CHAPTER 5

ELECTRIC POWER DEVELOPMENT PLAN

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LIST OF FIGURES

LIST OF TABLES

CHAPTER 5 ELECTRIC POWER DEVELOPMENT PLAN

5.1 BASIC CONSIDERATIONS

This project has two comparative sites for dam construction, the Boyabat site upstream and the Kepez site downstream, and a comparison study must be made of the two. The Boyabat site will result in a total construction cost of 1.4 times compared with the Kepez site in case of NWL at 330 m. In addition, the effective head will be reduced 12.6 m and the effective capacity of the reservoir will be made smaller so that it is clear it will be economically disadvantageous.

In this chapter the plan for the Kepez site will be examined in detail, and the study of the plan for the Boyabat site described in Part IV.

On the downstream of the Kızılırmak River the Altınkaya-Derbent Hydroelectric Power Development Project planned to be executed ahead of the Kepez Hydroelectric Project is presently at the stage of preparation for construction, and it will be necessary to include effects on the former in the examination.

With regard to Altınkaya Power Station, the additional benefit of it with the optimum plan for Kepez Project will be computed and this will be considered as a benefit of the Kepez Hydroelectric Power Development Project. As for Derbent Power Station, since there will be little effect, as the effective head is small, this will be ignored. The description of the Altınkaya Project are indicated in Table III-5-1.

5.2 OPERATION PLAN OF RESERVOIR

Operation rules for Kepez Reservoir are to be established for each case taking the following points into consideration:

(1) Operation is to be done storing run-offs of wet years for supplementing in dry years to make the amount of firm discharge as large as possible.

(2) During a single year, operation is to be done storing the run-off of the wet season for supplementing in the dry season.

(3) Operation is to be done in a manner to minimize over-flow from the reservoir as less as possible.

(4) Operation is to be done in a manner making it possible for stable output to be secured over a long term ar d in a manner to make energy production large.

Calculations are to be made by computer using monthly average inflows. Variations in efficiencies of turbines and generators due to water level are to be taken into consideration and the maximum available discharge is to be held down to match maximum output when the water level is higher than the standard design water level.

Table III-5-1 Brief Description of Altınkaya Reservoir and Power Station

Item	Unit	Description
Reservoir		
High Water Level	m	192.0
Normal Design Water Level	m	190.0
Standard Design Water Level	m	180.5
Low Water Level	m	160.0
Available Depth	m	30.0
Reservoir Area	km^2	118.5 (EL. 190.0)
Gross Storage Capacity	$10^6 m^3$	5,763
Effective Storage Capacity	$10^6 m^3$	2,892
Dam		
Type		rockfill
Height x Crest Length	m	195 x 634
Slope		upstream 1:2.2
		downstream 1:1.9
Power Station		
Normal Tailwater Level	m	61.0
Normal Effective Head	m	116.0
Maximum Discharge	m^3/sec	688.0
Installed Capacity	MW	700

The procedure for calculating electric energy generated is indicated in Fig. III-5-1 while the reservoir operation rule is shown in Fig. III-5-2.

Further, the firm discharge is to be determined to maximize through 37 years on estimating evaporation losses from the present run-off mass curve at the Kepez dam site and deducting these losses. The mass curve of the present run-off at the Kepez dam site, that is, inflows to the Kepez Reservoir, is indicated in Fig. III-5-3.

Fig. III-5-1 Procedure of Calculation of Power and Energy

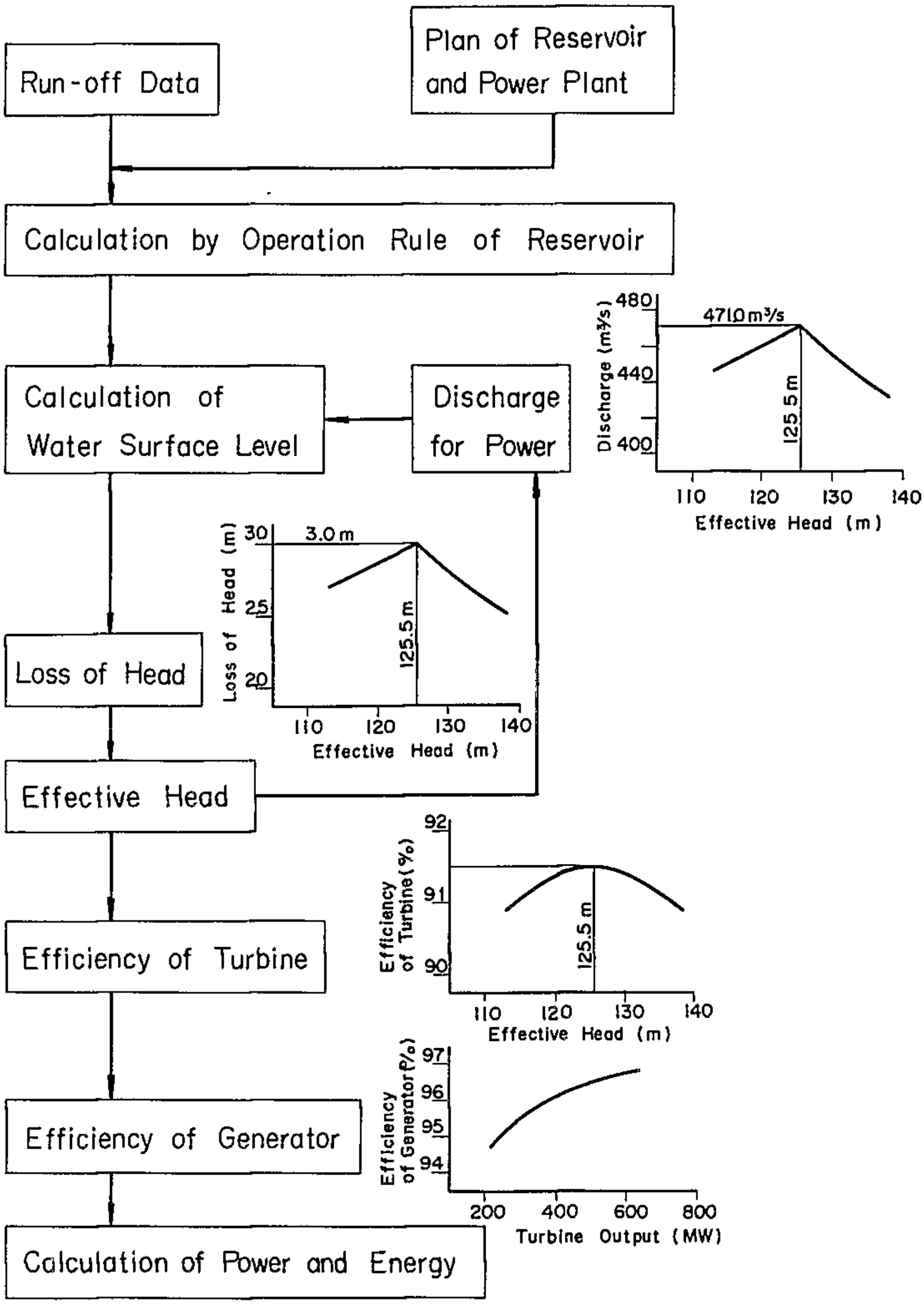
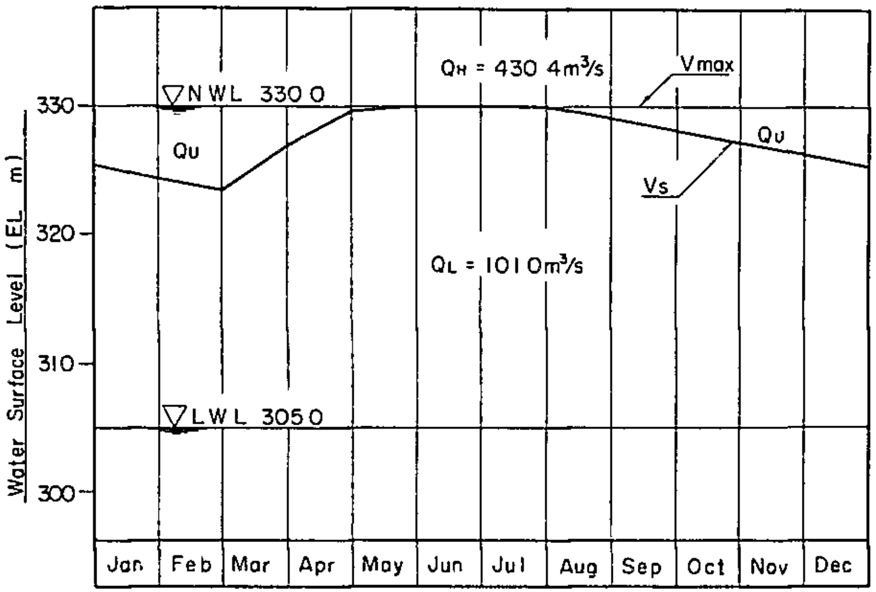


Fig.III-5-2 Operation Rule of Reservoir

Month	Vmax		Vs	
	m	10^6m^3	m	10^6m^3
Jan	330 0	1410	325 3	1109
Feb	330 0	1410	324 3	1049
Mar	330 0	1410	3234	994
Apr	330 0	1410	3269	1210
May	330 0	1410	3296	1382
Jun	330 0	1410	3300	1410
Jul	330 0	1410	3300	1410
Aug	330 0	1410	3300	1410
Sep	330 0	1410	329 1	1349
Oct	330 0	1410	328 2	1290
Nov	330 0	1410	327 2	1229
Dec	330 0	1410	326 3	1170



Symbols

V_{n-1}	Storage at the end of previous day
V_n	Storage at the end of current day
V_n'	Temporary storage in current day
V_{max}	Maximum storage
V_s	Standard storage
f_n	Overflow in current day
q_n	Inflow in current day
Q_n	Discharge for power in current day
Q_H	Maximum discharge at Normal Water Level
Q_U	Discharge for power
Q_L	Firm discharge for power
E	Evaporation, variable depending on Water Surface Area

