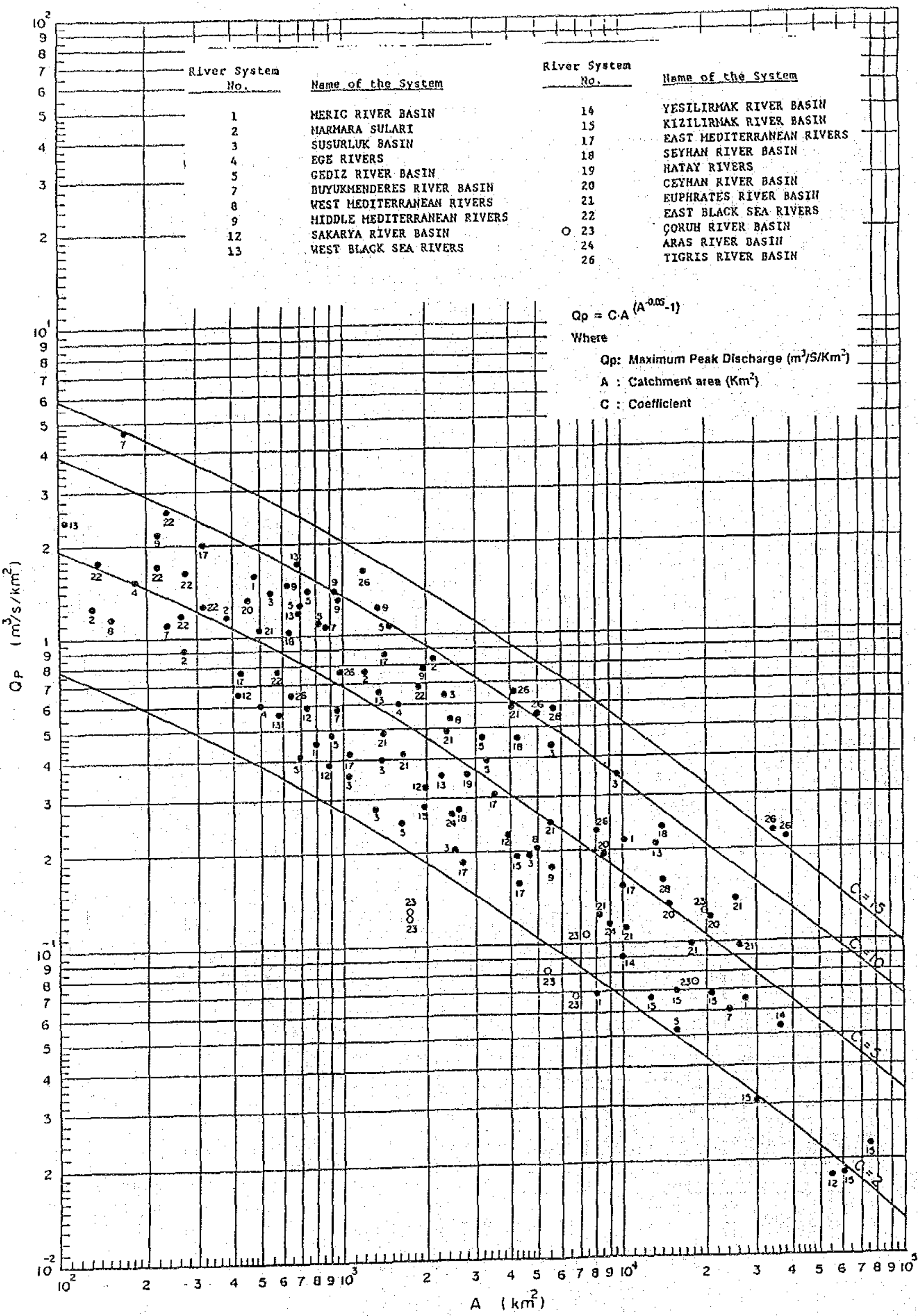


Fig. 6-13 Maximum Peak Discharges at Gauging Station in Turkey

6.6 Probable Maximum Flood

6.6.1 Probable Maximum Precipitation

The probable maximum flood (PMF) will be estimated from the probable maximum precipitation (PMP) by hydrological techniques. There is a reasonable basis on which to analyze the basic factors of major floods, i.e., storm rainfall and snowmelt, and to maximize them to their upper physical limits consistent with accepted meteorological and hydrological knowledge. For the period from 1959 to 1989 historical major storms were selected. The average precipitation over the Oltu river basin was respectively estimated by the Thiessen method. The estimated precipitation during these storms is given in Table 6-13.

Table 6-13 Storm Maximization of Historical Storms

Storm Date	Storm Duration (hr.)	Average Precipitation (mm)	Wm/Ws=rm	Maximum Precipitation (mm)
18-20 May 1959	30	44.2	25.4/6.05 = 4.20	185.6
19-22 May 1964	15	22.8	29.2/13.7 = 2.13	48.6
16-18 Apr. 1965	18	32.5	21.6/10.4 = 2.08	67.6
14-18 May 1966	24	24.1	28.2/13.7 = 2.06	49.6
17-20 Apr. 1968	18	21.0	21.6/13.2 = 1.64	34.4
10-13 Sep. 1968	16	21.3	33.8/17.7 = 1.91	40.7
5- 7 Oct. 1969	16	30.6	25.9/16.8 = 1.54	47.1
13-16 Apr. 1971	12	17.0	21.6/ 9.6 = 2.25	38.3
4- 5 Jul. 1979	14	37.0	45.4/25.4 = 1.79	66.2
2- 5 Oct. 1979	30	29.1	25.9/16.5 = 1.60	46.6
18-21 May 1984	36	44.6	29.2/14.8 = 1.97	87.9
20-23 Apr. 1985	28	19.7	21.6/12.2 = 1.77	34.9
22-24 Apr. 1986	12	19.6	21.6/ 9.6 = 2.25	44.1
7-10 May 1986	29	21.9	25.7/12.2 = 2.11	46.2
21-27 May 1986	24	22.0	29.2/15.2 = 1.92	42.2
3- 7 Oct. 1989	14	16.4	25.9/16.5 = 1.57	25.7

Storm maximization consists of multiplying the observed storm rainfall amounts by the ratio (Υm) of the maximum precipitable water (Wm) for the storm location to the precipitable water (Ws) estimated for the storm, that is, $\Upsilon m = Wm/Ws$. Precipitable water from the 1,000 mb surface to various altitudes can be presented as a function of the dew point temperature. Maximum precipitable water values used for storm maximization are usually estimated from maximum persisting 12-hour 1,000 mb dew points or vapor pressure values. In and around the catchment areas of the Olur and Ayvalı dam sites, there are four (4) meteorological stations at Oltu, Tortum, Artvin and Erzurum where vapor pressure values are observed at 7, 14 and 21 o'clock. 50 year frequency of monthly maximum persisting 12-hour vapor pressure is calculated.