Constants

Q_H = 430 4 m/s
Q_U , Variable depending on Effective Head
Q_L = 101 0 m/s

Operation Rule

$V_n' = V_{n-1} + q_n - E$

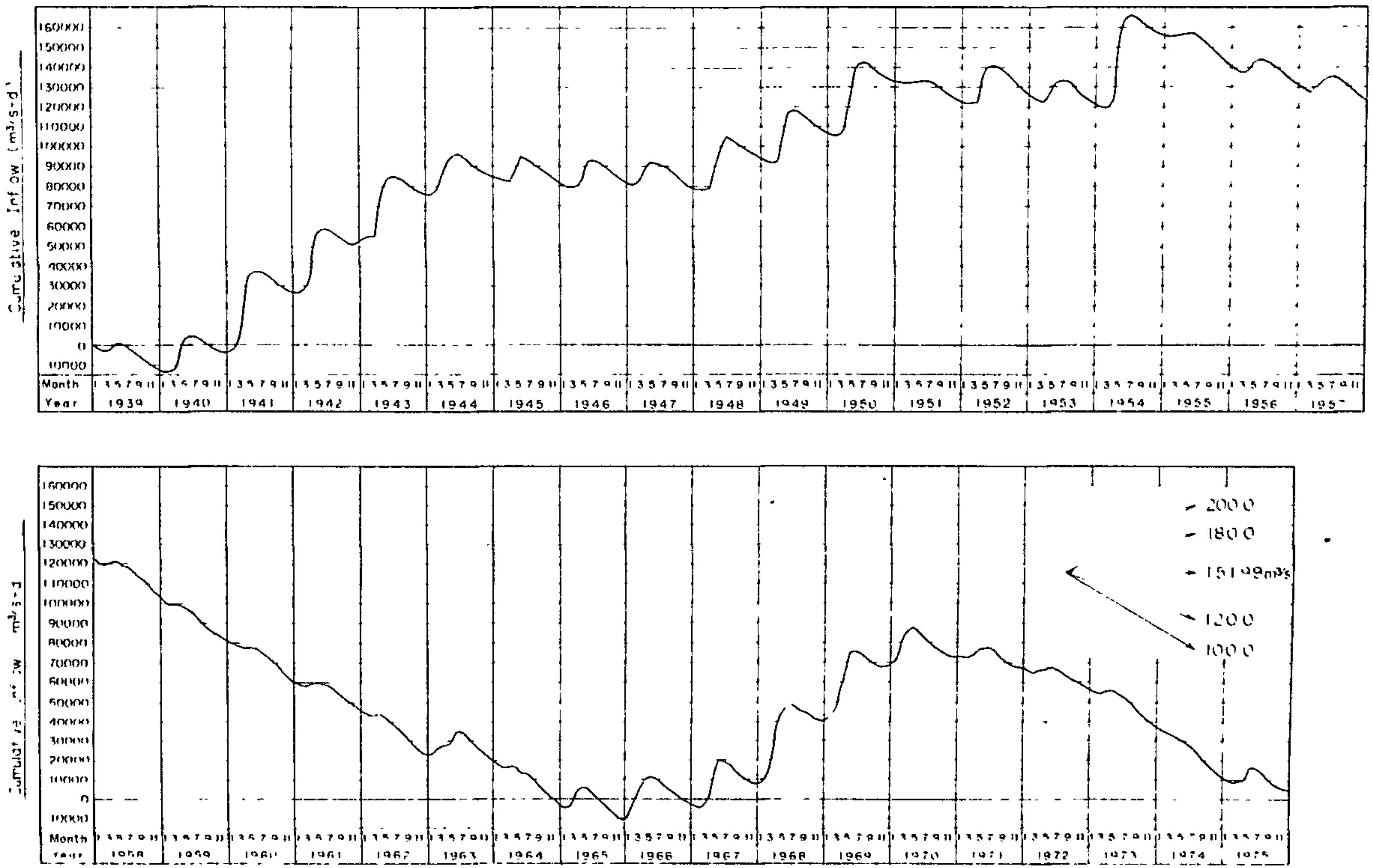
1. $V_n' \geqq V_{max}$
   - (1) $V_n' - V_{max} \geqq Q_H$ ——→ $Q_n = Q_H$
   - (2) $Q_H > V_n' - V_{max} \geqq Q_U$ ——→ $Q_n = V_n' - V_{max}$
   - (3) $Q_U > V_n' - V_{max}$ ——→ $Q_n = Q_U$
2. $V_{max} > V_n' \geqq V_s$
   - (1) $V_n' - V_s \geqq Q_U$ ——→ $Q_n = Q_U$
   - (2) $Q_U > V_n' - V_s \geqq Q_L$ ——→ $Q_n = V_n' - V_s$
   - (3) $Q_L > V_n' - V_s$ ——→ $Q_n = Q_L$
3. $V_s > V_n'$
   - (1) $V_n' \geqq Q_L$ ——→ $Q_n = Q_L$
   - (2) $Q_L > V_n'$ ——→ $Q_n = V_n'$

$V_n' - V_{max} - Q_n \geqq 0 0$ ——→ $f_n = V_n' - V_{max} - Q_n$

$V_n' - V_{max} - Q_n < 0 0$ ——→ $f_n = 0 0$

$V_n = V_n' - Q_n - f_n$

Fig III-5-3 Mass Curve at Kepez Dam Site



5.3 STUDY OF DEVELOPMENT SCALE

5.3.1 Study of Normal Water Level and Effective Storage Capacity of Reservoir

The seasonal and yearly variations in inflow to Kepez Reservoir are as indicated in the mass curve of Fig. III-5-3. This mass curve is prepared based on the present run-offs for the 37 years from 1939 to 1975 determined in Chapter 3.

As seen from the mass curve, seasonally, there is a trend generally for the first half of the year to have large inflow and the latter half to have small inflow. The average annual total inflow for the 37 years is 4,806 x 10^6 m^3 (152.3 m^3/sec) with the inflow from January through June 3,433 x 10^6 m^3 (219.2 m^3/sec) and that from July through December 1,373 x 10^6 m^3 (86.4 m^3/sec) so that the inflow in the former half of the year is approximately 2.5 times that in the latter half.

Looking at the annual inflows over the 37 years, fairly large fluctuations can be seen. The 14-year period from 1940 to 1954 is wet, the 10-year period from 1955 to 1965 is dry, the 4-year period from 1966 to 1970 is wet, and since then it has been dry so that there is a multiple-year periodic fluctuation seen. The driest year in the 37-year period is 1962 with 2,817 x $10^6 m^3$ (89.3 m^3/sec), while the wettest year is 1954 with 7,853 x $10^6 m^3$ (249.0 m^3/sec).

In order to adjust the seasonal and yearly fluctuations in inflow and develop the water resources in the most effective manner it is necessary to secure a storage capacity making it possible to effectively regulate the inflow to the reservoir, supplementing water not only in dry seasons, but also dry years aiming for long-term stabilization of generating output. Reservoir normal water level and effective storage capacity must further be such that there will be the greatest merit in the economics of power generation.

In contemplating the normal water level, comparison studies are to be made of 4 cases between the elevations of 310 m and 340 m, in effect, 310 m, 320 m, 330 m and 340 m, taking such factors as submergence compensation costs, sedimentation, dam height and effective storage capacity into consideration.

Regarding the effective capacity of the reservoir, the cases below are selected in a range of 300 x 10^6 m^3 to 2,200 x 10^6 m^3 for the various normal water levels above and comparison studies made of energy costs per 1 kwh and benefit-cost ratios. The reservoir capacity and area curves are shown in Fig. III-5-4.

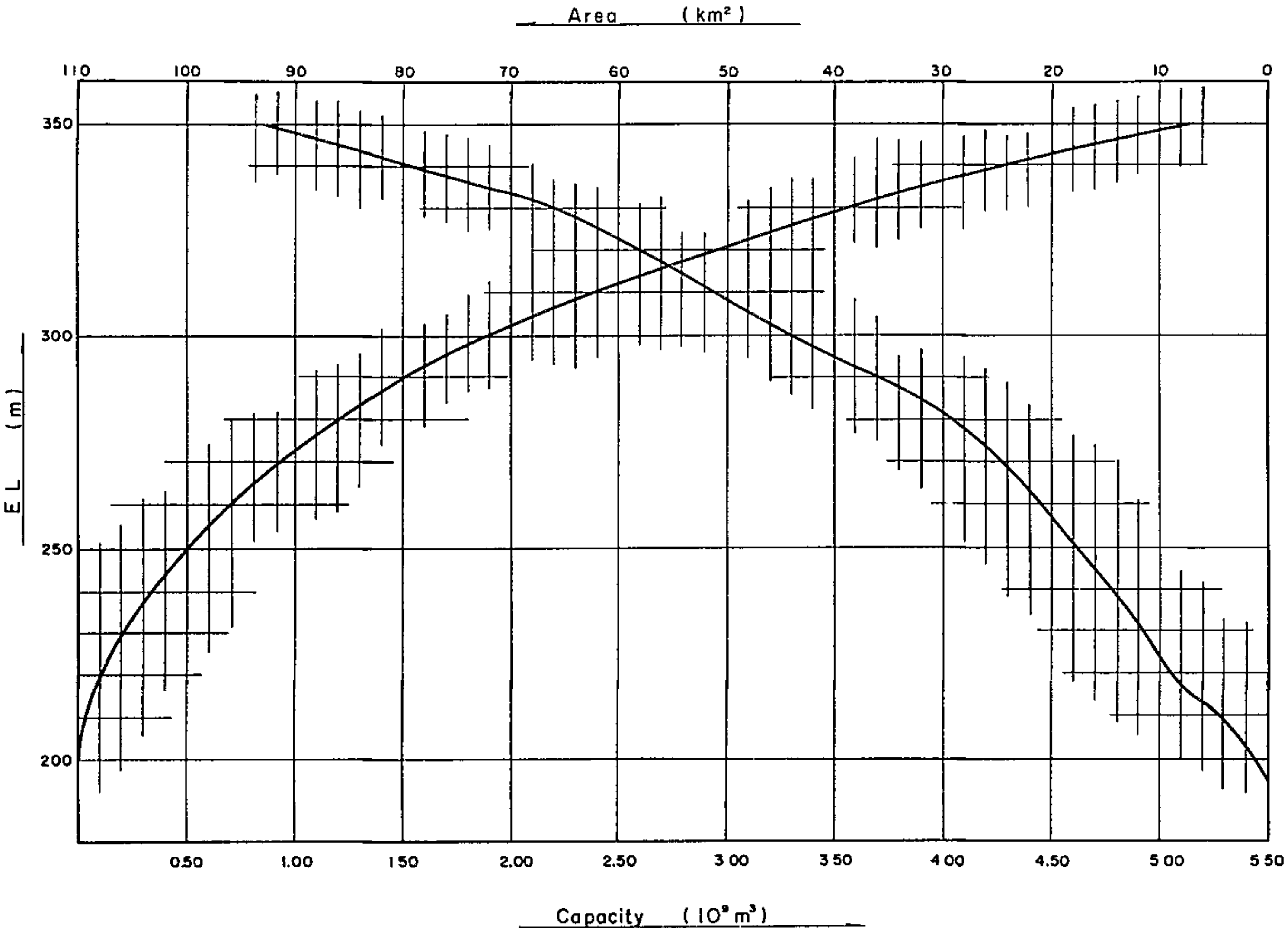
	Normal Water Level (m)	Effective Storage Capacity (10^6 m^3)			
Case 1	340	2,200,	1,800,	1,410,	1,150
Case 2	330	1,640,	1,410,	1,150,	1,000
Case 3	320	1,000,	800	600,	400
Case 4	310	500,	400,	300	

The conditions for calculations are as described next.

The results of studies according to the above are indicated in Table III-5-2 and Fig. III-5-5.

Seen from these study results, the case of normal water level of the reservoir at 330.0 m and effective storage capacity of 1,410 x 10^6 m^3 is the most economical, and may be said to be the optimum scale. Accordingly, it is decided that the normal water level is to be at an elevation of 330.0 m, with available depth of 25.0 m and effective storage capacity of 1,410 x 10^6 m^3.

Fig. III-5-4 Kepez Reservoir Capacity and Area Curve



E.L. (m)	Capacity ($10^6 m^3$)	Area (km^2)
194	–	0
200	4	1.5
210	36	4 7
220	104	9 0
230	208	11 6
240	339	14 6
250	500	17 7
260	694	21 1
270	922	24.4
280	1 190	29 2
290	1 517	36.3
300	1 918	43 8
310	2.393	51 2
320	2.940	58.2
330	3 557	65 4
340	4 277	78.6
350	5 137	93.4

Fig. III-5-5 Study on Optimum Normal Water Level and Effective Storage Capacity of Reservoir

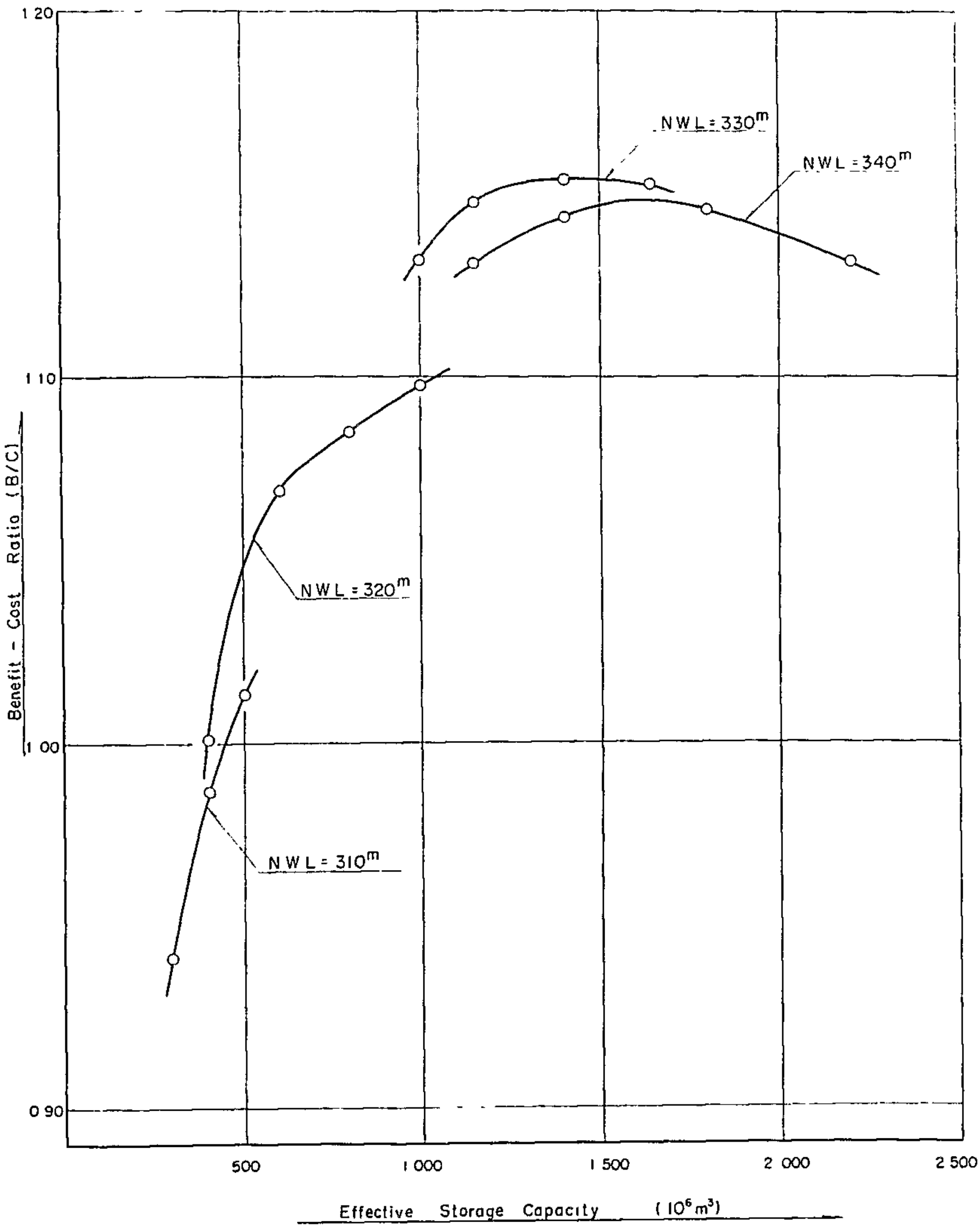


Table III-5-2 Study on Optimum Normal Water Level and Effective Storage Capacity of Reservoir

Case	N.W.L. (m)	Storage Capacity (10^6 m^3) Gross	Effective	Firm Discharge (m^3/s)	Max. Discharge (m^3/s)	Effective Head (m)	Installed Capacity (MW)	Firm Peak Power (MW)	Annual Energy Production (10^6kwh) Firm	Secondory	Total	Construction Cost (10^6 TL)	Annual Cost (10^6 TL)	Cost of Energy (TL/kwh)	Benefit-Cost Ratio
1			2200	106.0	495.0	129.8	555	461	1010	558	1568			1.142	1.132
2	340	4277	1800	103.0	480.0	133.9	"	468	1026	554	1580	15562	1790	1.133	1.146
3			1410	101.0	486.0	137.4	"	465	1019	567	1586			1.129	1.144
4			1150	97.0	460.0	139.5	"	456	999	593	1592			1.124	1.131
5			1640	103.0	480.0	123.0	510	424	928	531	1459			1.133	1.153
6	330	3557	1410	101.0	471.0	125.5	"	422	925	543	1468	14124	1624	1.106	1.154
7			1150	97.0	462.0	128.0	"	417	914	561	1475			1.101	1.148
8			1000	95.0	444.0	129.3	495	408	894	579	1473			1.103	1.132
9			1000	95.0	441.0	118.0	450	377	826	531	1357			1.139	1.098
10	320	2940	800	90.0	420.0	120.3	435	369	810	546	1356	13435	1545	1.139	1.085
11			600	86.0	396.0	122.4	420	361	791	558	1349			1.145	1.069
12			400	76.0	350.0	124.1	375	326	714	612	1326			1.165	1.001
13			500	80.0	369.0	112.8	360	310	680	548	1228			1.169	1.013
14	310	2393	400	76.0	351.0	113.6	345	298	653	566	1219	12486	1436	1.178	0.987
15			500	70.0	333.0	114.6	330	274	601	607	1208			1.189	0.941

5.3.2 Study of Maximum Available Discharge

The maximum available discharge and installed capacity of Kepez Power Station must be selected to be the most economical under operating conditions taking account of the demand and supply plan. As stated earlier in this chapter, it is considered that Kepez Power Station should carry the peak portion of load and the peak duration is selected to be 6 hours from the daily load curve.

If the installed capacity is made larger it would be excessive compared with firm peak output and output would become latent to impair the economic effect, while when installed capacity is made smaller, the firm peak output would be determined by the critical output and there will be a tendency for the peak duration to become long.

It is necessary for the installed capacity to be decided upon thoroughgoing studies including those of the site characteristics. Therefore, comparison studies are to be made for 4 cases between 390 MW and 570 MW, namely, 390 MW, 450 MW, 510 MW and 570 MW. The construction costs per kW of installed capacity, the energy costs per kWh and the benefit-cost ratios of the various alternatives are indicated in Table III-5-3 and Fig. III-5-6.

According to these, the construction cost per kW is decreased linearly as installed capacity is increased, but the energy cost per kWh is not decreased very much when installed capacity is smaller than about 500 MW. The benefit-cost ratio is highest when the installed capacity is 510 MW.

Based on the above results, the maximum discharge and installed capacity of Kepez Power Station are to be 471.0 m^3/sec and 510 MW, respectively.

The available discharges, evaporation quantities, and overflow quantities when operating Kepez Reservoir during the 37-year period from 1939 to 1975 are shown in Table III-5-4. The water storage, water supply and reservoir surface water level by month are indicated in Fig. III-5-7.

The amounts of electric energy generated at Kepez Power Station through the above reservoir operation are indicated in Table III-5-5 and Fig. III-5-8.

Fig. III-5-6 Study on Optimum Maximum Discharge and Installed Capacity

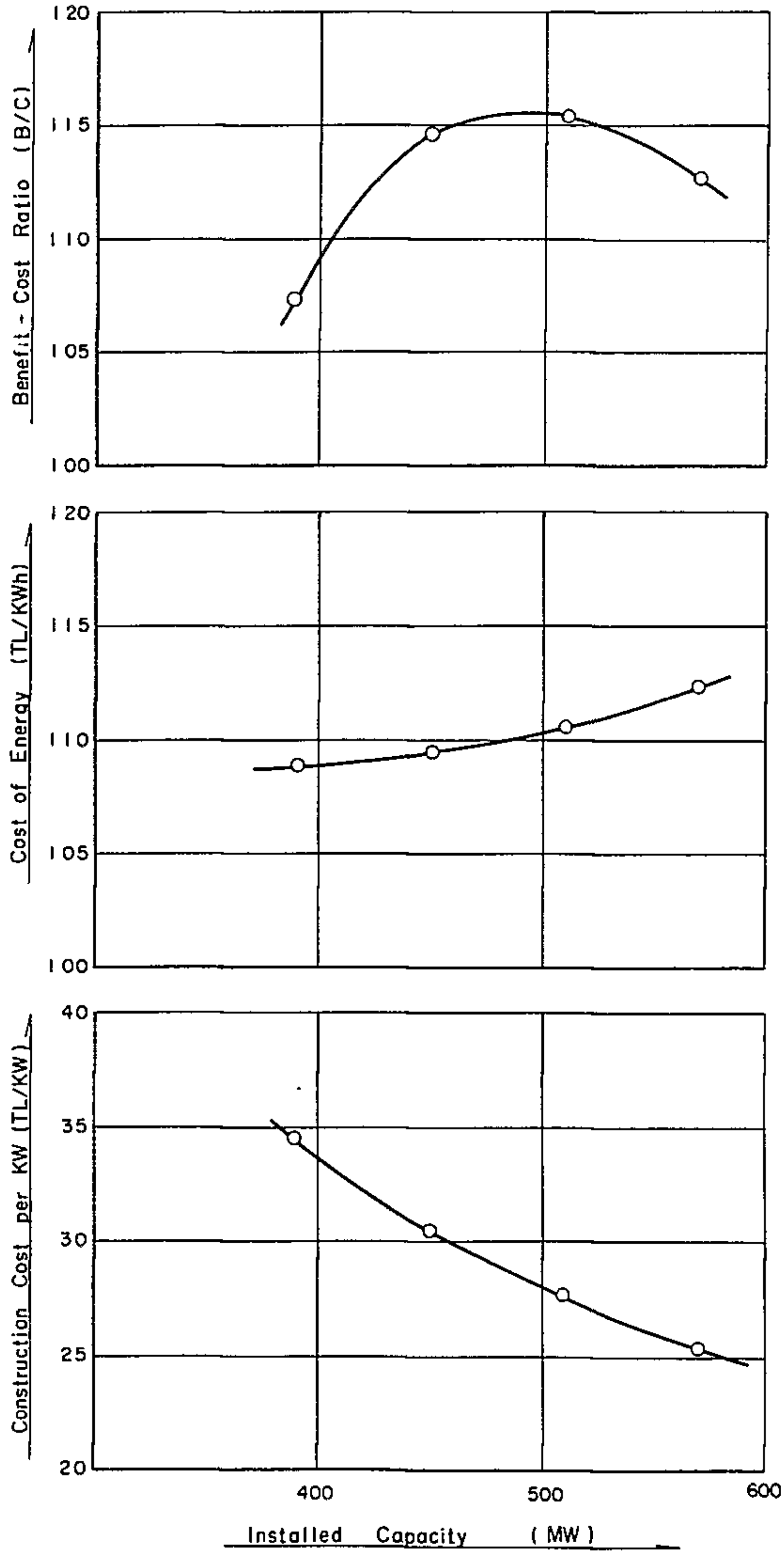


Table III-5-3 Study on Optimum Maximum Discharge and Installed Capacity

Case	N.W.L. (m)	L.W.L. (m)	Effective Storage Capacity (10^6 m^3)	Firm Discharge (m^3/s)	Max. Discharge (m^3/s)	Installed Capacity (MW)	Firm Peak Power (MW)	Annual Energy Production (10^6 kwh)			Plant Factor (%)	Costruction Cost		Annual Cost (10^6TL)	Cost of Energy (TL/kwh)	Benefit-Cost Ratio
								Firm	Secondary	Total		(10^6TL)	(10^3TL/kw)			
1					528.0	570	420.4	921	562	1483	29.7	14482	25.41	1665	1.123	1.127
2	330	305	1410	101.0	471.0	510	422.4	925	543	1468	32.8	14124	27.69	1624	1.106	1.154
3					414.0	450	404.8	927	519	1446	36.6	13756	30.57	1582	1.094	1.148
4					357.0	390	351.0	932	489	1421	41.6	13463	34.52	1548	1.089	1.074

Table III-5-4 Summary Operation Study of Kepez Reservoir

Year	Inflow (10^6 m^3)	Evaporation (10^6 m^3)	Outflow for Energy (10^6 m^3)	Outflow from Spillway (10^6 m^3)
1939	3663.4	40.8	3565.6	0.0
1940	5548.0	41.2	5429.1	61.6
1941	7479.9	41.2	6735.8	702.9
1942	7061.7	41.1	6397.3	623.3
1943	6741.4	41.2	5860.9	839.4
1944	5651.2	41.1	5610.1	0.0
1945	4481.0	40.8	4440.2	0.0
1946	4789.2	41.0	4748.2	0.0
1947	4575.2	41.0	4534.2	0.0
1948	6097.0	41.1	5703.0	353.0
1949	5949.0	41.0	5365.0	543.0
1950	7005.4	41.2	5971.7	992.5
1951	3933.1	41.1	3892.0	0.0
1952	5112.2	40.8	4857.8	357.1
1953	4306.2	40.8	4175.3	0.0
1954	7853.2	41.2	5821.1	1937.5
1955	3412.5	40.5	3606.8	0.0
1956	3978.8	40.9	3703.1	0.0
1957	4080.7	41.0	4151.6	0.0
1958	3106.3	40.6	3250.9	0.0
1959	2893.6	37.1	3185.1	0.0
1960	3018.6	36.4	3193.9	0.0
1961	3494.5	37.0	3185.1	0.0
1962	2816.9	35.1	3185.1	0.0
1963	4527.8	40.1	3812.7	0.0
1964	2827.8	37.6	3193.9	0.0
1965	4047.6	40.3	3571.8	0.0
1966	5590.4	40.6	5367.5	0.0
1967	5693.7	40.8	5429.3	144.4
1968	7680.9	41.2	7141.1	498.6
1969	7199.5	41.0	7147.5	11.0
1970	5167.4	40.2	5127.2	0.0
1971	4323.8	40.6	4283.1	0.0
1972	3860.5	41.1	3819.4	0.0
1973	3219.2	40.3	3406.9	0.0
1974	2445.8	35.7	3185.1	0.0
1975	4173.2	38.8	3185.1	0.0
Average	4805.6	40.1	4574.0	190.9