Representative persisting 12-hour storm dew point temperatures are estimated as average values of persisting 12-hour, 1,000 mb dew points at the above stations. In maximizing storm rainfall the mean crest elevation of 2,800 m of the mountain barrier which lies to the south of the basin was selected as the base of the moisture column. Maximization was made on the basis of the maximum persisting 12-hour dew points within 15 days of the storm occurrence dates. For the storm in May 1959 only two stations, Artvin and Erzurum, have vapor pressure records in Hg. The representative persisting 12-hour 1,000 mb dew point temperature was estimated to be 11.7°C as follows.

Station	Persisting 12-h vapor pressure (mb)	Persisting 12-h dew point (°C)	Persisting 12-h 1,000 mb dew point (°C)
Artvin	12.9	10.8	12.6
Erzurum	5.7	-0.9	9.7
			Average 11.7°C

The maximum persisting 12-hour 1,000 mb dew point temperature was also estimated to be 22.6°C from the following four stations.

Station	Max-persisting 12-h vapor pressure (mb)	Max-persisting 12-h dew point (°C)	Max-persisting 12-h 1,000 mb dew point (°C)
Artvin	23.7	20.0	21.8
Erzurum	17.3	14.9	22.8
Oltu	20.7	18.1	23.2
Tortum	18.0	15.8	22.4
			Average 22.6°C

The precipitable water value used in determining Wm an Ws is for a moisture column with base at 1,000 mb and top at 200 mb minus the precipitable water in a column with base at 1,000 mb and top at the elevation of 2,800 m. Ym was determined as follows.

Wm = 66.00 - 40.60 = 25.40

Ws = 25.10 - 19.05 = 6.05

Ym = Wm / Ws = 4.20

The maximization results of historical selected storms are given in Table 6-13.

River basin distributions of the PMP were studied for the following two (2) cases to produce maximum runoff.

1 : The PMP based on May 1959 precipitation over the Oltu river basin estimated by the Thiessen method uniformly distributed over the catchment area of both the Olur and Ayvalı dam sites.

2 : The PMP is based on the depth-area-duration relationship of the Oltu river basin derived from May 1959 precipitation distributed over the catchment area of the Olur and Ayvalı dam sites respectively.

As the result of studies, PMP=185.6 mm/30 hrs. was calculated from the condition of case 1 and PMP=196.4 mm/30 hrs, was calculated from the condition of case 2. So case 2 was found to produce maximum runoff. Table 6-14 gives the Depth-duration curves shown in Fig. 6-14 the effective PMP duration, assuming uniform rainfall loss of 2 mm/hr.

Table 6-14 Time Distribution of PMP

(Unit: mm)

Duration	0-6hr	6-12hr	12-18hr	18-24hr	24-30hr	Total
<u>Olur Damsite</u>						
PMP	103	33	24	20	17	196
Loss	12	12	12	12	12	60
PMP (*)	91	21	12	8	5	136
<u>Ayvalı Damsite</u>						
PMP	101	32	23	19	16	191
Loss	12	12	12	12	12	60
PMP (*)	89	20	11	7	4	131

PMP (*) : Effective PMP

6.6.2 Unit Hydrograph

Using the Snyder's concept of "Synthetic Unit Hydrograph", unit hydrographs of the catchment area of the Olur and Ayvalı dam sites were constructed under the following conditions respectively:

Rainfall duration; 6-hour
Rainfall intensity; 10 mm

Unit hydrographs are illustratively shown in Figs. 6-15 and 6-16.

6.6.3 Probable Maximum Flood by Means of PMP

Probable maximum flood hydrographs according to PMP resulting from the 6 hours rainfall increments in Table 6-14 are given by multiplying the unit hydrograph of the catchment area of the Olur and Ayvalı dam sites respectively by those period effective precipitations, the hydrographs of the Olur and Ayvalı dam sites are shown in Figs. 6-17 and 6-18.