Fig. III-5-7 Reservoir Operation (1)

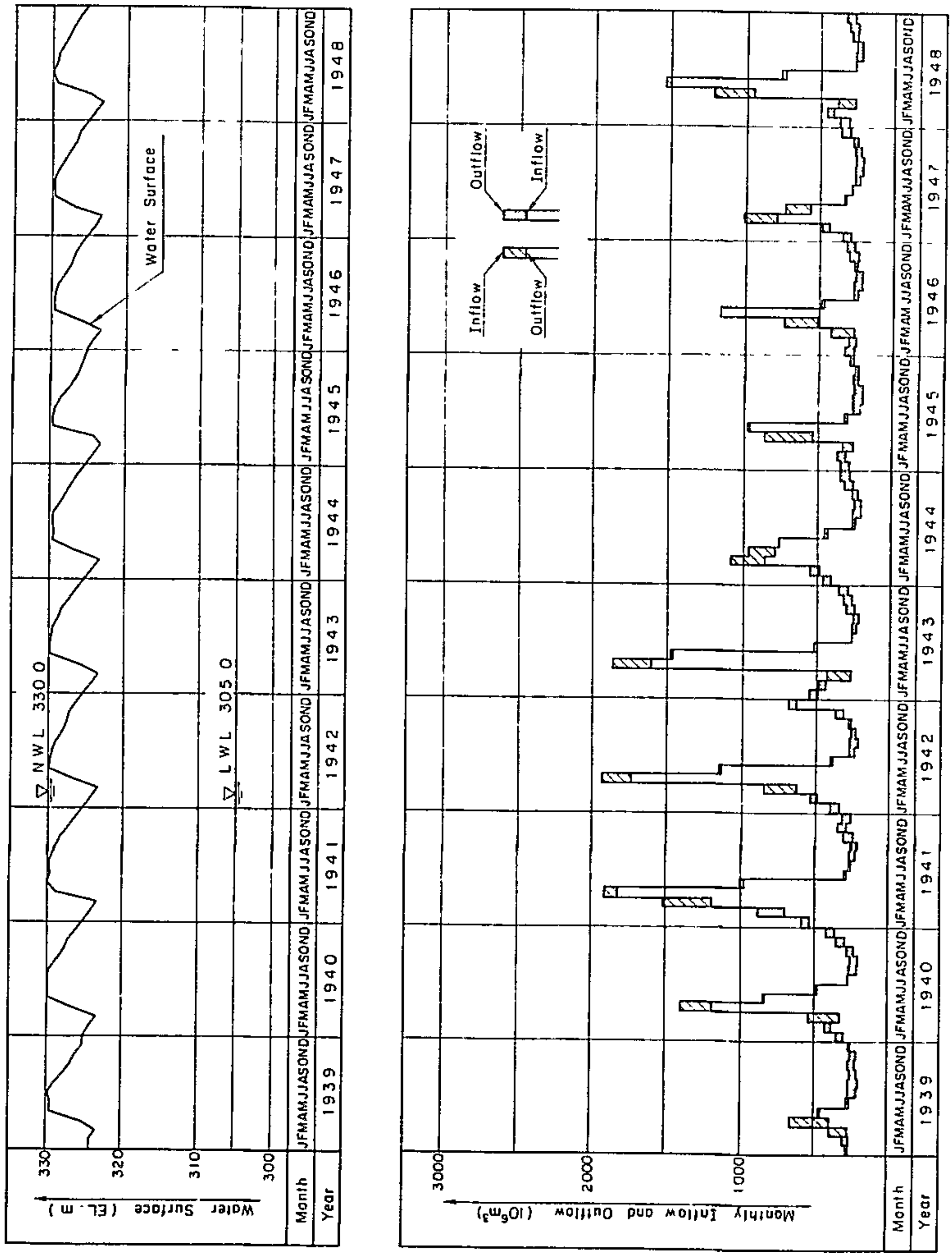


Fig. III-5-7 Reservoir Operation (2)

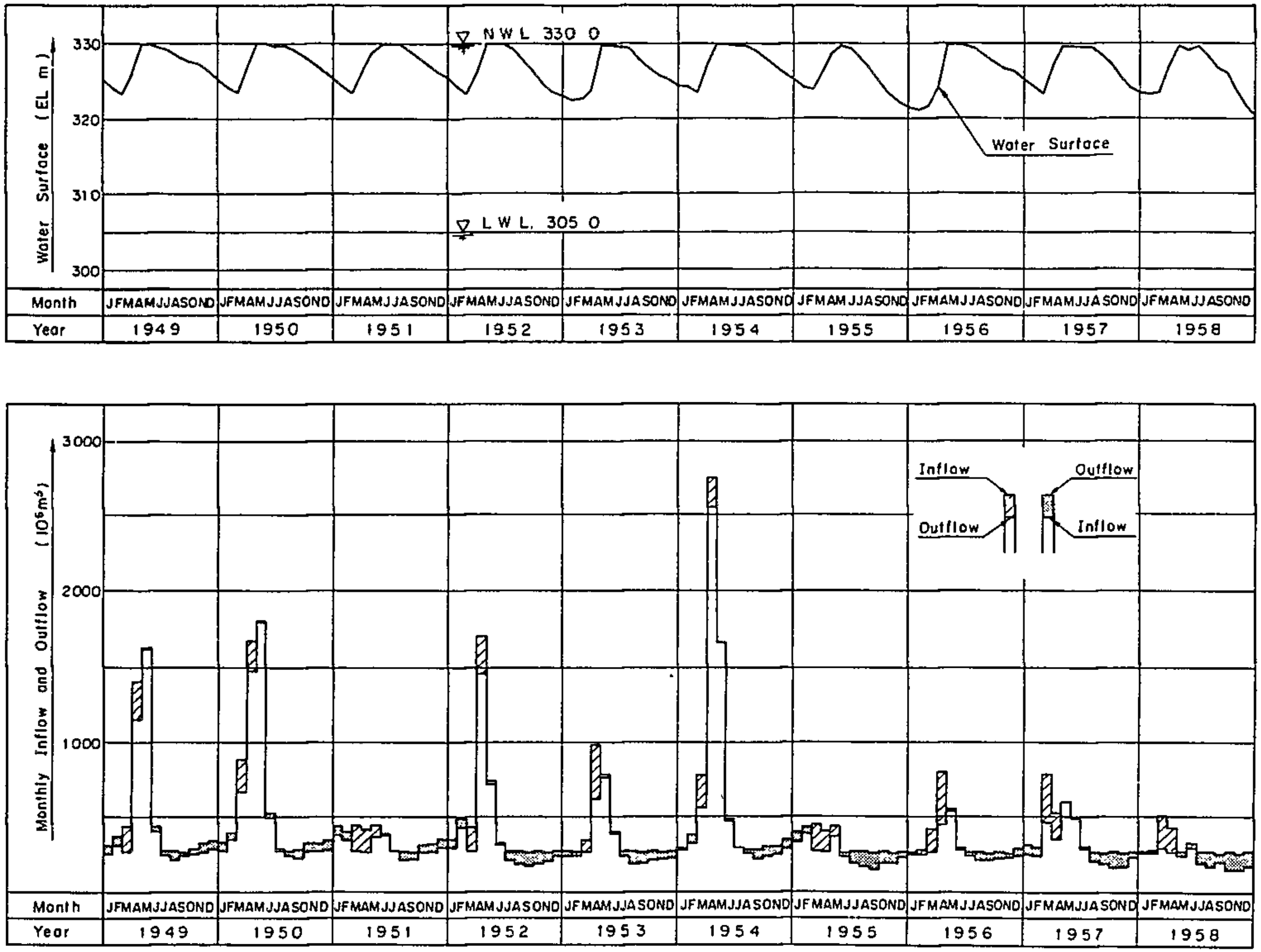


Fig. III-5-7 Reservoir Operation (3)

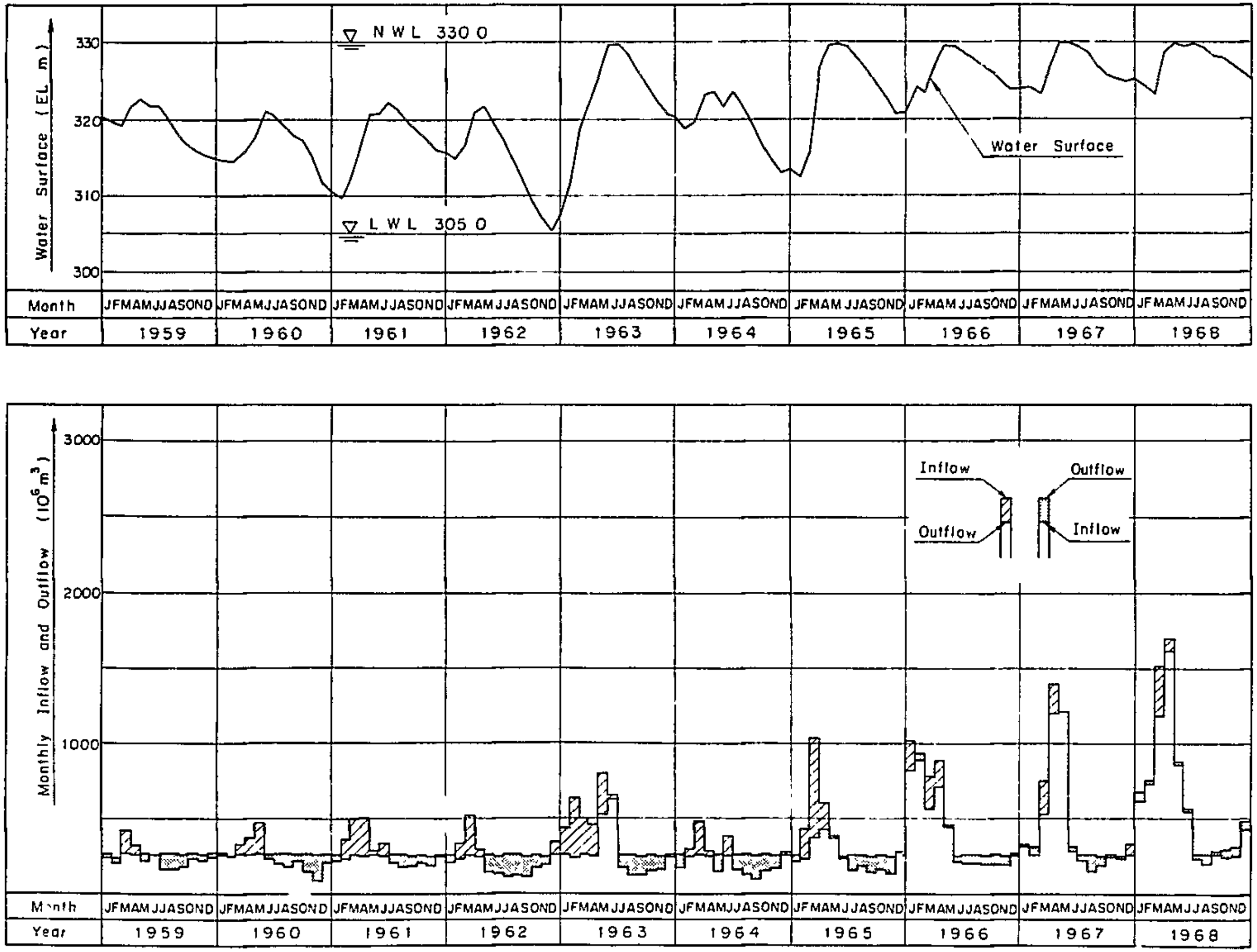


Fig. III-5-7 Reservoir Operation (4)

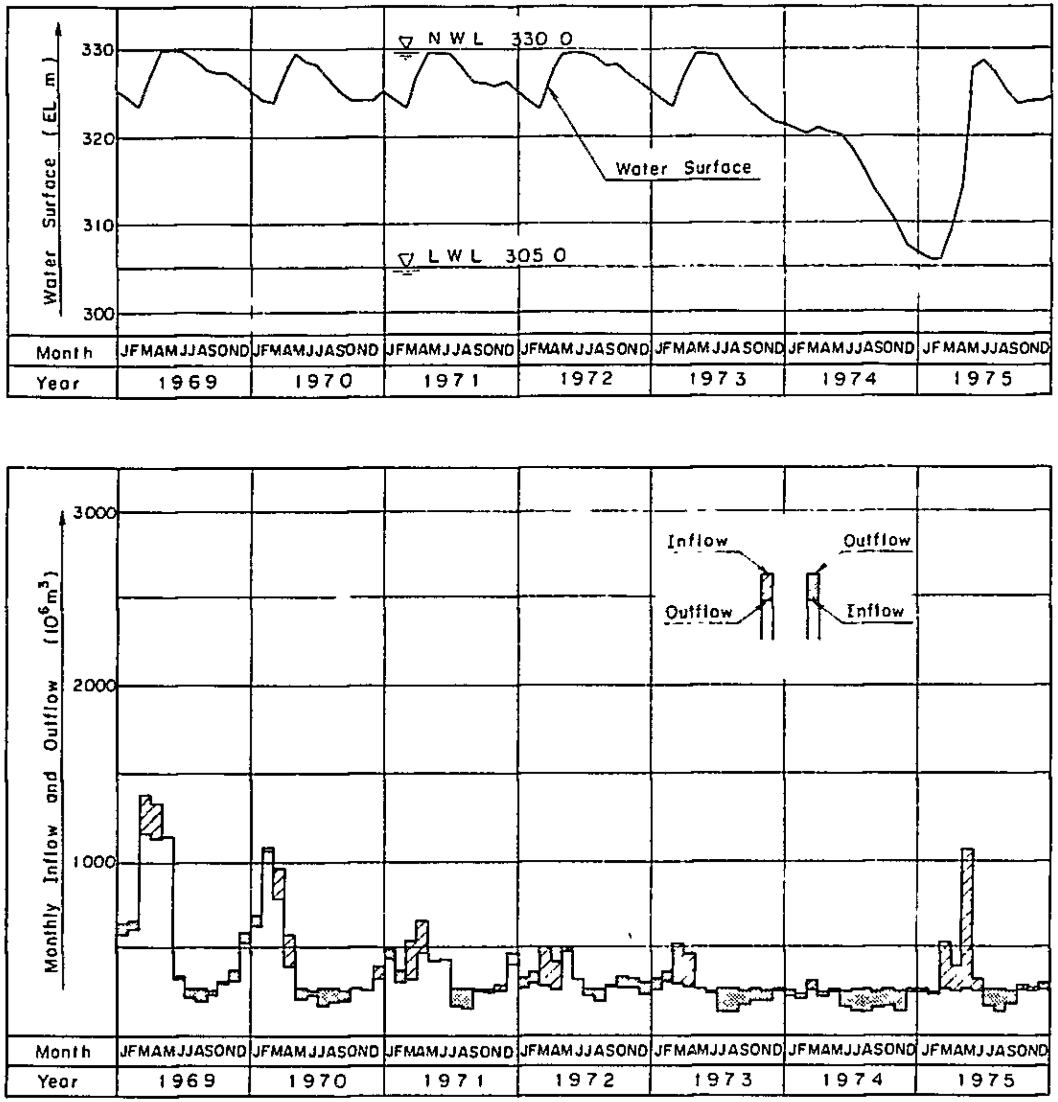


Table III-5-5 Energy Production at Kepez P.S.

Unit : GWh

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1939	86.0	96.6	86.2	127.1	153.0	86.4	89.1	88.5	85.1	87.4	84.1	86.6	1156.0
1940	111.6	137.9	104.3	367.2	281.0	161.3	89.3	89.0	85.7	89.6	113.7	135.3	1765.8
1941	189.0	240.7	379.4	367.2	330.6	95.8	89.2	89.0	86.7	101.2	112.7	103.9	2185.4
1942	127.3	172.8	203.2	367.2	379.4	133.2	89.1	88.7	85.4	91.4	120.5	221.0	2079.1
1943	175.4	155.6	86.3	357.8	379.4	170.6	89.3	89.0	86.4	99.7	104.6	114.2	1908.4
1944	151.2	174.4	276.7	257.8	251.7	142.6	89.3	88.9	85.6	88.0	102.7	111.3	1820.2
1945	110.7	116.3	85.9	176.4	318.8	105.1	88.9	88.4	85.0	87.4	84.3	94.1	1441.4
1946	104.4	98.3	86.3	166.0	379.4	161.3	89.1	88.7	85.4	87.9	95.6	102.9	1545.3
1947	111.3	156.6	254.0	186.1	107.4	95.8	89.2	88.8	85.4	87.8	90.2	116.4	1468.9
1948	118.9	147.2	86.1	309.7	379.4	254.9	89.1	88.8	85.6	93.5	98.8	105.1	1857.0
1949	100.1	116.3	86.4	353.1	379.4	142.6	89.0	88.6	85.4	90.5	104.7	110.4	1746.6
1950	104.5	124.8	211.1	367.2	379.4	170.6	89.2	90.1	92.3	104.0	103.4	108.2	1944.9
1951	140.2	126.6	86.4	85.1	117.6	123.8	89.4	89.1	85.8	101.8	104.2	113.1	1263.1
1952	110.9	155.0	86.3	357.3	242.4	105.1	89.1	88.4	84.7	86.7	83.1	85.4	1574.4
1953	85.1	76.8	85.5	201.8	251.0	133.2	89.1	88.6	85.1	87.3	84.0	86.4	1354.0
1954	91.0	120.4	180.1	367.2	379.4	161.3	98.6	93.4	92.9	99.3	100.6	113.4	1897.6
1955	126.7	140.6	86.5	85.2	121.1	86.3	88.7	87.9	84.1	85.9	82.3	84.5	1159.6
1956	84.2	78.8	85.2	147.6	177.2	95.7	89.2	88.7	85.4	87.7	84.6	94.6	1198.8
1957	98.6	94.9	150.1	116.0	196.3	161.3	98.7	88.9	85.5	87.4	83.7	85.8	1347.2
1958	85.5	81.8	94.0	85.6	89.1	95.7	88.9	88.1	84.6	86.5	82.6	84.1	1046.7
1959	83.4	75.0	83.6	82.0	84.8	81.8	83.9	82.7	78.9	80.8	77.8	79.9	974.5
1960	79.7	74.5	80.0	78.4	82.8	81.1	83.3	82.4	79.1	80.7	76.3	77.4	955.8
1961	76.7	69.7	79.4	79.6	83.7	81.6	84.4	83.6	80.1	82.0	78.5	80.6	959.9
1962	80.2	72.7	82.5	81.5	83.8	79.7	80.8	79.0	74.6	75.5	72.0	74.5	936.8
1963	76.4	72.2	83.5	83.0	172.9	208.1	89.0	88.0	83.9	85.5	81.7	83.8	1207.9
1964	83.1	77.5	84.3	82.8	85.1	82.3	85.2	83.8	79.5	80.5	76.7	78.8	979.5
1965	78.5	71.7	120.7	139.8	125.4	86.4	88.6	87.7	84.0	85.7	81.8	83.9	1134.4
1966	260.4	299.1	181.5	233.7	151.3	86.1	88.6	88.0	84.7	86.9	83.4	85.9	1729.5
1967	100.9	101.2	170.2	367.2	379.4	105.1	89.0	88.3	84.6	86.9	83.9	106.2	1762.9
1968	215.9	248.4	379.4	367.2	290.9	180.0	89.3	88.8	93.3	101.4	104.1	157.8	2316.4
1969	205.1	207.8	373.5	367.2	379.4	114.5	89.1	88.5	85.2	98.8	119.2	187.1	2315.6
1970	218.1	342.7	249.7	127.0	89.0	85.7	87.9	87.1	83.6	86.1	83.3	103.8	1643.9
1971	156.7	113.5	102.0	154.8	137.9	142.6	88.8	87.8	84.4	87.1	84.3	146.8	1386.8
1972	106.3	113.2	91.3	85.5	156.7	105.1	89.2	86.7	91.8	109.6	108.0	95.5	1240.9
1973	104.4	114.6	94.9	93.1	89.2	86.3	88.5	87.3	83.5	85.5	82.0	84.4	1093.6
1974	84.1	75.7	83.8	81.2	83.6	80.3	81.8	80.2	76.2	77.4	73.4	74.8	952.5
1975	74.5	67.1	76.1	76.2	34.1	85.6	88.3	87.2	83.4	85.8	83.1	86.0	977.5
Average	118.8	130.0	141.0	200.8	212.2	120.4	88.6	87.5	84.7	89.4	91.1	103.9	1468.4

Fig. III-5-8 Energy Production (1)