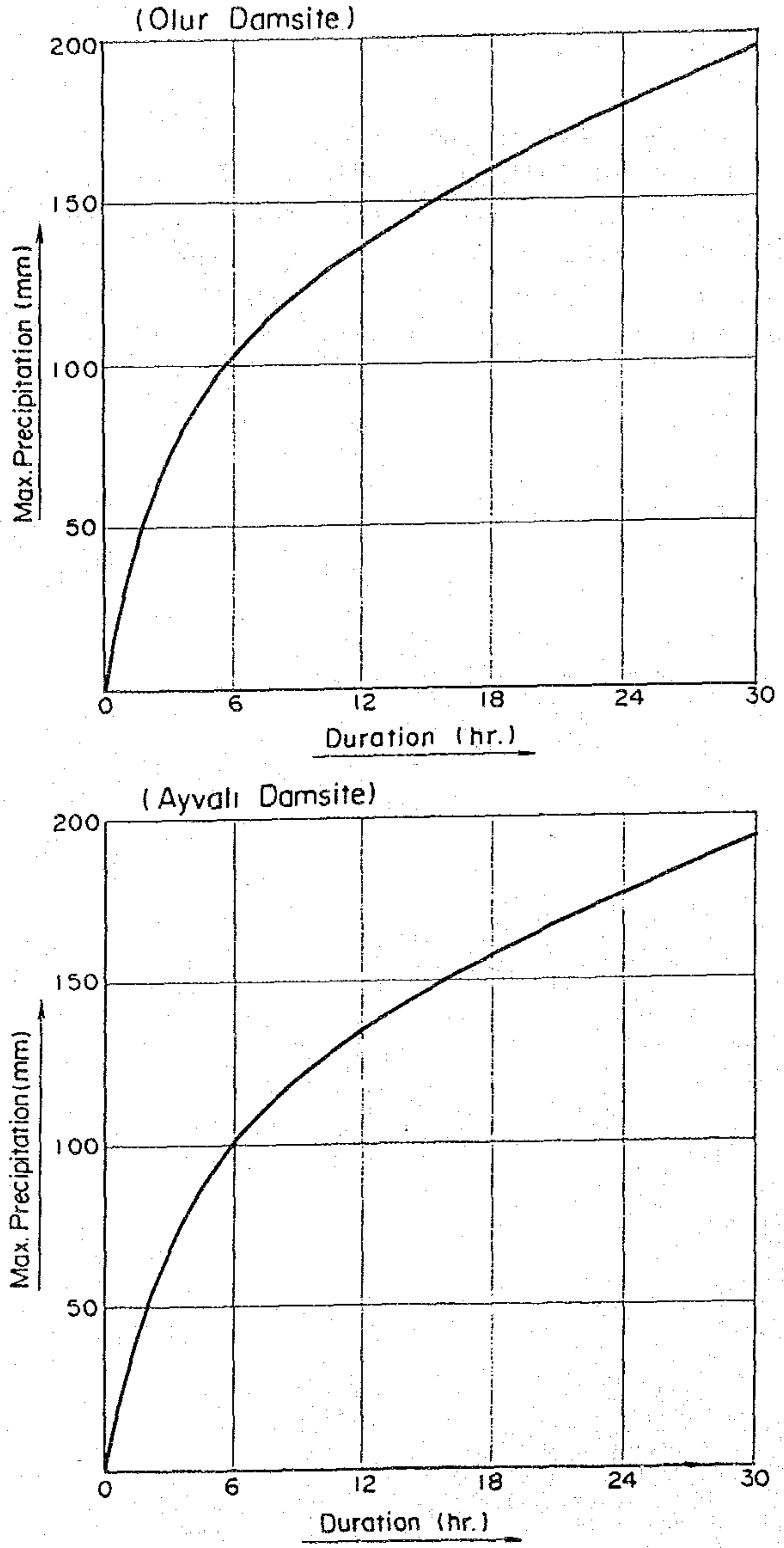
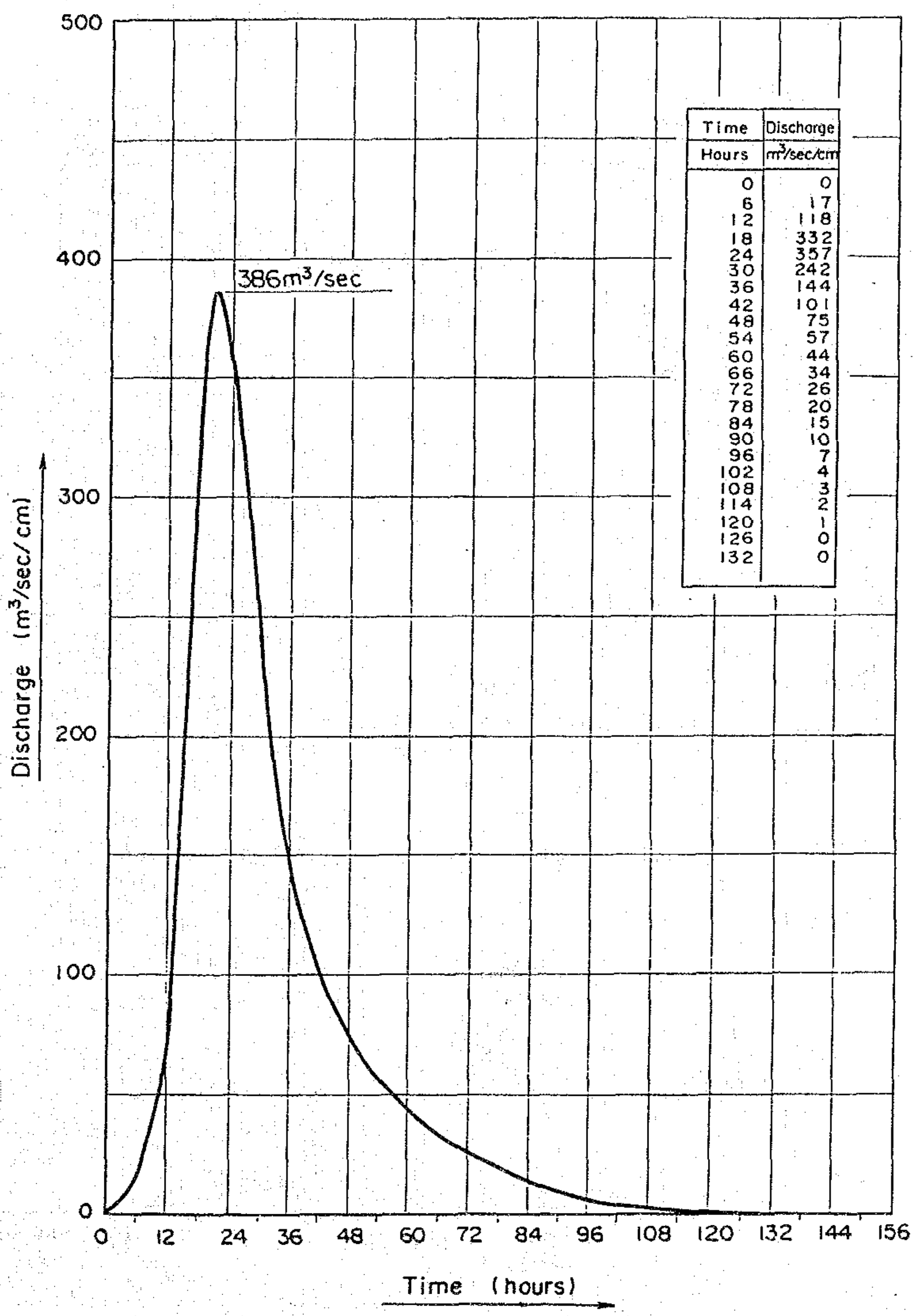
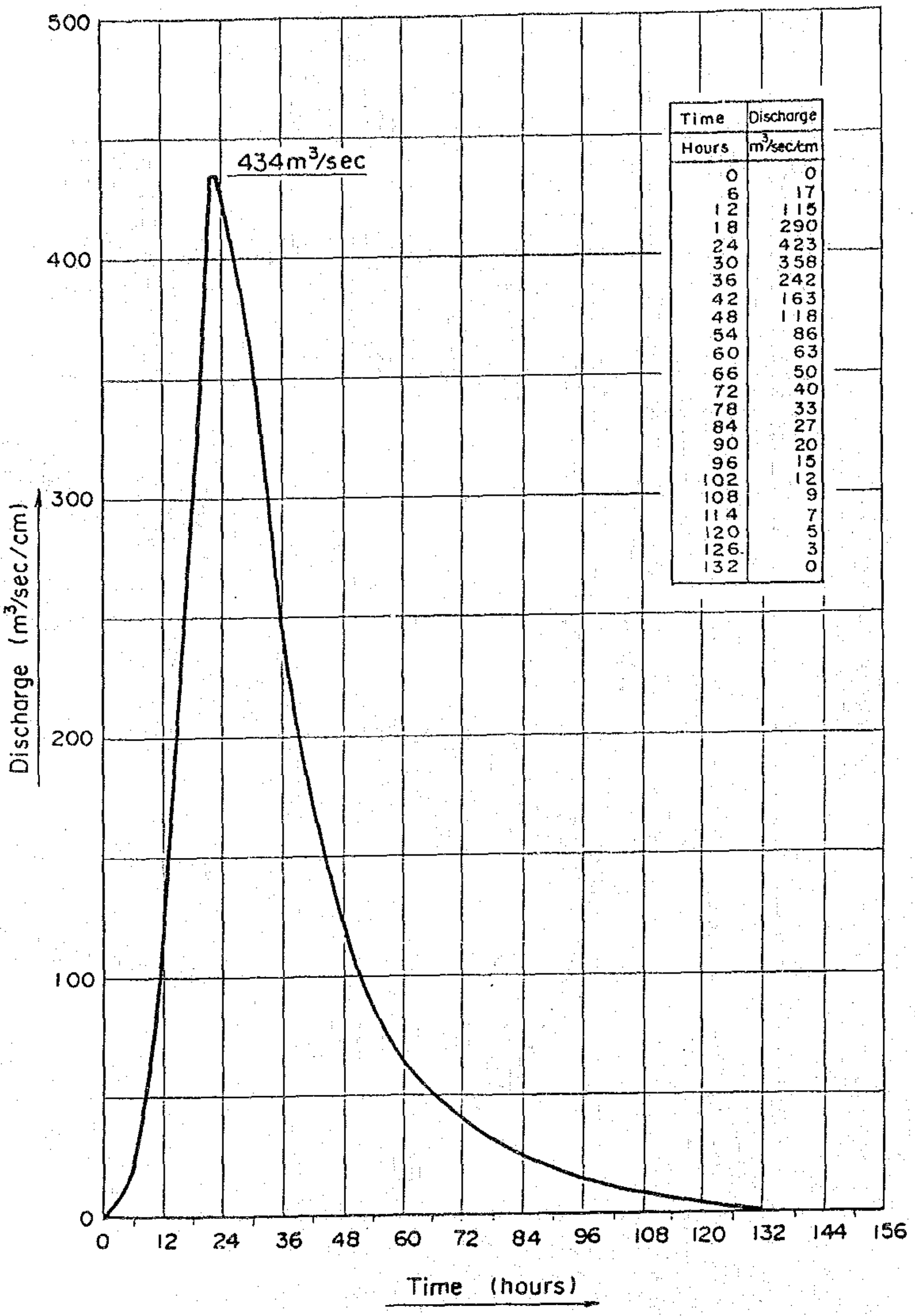