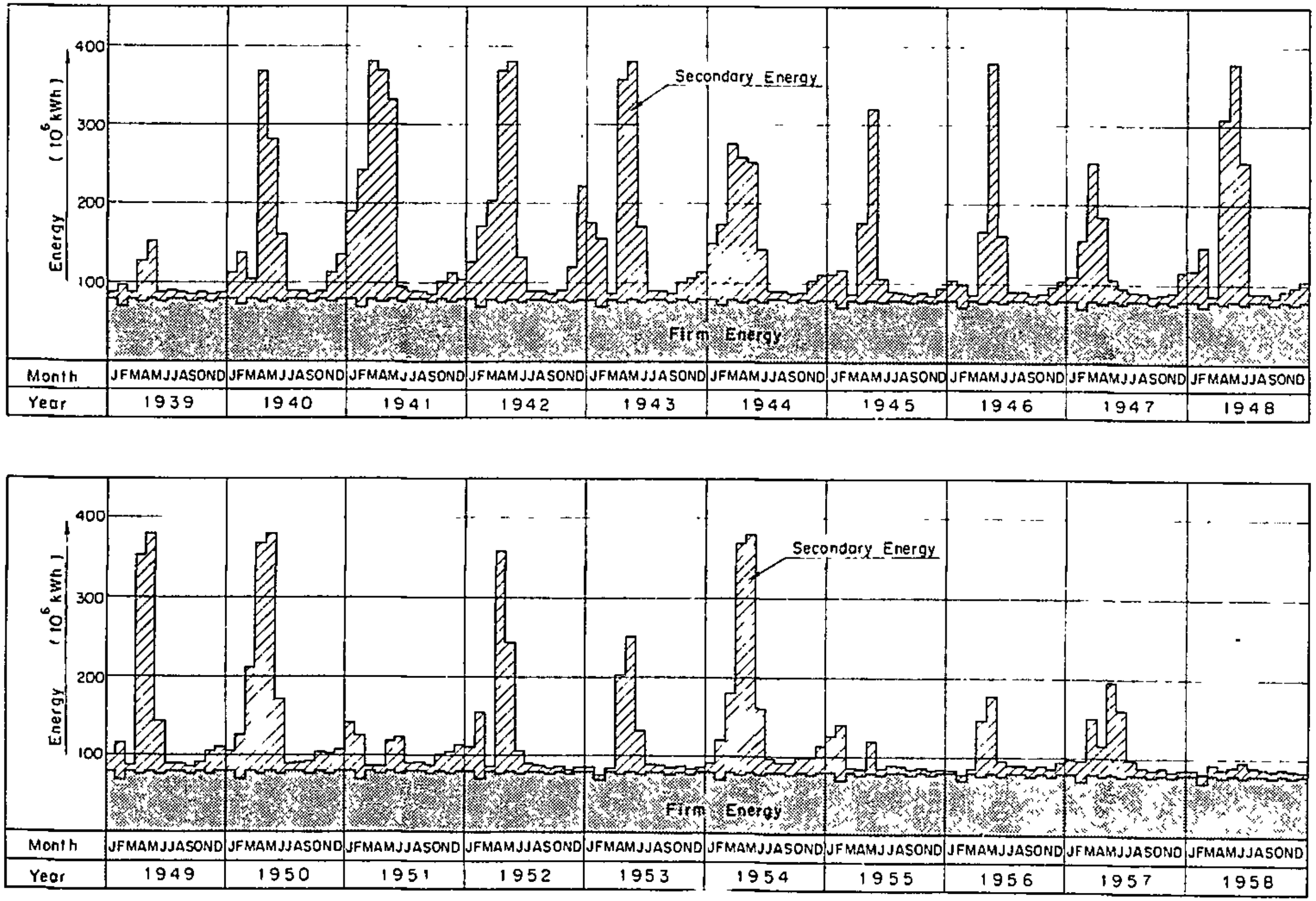
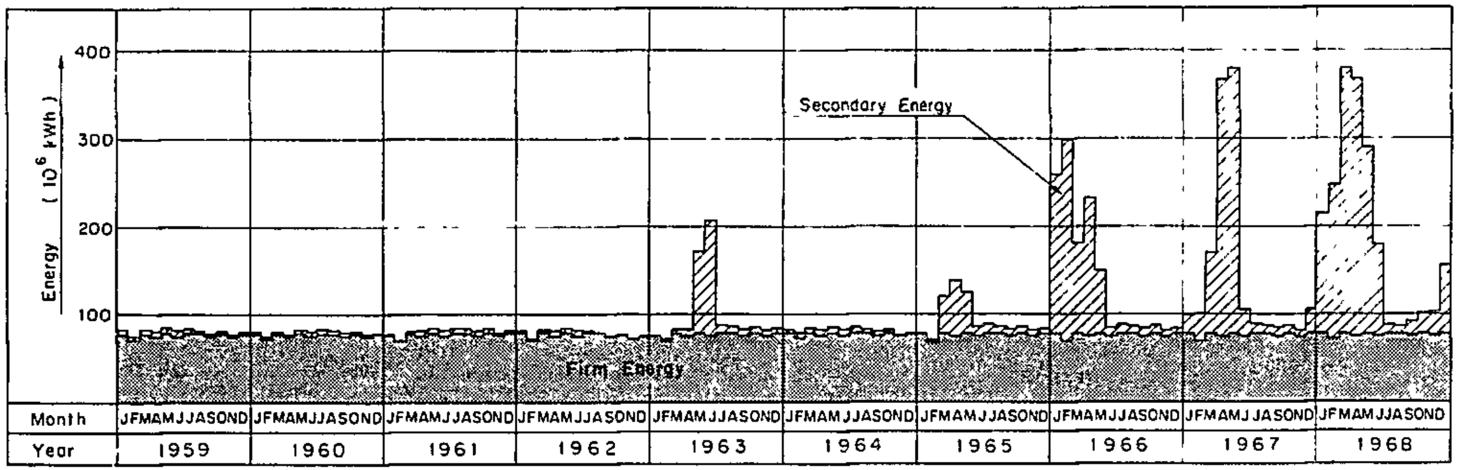
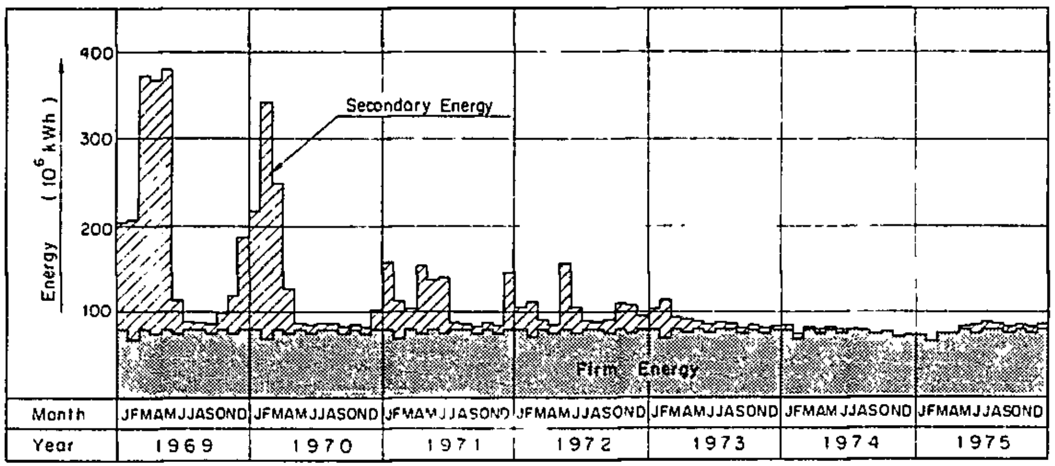


Fig. III-5-8 Energy Production (2)





5.4 ADDITIONAL MERIT AT ALTINKAYA POWER STATION

Through provision of Kepez Reservoir, the run-off duration of the Kızılırmak River will be improved, and therefore, the benefit at Altınkaya Power Station is expected to be increased compared with before construction of the Kepez Project. This benefit should be evaluated as a part of the benefit of the Kepez Project.

The run-off at the Altınkaya dam site after construction of the Kepez Project is indicated in Table III-5-6. Further, the degree to which the run-off duration at the Altınkaya dam site will be improved compared with the present run-off is shown in Fig. III-5-9.

With regard to Altınkaya Reservoir also, operation rules are to be set up similarly to Kepez Reservoir so that firm discharge can be made large based on the general discription given in Table III-5-1. As for the operation rules, they are set up as expediences to calculate the variations in electric energy at Altınkaya Power Station and are different from the operation rules in the Altınkaya Feasibility Report. Energy productions for the 37-year period from 1939 to 1975 setting up respectively operation rules for the run-off at Altınkaya dam site were calculated.

The overflow from Altınkaya Reservoir under present conditions is 29.2 x 10^6 m^3 annually while the evaporation from Kepez Reservoir will be 40.1 x 10^6 m^3. Consequently, through operation of Kepez Reservoir, the run-off duration of the Kızılırmak River will be improved, and even if overflow from Altınkaya Reservoir is completely eliminated, there will be a decrease in available discharge at Altınkaya Power Station of 10.9 x 10^6 m^3 annually so that increase in electric energy cannot be looked forward to.

According to the results of calculations by computer, the energy production are not increased, because the decrease of the energy due to the reduction in available discharge offset by the increase due to higher water level operation of Altınkaya Reservoir according to the improvement of run-off duration. But since the firm available discharge is increased from 132 m^3/sec to 139 m^3/sec, the effective output will be increased by 25 MW and the annual benefit increased by 700,000 TL.

Recalculating the economic evaluation of the Kepez Project according to the above and expressing in terms of benefit-cost ratio, the result will be 1.197.

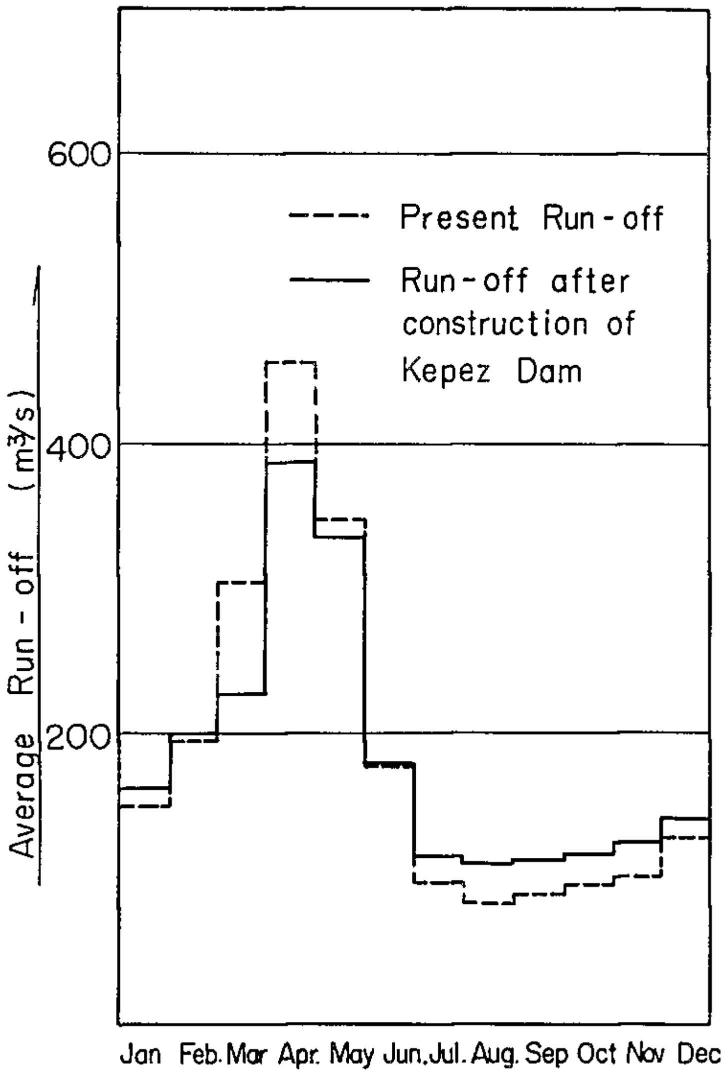
Table III-5-6 Monthly Run-off at Altınkaya Dam Site after Construction of Kepez Dam

($10^6 m^3$)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1939	328.96	359.11	369.08	582.99	589.10	323.14	307.32	304.37	296.84	311.61	299.71	321.01	4393.25
1940	417.43	531.89	477.32	1588.37	1023.19	598.10	328.21	308.58	296.65	319.27	416.59	500.65	6806.25
1941	683.56	881.74	1547.76	2200.49	1197.66	360.09	324.22	314.60	306.20	360.20	412.23	376.42	8965.18
1942	465.51	629.73	845.62	2163.30	1376.30	493.66	315.41	307.75	305.05	334.44	444.92	809.84	8491.53
1943	633.50	566.18	382.77	2039.82	1756.63	628.16	325.00	313.77	305.06	353.85	378.54	419.44	8102.72
1944	546.78	636.14	1115.74	1021.42	931.05	536.06	323.18	307.32	298.83	314.26	371.96	407.47	6810.21
1945	407.93	421.58	349.34	795.88	1176.25	389.96	310.80	305.87	296.29	315.57	307.93	347.38	5124.79
1946	381.36	364.47	381.78	730.69	1404.50	595.25	319.96	308.20	300.59	319.29	343.69	372.22	5822.01
1947	410.61	574.38	1032.38	763.10	407.90	356.49	315.14	308.10	299.71	310.61	329.82	429.63	5537.27
1948	442.59	552.68	364.61	1266.89	1805.44	928.05	324.86	310.86	302.38	336.45	354.15	381.38	7370.33
1949	363.39	424.75	385.31	1499.05	1934.50	524.32	317.98	309.36	306.45	329.63	378.95	403.53	7176.62
1950	379.73	451.80	874.73	1842.88	2134.36	624.07	331.37	321.15	323.75	371.66	373.30	394.32	8423.12
1951	504.27	458.55	386.89	368.22	474.88	473.52	329.20	307.80	300.00	364.18	376.64	414.99	4759.16
1952	408.73	589.87	382.80	1850.31	883.22	396.29	307.56	297.14	284.11	296.66	294.13	315.60	6306.70
1953	316.80	299.52	351.27	924.50	947.25	496.69	319.35	299.98	293.44	306.44	301.68	295.67	5152.59
1954	312.71	432.03	790.47	2815.02	1864.92	611.90	333.56	303.53	307.55	327.84	334.55	381.38	8815.46
1955	428.82	477.30	317.47	348.68	408.30	285.98	284.66	293.47	312.44	296.20	288.67	310.53	4052.52
1956	313.24	349.53	419.49	684.62	663.35	377.09	296.95	280.16	273.79	285.25	281.26	311.66	4536.39
1957	325.49	329.63	540.20	406.24	773.79	566.95	323.84	285.36	292.22	295.24	288.88	310.48	4738.32
1958	313.37	321.28	465.88	536.86	392.39	442.60	302.36	295.51	298.37	293.87	285.30	300.30	4218.08
1959	308.93	276.49	489.53	517.16	429.21	451.94	303.03	308.95	290.93	298.21	293.52	306.28	4274.18
1960	305.02	303.00	341.55	481.70	373.96	333.64	296.45	288.95	282.58	293.85	276.54	308.79	3886.02
1961	309.84	312.95	374.47	407.33	333.97	334.60	304.32	294.36	289.34	292.24	283.07	307.29	3843.78
1962	304.67	309.25	495.77	403.73	347.42	289.37	273.73	271.67	293.49	296.45	282.40	350.52	3918.46
1963	423.70	474.19	504.37	526.38	852.71	812.23	323.26	283.48	284.26	303.36	292.48	313.37	5393.78
1964	295.80	302.88	433.47	371.36	418.74	508.52	313.99	291.89	285.30	291.17	289.01	346.53	4148.66
1965	323.93	334.21	713.99	752.86	581.22	368.87	290.50	287.90	283.72	293.28	289.22	328.02	4847.72
1966	997.80	1084.06	730.85	1068.60	619.92	352.75	291.03	288.68	279.68	292.29	284.21	301.37	6591.23
1967	351.06	346.20	650.95	1558.14	1495.91	503.48	318.84	297.54	303.42	304.83	291.55	399.76	6821.68
1968	779.32	941.43	1505.20	1931.97	1019.56	606.25	294.84	305.34	358.48	360.44	366.17	542.24	9011.23
1969	701.70	763.78	1430.07	1474.20	1446.15	454.54	309.97	285.76	288.80	335.27	400.54	642.12	8532.89
1970	759.17	1213.12	962.26	535.94	339.25	326.93	280.51	278.82	272.29	289.70	284.65	360.31	5902.94
1971	556.47	396.08	465.88	683.97	659.91	608.53	293.20	287.95	290.64	295.05	291.19	505.39	5334.28
1972	376.46	414.30	447.86	495.85	735.47	423.20	387.48	327.89	325.78	423.06	417.26	351.49	5126.08
1973	371.90	462.61	489.61	500.97	386.57	348.65	292.91	278.10	277.73	292.05	290.33	314.50	4305.94
1974	300.97	278.72	384.30	348.00	384.75	289.19	284.23	280.56	272.86	281.02	276.26	293.12	3673.98
1975	302.34	280.36	435.32	458.50	627.76	370.37	288.68	281.71	274.67	292.94	286.88	297.81	4197.35
Average	436.59	490.43	611.79	998.54	897.23	470.04	310.48	297.90	296.05	315.60	325.91	380.33	5830.88