Fig. 6-14 Depth-Duration Curves of Max. Precipitation



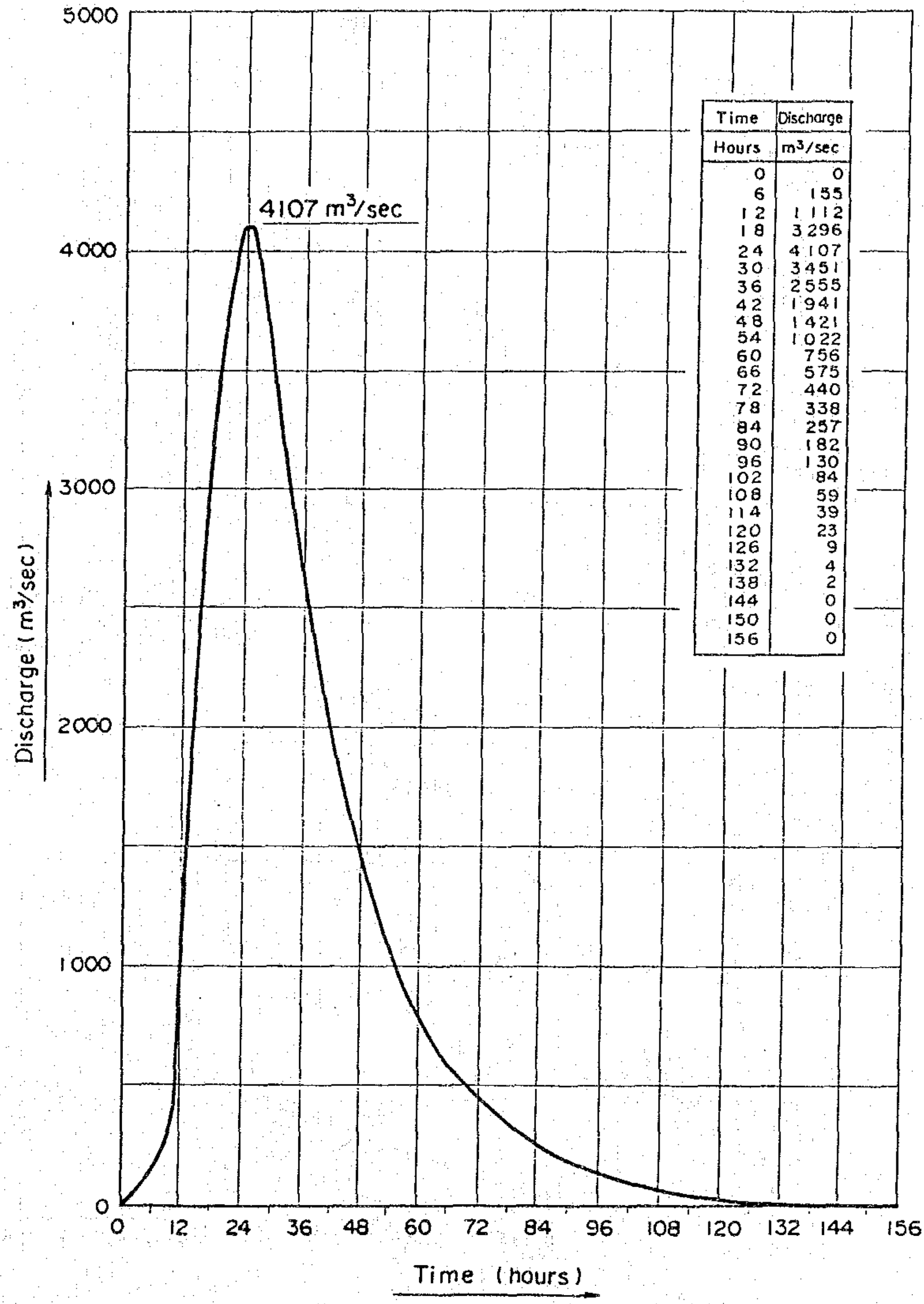
Time Hours	Discharge m³/sec/cm
0	0
6	17
12	118
18	332
24	357
30	242
36	144
42	101
48	75
54	57
60	44
66	34
72	26
78	20
84	15
90	10
96	7
102	4
108	3
114	2
120	1
126	0
132	0

Fig. 6-15 6 hours-1cm Unit Hydrography of Olur Damsite



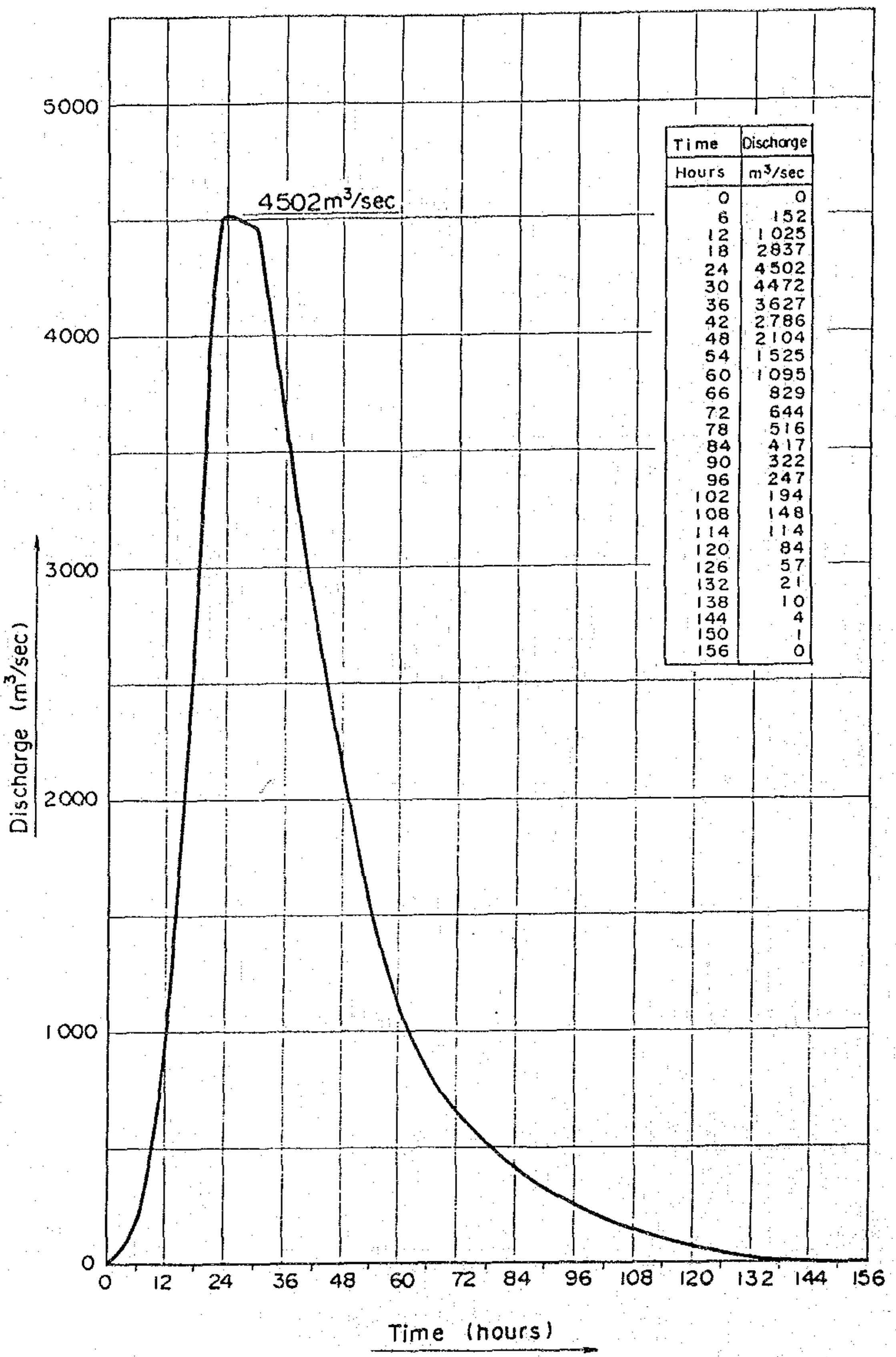
Time Hours	Discharge m³/sec/cm
0	0
6	17
12	115
18	290
24	423
30	358
36	242
42	163
48	118
54	86
60	63
66	50
72	40
78	33
84	27
90	20
96	15
102	12
108	9
114	7
120	5
126.	3
132	0

Fig. 6-16 6 hours-1cm Unit Hydrography of Ayvalı Damsite



Time Hours	Discharge m³/sec
0	0
6	155
12	1 112
18	3 296
24	4 107
30	3451
36	2555
42	1941
48	1421
54	1022
60	756
66	575
72	440
78	338
84	257
90	182
96	130
102	84
108	59
114	39
120	23
126	9
132	4
138	2
144	0
150	0
156	0

Fig. 6-17 PMF Hydrography of Olur Damsite by means of PMP



Time Hours	Discharge m³/sec
0	0
6	152
12	1 025
18	2837
24	4502
30	4472
36	3627
42	2786
48	2104
54	1525
60	1095
66	829
72	644
78	516
84	417
90	322
96	247
102	194
108	148
114	114
120	84
126	57
132	21
138	10
144	4
150	1
156	0

Fig. 6-18 PMF Hydrography of Ayvalı Damsite by means of PMP

6.6.4 Snow Melt

In the catchment area of the Olur and Ayvalı dam site snowmelts are an important factor in major floods. The snowmelt season extends from march to May. Maximum snowmelt runoffs of the Olur and Ayvalı dam site are given in Table 6-15.

Table 6-15 Maximum Snowmelt Runoff at Olur and Ayvali Damsites

Days	Temp. Design Pattern	Temp. at Ave. Elev. (2330 m.)	Max. Snowmelt Ratio x Temp.	Olur Damsite		Ayvalı Damsite	
				Daily Snowmelt Volume ($2440\ km^2$)	Daily Snowmelt Discharge	Daily Snowmelt Volume ($2925\ km^2$)	Daily Snowmelt Discharge
		°C	cm	$10^6 m^3$	m^3/sec	$10^6\ m^3$	m^3/sec
1	14.4	7.7	1.155	28.2	326.4	33.8	391.2
2	16.1	9.4	1.410	34.4	398.1	41.2	476.9
3	16.8	10.1	1.520	37.1	429.4	44.5	515.0
4	17.4	10.7	1.610	39.3	454.9	47.1	545.1
5	20.8	14.1	2.120	61.7	598.4 Peak	62.0	717.6 Peak
6	17.9	11.2	1.680	41.0	474.5	49.1	568.3
7	17.0	10.3	1.550	37.8	437.5	45.3	524.3
8	16.4	9.7	1.460	35.6	412.0	42.7	494.2
9	16.0	9.3	1.400	34.2	395.8	41.0	474.5
10	14.1	7.4	1.110	27.1	313.7	32.5	376.2

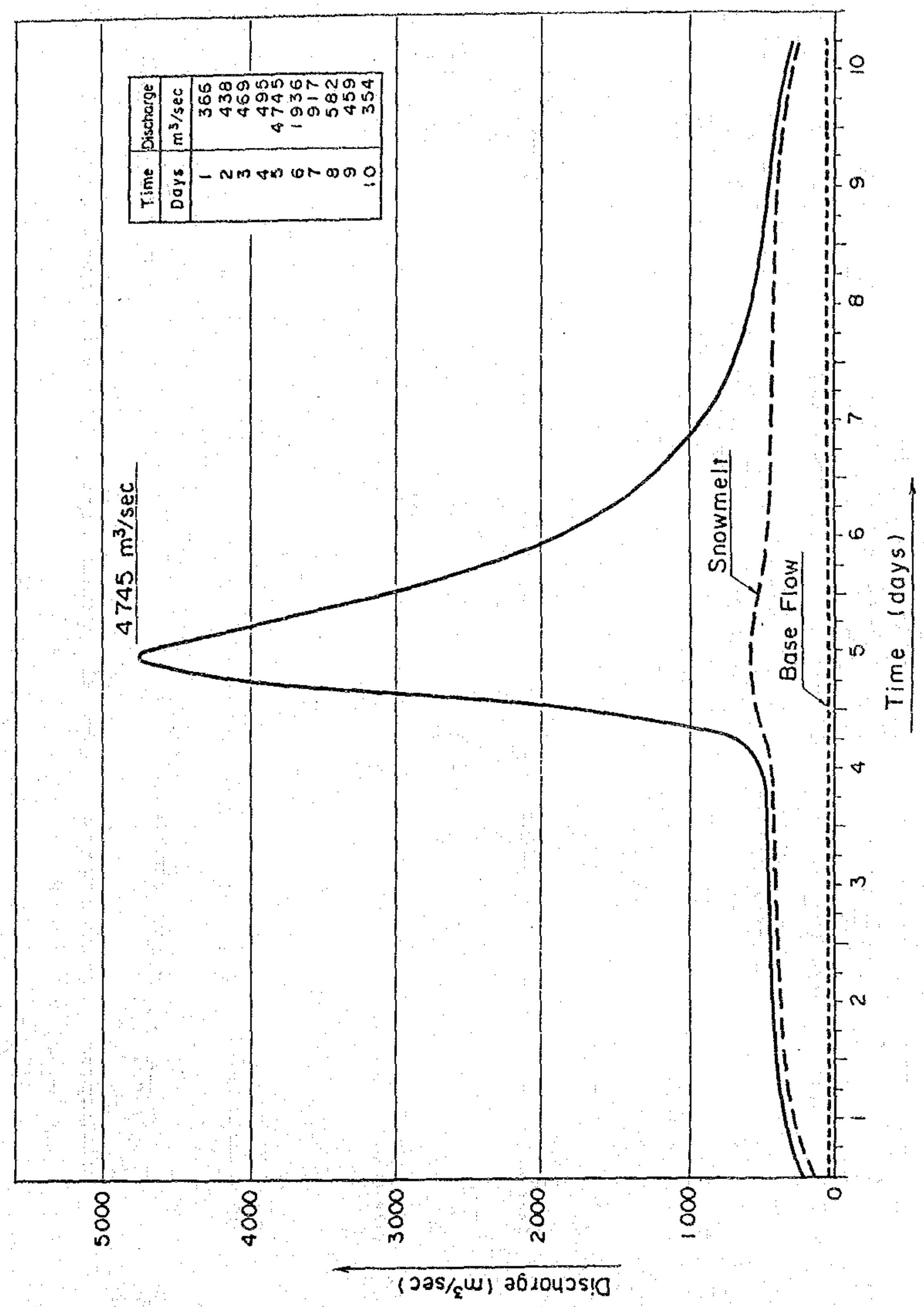
Elevation of Oltu Meteorological Station : 1275 m.
Lowest Elevation of 10-day Maximum Snowmelt : 1800 m.
Average Elevation of the Area Above 1800 m. : 2230 m.
The Area Above 1800 m. (For Olur and Ayvalı): 2440 km^2 - 2925 km^2
Lapse-Rate : 0.7 °C/100 m.