Fig. III-5-9

Monthly Average Run-off at Altınkaya Dam Site



CHAPTER 6

PRELIMINARY DESIGN

CHAPTER 6 PRELIMINARY DESIGN

LIST OF FIGURES

LIST OF TABLES

LIST OF DRAWINGS

CHAPTER 6 PRELIMINARY DESIGN

6.1 PRELIMINARY DESIGN

6.1.1 Civil Engineering Structures

(1) Selection of Layouts

Topographically, the dam site has a width-height ratio of 1.4 and is a narrow gorge with sheer cliffs at both banks, while upstream of the dam site both banks suddenly widen out. The downstream side is a continuation of the narrow gorge, and other than the neighborhood of this site there is none to be found upstream or downstream which is suitable as a site for a dam. A dam other than a concrete type is technically unsuitable for this site. Further, as described in Chapter 4, the geological conditions of the dam site are such that the foudation will be satisfactory for a concrete dam.

For the type of the dam, the two alternatives of a gravity type and gravity arch type are selected for the reasons given below. Drawings of these selected layouts are indicated in DWG. III-6-2 through DWG. III-6-6, and the general features in Table III-6-1.

As concrete dam types, buttress, arch, gravity arch and gravity types are conceivable. The merits and demerits of these dam types considering also their relations with other structures such as the spillway and powerhouse are discussed below.

A buttress type dam is neither technically suitable nor economical for the site from the viewpoints of topographical conditions of the site, river deposit depth, dam height and seismic conditions.

An ordinary arch dam has no such a decisive drawback for it to be set aside upon due consideration. Moreover, when only the dam is considered, it may be said that an arch type, topographically and geologically, would be the most economical dam type. However, when the river characteristic of large design flood flow of 9,300 m^3/sec is considered, and from the standpoint of topography, a center overflow type with stilling basin is conceivable for the spillway structure, but in the case of such a layout the powerhouse would need to be an underground type and this is judged to be uneconomical. In the case of an arch type dam, layouts the same as in DWG. III-6-5 and DWG. III-6-6 are also conceivable, but the structures will be complex and thus it is judged to be unsuitable.

From the above considerations, and in consideration also of structures other than dam, a gravity of gravity arch type is judged to be the most suitable and recommendable.

Regarding the layout for structures other than dam, in both cases of gravity and gravity arch type dams, the powerhouses are to be constructed immediately downstream of the dam, while the spillways are to be center overflow type with flip bucket.

Our comparing the two alternatives of gravity and gravity arch type, the following may be pointed out.

In case of a gravity arch type dam:

(a) The volume of dam concrete will be smaller, but on the other hand, because the dam surface will be curved and the scale of construction facilities will be the same as for the case of a gravity dam, the unit cost of dam concrete will be higher.

(b) Since stresses inside the dam body will be larger, more severe construction control than for a gravity dam will be required.

(c) In order to secure stability of the dam, it is unavoidable for the arc of the dam to be sharp, and as shown in DWG. III-6-5, the intersecting angle of the chute portion of the spillway will be large which is undesirable from the standpoint of hydraulics.

Based on the above, it may be said that the layout for a gravity dam type is appropriate for structures.

The powerhouse consisting of a machine hall and a transformer hall is to be located below the spillway immediately downstream of the dam, with the transformer hall arranged on the downstream side of the machine hall. The erection bay is to be provided at the left-bank side of the powerhouse in consideration of the route of the access road.

Further, since the switchyard is at a distance from the powerhouse as described later, the bus lines outgoing from the transformers are to be extended by OF cable to the OF cable yard which is provided at the left-bank side downstream of the dam. They are to be connected here to overhead bus lines to the switchyard.

Regarding the switchyard, since the vicinity of the dam site has a steeply sloped topography at both banks and suitable space cannot be secured, it is planned at the left-bank side at a location at EL. 580 m as shown in DWG. III-6-1.

The access road is to be provided by improving a forest road running from Yalnızkavak Village to Kepez Village, and from Kepez Village a new road is to be constructed to the left-bank of the dam site passing by the switchyard. To the powerhouse, a vertical shaft and a tunnel are to be constructed from the access road passing through the left-bank of the dam crest and these will be used as passages for maintenance and control.

Delivery of mechanical and electrical equipment is to be done utilizing an access road constructed to the powerhouse at the left-bank side on the Kızılırmak River branching from the relocated road planned to be constructed at the right-bank of Altınkaya Reservoir to Durağan Town.

(2) Design Criteria

(a) With regard to the crest elevation of the dam, it is assumed that the reservoir water level will be at normal water level of 330.00 m at the time the design flood occurs, and taking the regulating capacity of the reservoir against the design flood hydrograph into consideration, the high water level is decided to be 330.50 m. Freeboard is selected to be 3.00 m considering that the probability of an earthquake occurring during design flood will be zero, and not taking account of wave height due to earthquake. Accordingly, the crest elevation of the dam is selected 335.00 m considering an allowance for the spillway bridge. The spillway overflow capacity curve is indicated in Fig. III-6-1.

With regard to the watertightness of the foundation rock at the dam site it is as stated in the conclusions of Chapter 4. The method of treatment of this foundation rock is to be as described below. In effect, zones of high permeability such as the zone from the ground surface to a depth of 100 m and the zone along the F-5 fault to deep underground are to be treated by grouting to reduce leakage. The grouting is to be done from an inspection gallery to be provided at the dam foundation and from grouting galleries to be provided at both banks. These galleries are to be further utilized for investigations of leakage quantities during and after water impoundment and for additional grouting in case leakage is heavy.

Localized areas deep underground and the vicinity of the boundary with green schist deep underground cannot be thought to show much leakage, and since these are at depths of 300 m to 500 m from the ground surface, they have no influence on stability of the dam and it is judged foundation treatment for these zones can be omitted.

The method of plugging cavities in the reservoir area is also conceivable for reducing the amount of leakage, but this is a matter which should be judged from the results of further geological investigations.

The standard section of the dam is to have a back surface gradient of 1:0.8 in case of a gravity type and 1:0.6 in case of gravity arch type assuming that the unit weight of concrete will be 2.35 t/m^3 and the seismic coefficient 0.15.

(b) The spillway is designed to overflow safely the design flood of 9,300 m^3/sec (by the maximum probable flood method) at high water level of 330.50 m, and the dissipator is designed considering 1/2 of the design flood, or 4,650 m^3/sec. The crest width and number of gates of the spillway are determined taking account of the subject discharge, width and height of intake, and length of the powerhouse.

(c) The subject discharge for the diversion tunnels is taken to be 1,355 m^3/sec for a return period of 10 years of the flood hydrograph (statistic flood) taking account of the fact that the dam is a concrete type. The diameter of the diversion tunnel and the height of the upstream cofferdam are selected referring to the rating curve at the dam site in order that the construction costs of the diversion tunnels and the cofferdam will be minimized. The results of economic evaluations of the diversion tunnels and the cofferdam are indicated in Fig. III-6-2.

(d) The diameter of penstock pipe is determined by economic study show in Fig. III-6-3.

(e) The dimensions of the powerhouse are determined considering the layout of turbines, generators, etc. Further, the elevations of the turbines and erection bay are selected referring to the rating curve at the dam site. Especially, as stated in the time on the spillway, the elevation of the erection bay is set with 4,650 m^3/sec (half of design flood) as the basis.

Table III-6-1 General Features of Two Alternatives

Item	Unit	Gravity Type	Gravity Arch Type
Dam			
Type		Concrete Gravity	Concrete Gravity Arch
Crest Elevation	m	335.00	335.00
Foundation Elevation	m	140.00	140.00
Dam Height (above Foundation)	m	195.00	195.00
Crest Length	m	265.00	297.00
Width of Crest	m	10.00	10.00
Concrete Volume	10^3m^3	2,060	1,780
Spillway			
Type		Ski-jump	Ski-jump
Capacity at Max. Storage Level	m^3/sec	9,300	9,300
Number of Gates		8	9
Size of Gate	m	(B x H) 10 x 14	(B x H) 10 x 13
Spillway Crest Elevation	m	316.00	317.10
Diversion			
Type		Horse-shoe	Horse-shoe
Number of Tunnel		2	2
Tunnel Diameter	m	7.80	7.80
Tunnel Length	m	(No.1)900 + (No.2)980 = 1,880	(No.1)870 + (No.2)960 = 1,830
Penstock Line			
Type		Embeded in Dam	Embeded in Dam
Number of Lines		3	3
Diameter	m	6.50 - 5.00	6.50 - 5.00
Length	m	171	144
Power House			
Type		Semi-underground	Semi-underground
Length	m	101.00	101.00
Width	m	43.00	43.00
Concrete Volume	10^3m^3	282	258
Switchyard			
Space (Width x Length)	m	150 x 185	150 x 185