6.6.5 Probable Maximum Flood

The probable maximum flood hydrographs were presented as the sum of the PMP hydrograph, snowmelt hydrograph and the estimated base flow of 40 m^3/sec at the Olur dam site and 50 m^3/sec at the Ayvalı dam site, as given in Figs. 6-19 and 6-20.

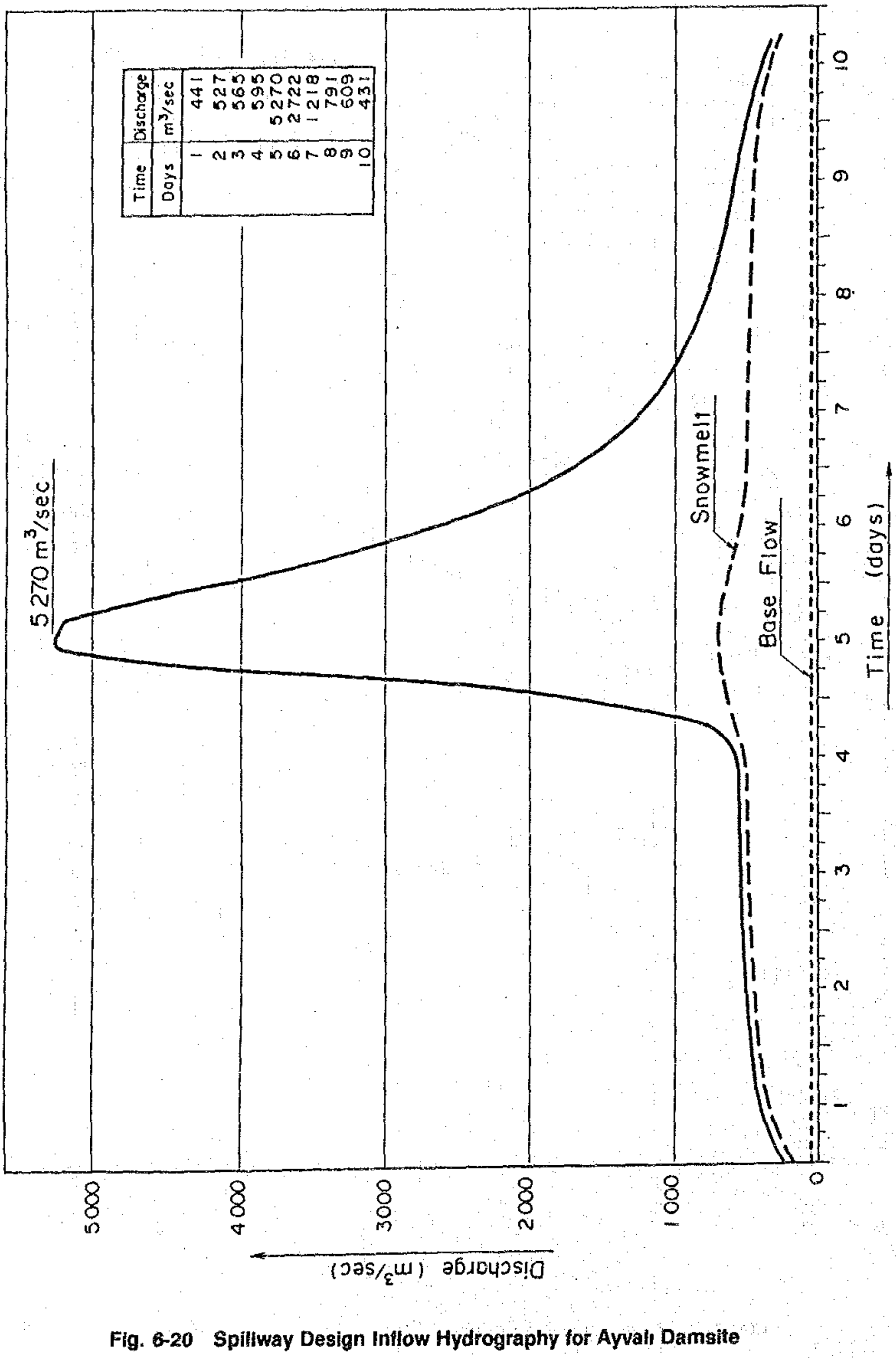
The probable maximum flood discharges were estimated to be 4,745 m^3/sec at the Olur dam site and 5,270 m^3/sec at the Ayvalı dam site.

The probable maximum floods of existing and projected dams in Turkey are shown in Fig. 6-21.



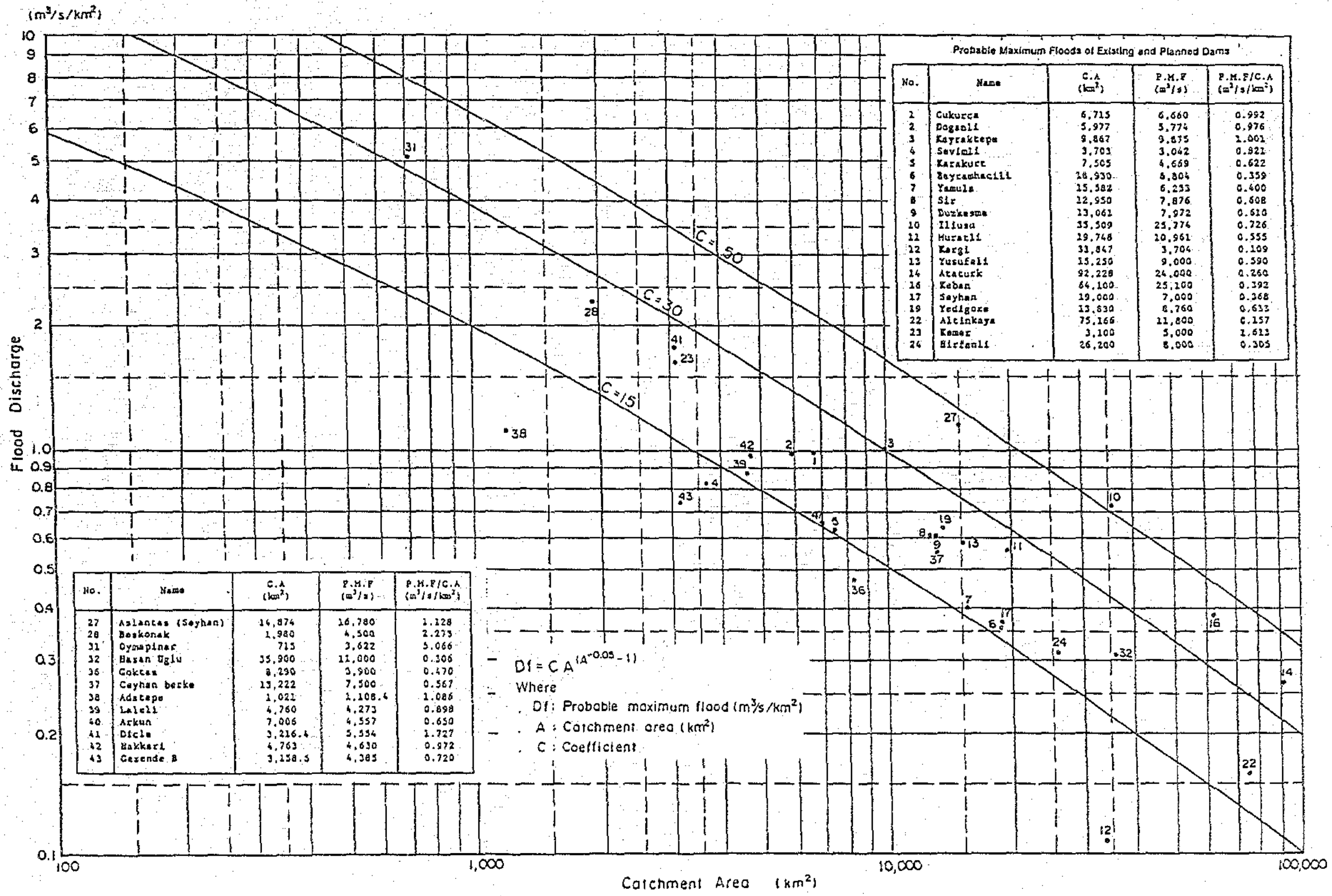
Time Days	Discharge m³/sec
1	366
2	438
3	469
4	495
5	4745
6	1936
7	917
8	582
9	459
10	354

Fig. 6-19 Spillway Design Inflow Hydrography for Olur Damsite



Time Days	Discharge m³/sec
1	441
2	527
3	565
4	595
5	5 270
6	2 722
7	1 218
8	791
9	609
10	431

Fig. 6-20 Spillway Design Inflow Hydrography for Ayvalı Damsite



Probable Maximum Floods of Existing and Planned Dams

No.	Name	C.A (km^2)	P.M.F (m^3/s)	P.M.F/C.A ($m^3/s/km^2$)
1	Cukurca	6,715	6,660	0.992
2	Dogsnli	5,977	5,774	0.976
3	Kayraktepe	9,867	9,875	1.001
4	Sevimli	3,703	3,042	0.821
5	Karakurt	7,505	4,669	0.622
6	Bayramhacili	18,930	6,804	0.359
7	Yamula	15,582	6,233	0.400
8	Sir	12,950	7,876	0.608
9	Durkesme	13,061	7,972	0.610
10	Ilisu	35,509	25,774	0.726
11	Muratli	19,748	10,961	0.555
12	Kargi	33,847	3,704	0.109
13	Yusufeli	15,250	9,000	0.590
14	Ataturk	92,228	24,000	0.260
16	Keban	64,100	25,100	0.392
17	Seyhan	19,000	7,000	0.368
19	Yedigoze	13,830	8,760	0.633
22	Altinkaya	75,166	11,800	0.157
23	Kemer	3,100	5,000	1.613
24	Birfanli	26,200	8,000	0.305

No.	Name	C.A (km^2)	P.M.F (m^3/s)	P.M.F/C.A ($m^3/s/km^2$)
27	Aslantas (Seyhan)	14,874	16,780	1.128
28	Beskonak	1,980	4,500	2.273
31	Oymapinar	715	3,622	5.066
32	Hasan Uglu	35,900	11,000	0.306
36	Goktas	8,290	3,900	0.470
37	Ceyhan berke	13,222	7,500	0.567
38	Adatepe	1,021	1,108.4	1.086
39	Laleli	4,760	4,273	0.898
40	Arkun	7,006	4,557	0.650
41	Dicle	3,216.4	5,554	1.727
42	Hakkari	4,763	4,630	0.972
43	Gezende B	3,158.5	4,385	0.720

$$Df = C A^{(A^{-0.05}-1)}$$

Where

- Df : Probable maximum flood ($m^3/s/km^2$)
- A : Catchment area (km^2)
- C : Coefficient

Fig. 6-21 Probable Maximum in Turkey