Fig. III-6-1 Spillway Discharge Curve

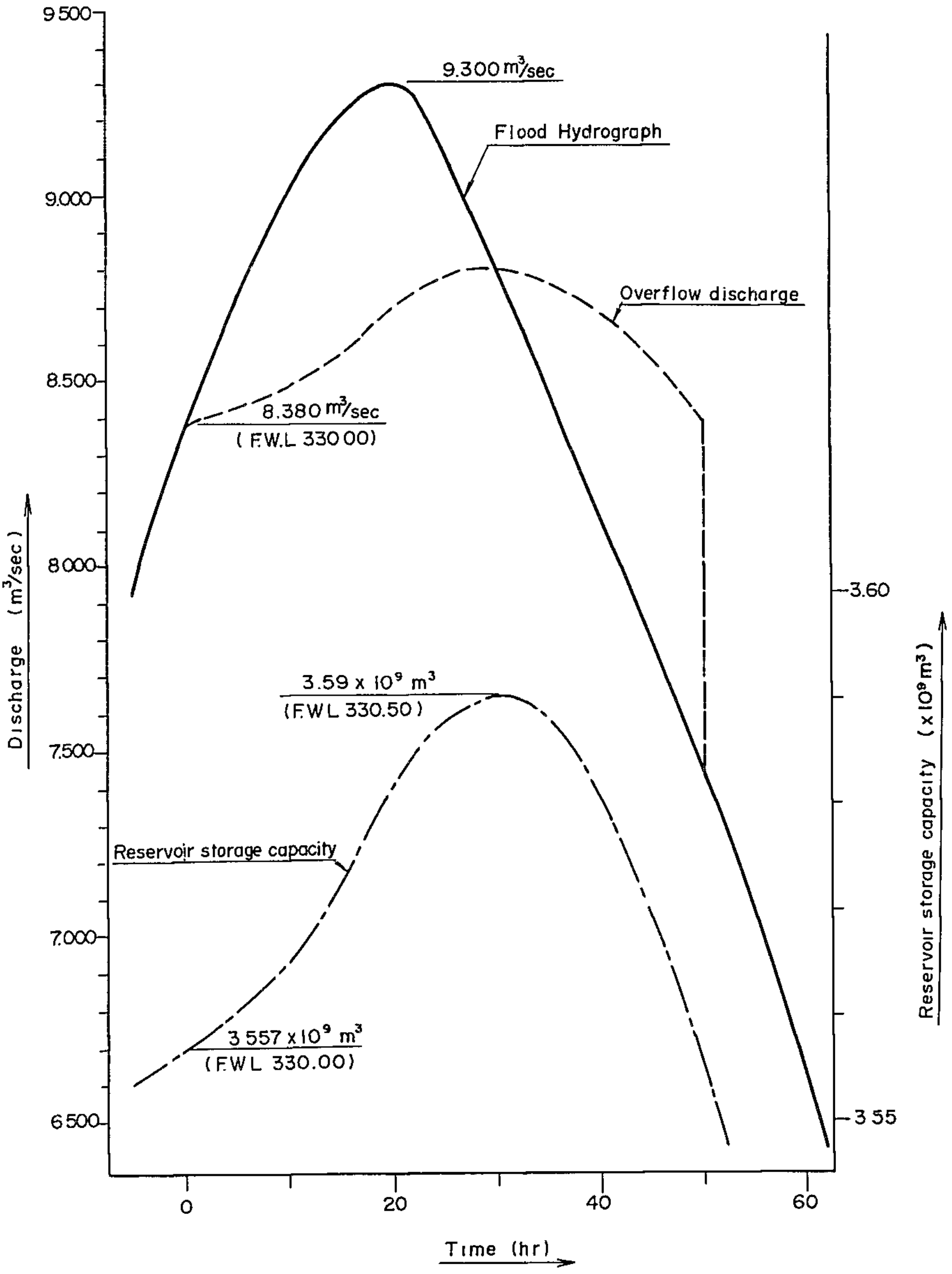
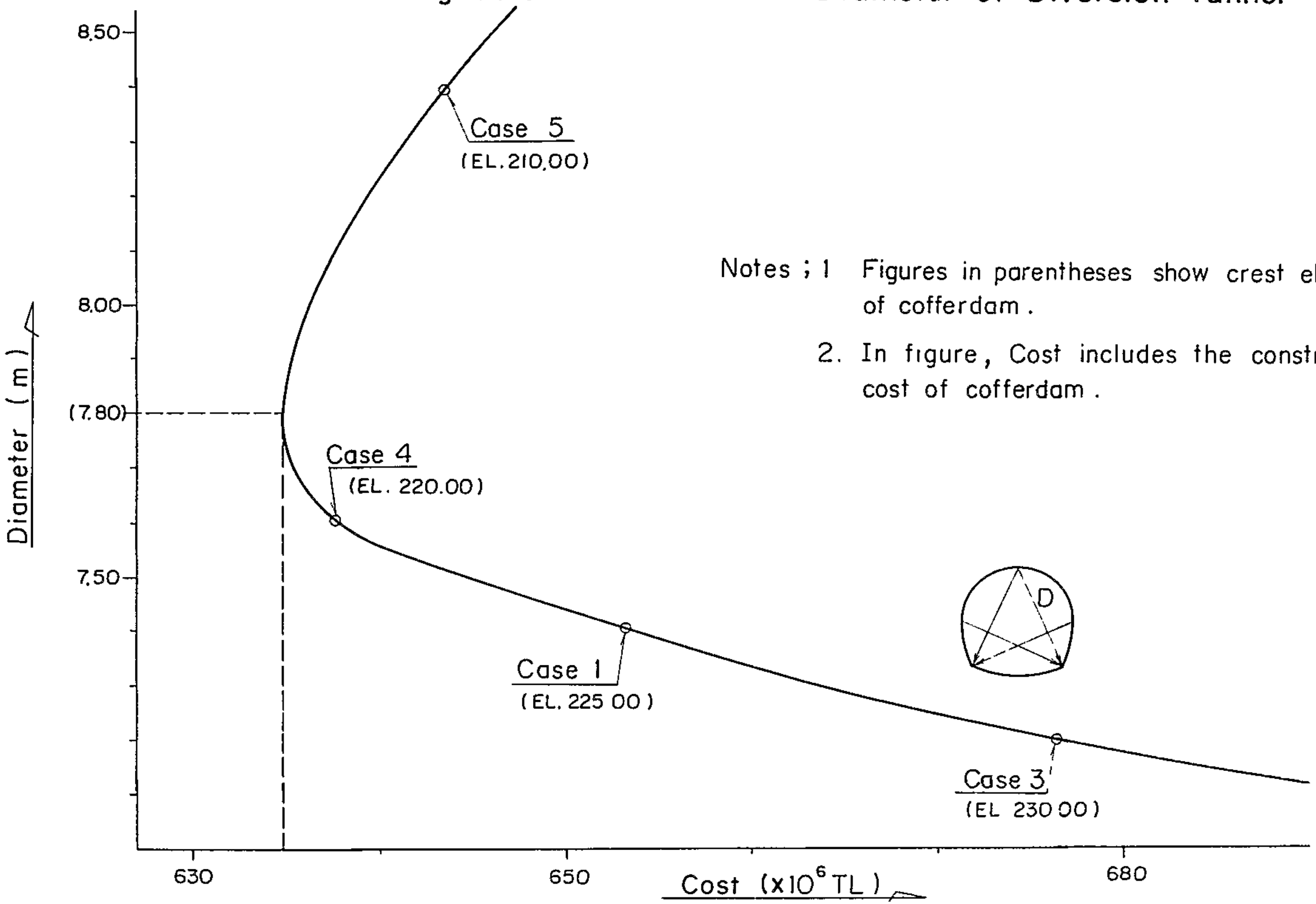


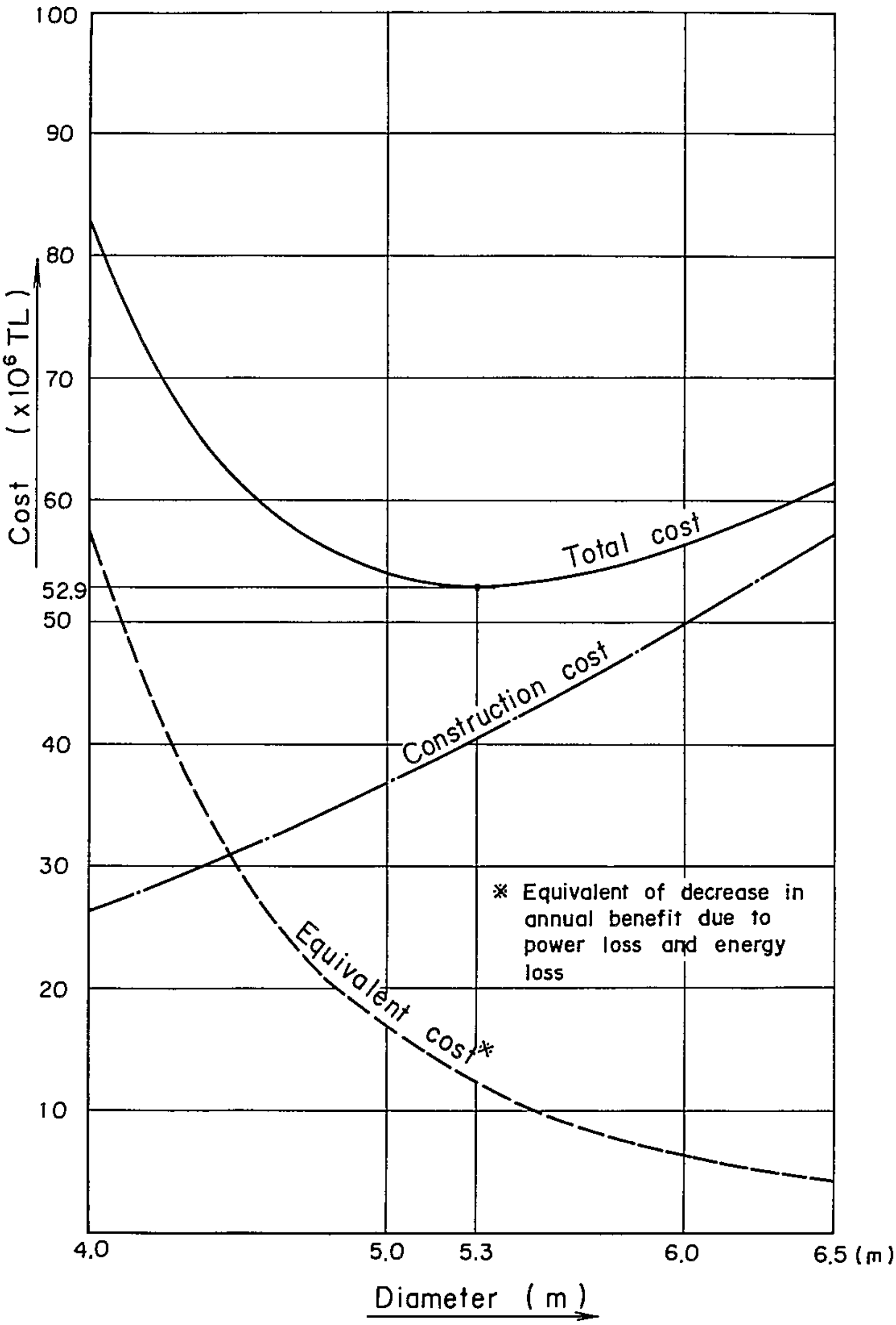
Fig. III-6-2 Economical Diameter of Diversion Tunnel



Notes ; 1 Figures in parentheses show crest elevation of cofferdam.

2. In figure, Cost includes the construction cost of cofferdam.

Fig. III-6-3 Economical Diameter of Penstock



6. 1. 2 Electrical Machinery

(1) Selection of Main Unit

It has been decided that the scale of power generation in this project will be a power station output of 510 MW with normal effective head of 125.5 m. For this output, the three alternatives of 2, 3 and 4 main units are conceivable. Any of these alternatives can be selected with no technical restriction at all.

In the case of 2 units, reduction in construction cost due to scale effect may be expected, but they will involve expenditure of large-scale reinforcing costs for roads and bridges necessary for transportation of extremely heavy objects exceeding 100 tons in weight, and not very much overall economic effect can be expected. After all the flexibility in operation which would be impaired owing to the small number of units would be more of a problem.

In the case of 4 units, rather than improvement in flexibility, adverse effects on the economics would be problematic. In this case, not only will the prices of the electrical machinery be increased, but the powerhouse dimensions will also be increased to greatly affect the layout of the entire dam, and therefore, cannot be said to be a desirable selection.

In the case of 3 main units, it is possible for equipment to be designed restricting weights of the largest objects to be transported to less than 75 tons, so that large-scale repairs for the transportation route will be unnecessary. Therefore, the 3-unit scheme will be nearly equal to the 2-unit scheme in terms of economics.

As the result of the study above, it has been decided that the number of main units for this project will be 3, with the output per unit 170 MW. Each unit would consist of a 176 MW vertical-shaft Francis turbine, a 190 MVA synchronous generator and a 190 MVA main transformer.

The compositions of main units are as indicated in Table III-6-2.

Table III-6-2 Composition of Main Units

Item	Unit	Description
Turbine		
Number	unit	3
Type	-	Vertical-shaft Francis
Normal Effective Head	m	125.5
Maximum Discharge	m^3/sec	157
Output	kw	176,000
Speed	ppm	167
Generator		
Number	unit	3
Type		Vertical-shaft synchronous
Output	kVA	190,000
Voltage	kV	16.5
Power Factor	%	90 (lagging)
Frequency	Hz	50
Speed	ppm	167
Main Transformer		
Number	unit	3
Type	-	3-phase, indoor
Capacity	kVA	190,000
Voltage	kV	16.5/380
Frequency	Hz	50

(2) Powerhouse

The powerhouse, as described previously, is to be provided immediately below the spillway and is to consist of a machine hall and a transformer hall.

The machine hall will have a width of 24 m and a length of 101 m. It will contain the above-mentioned 3 units each of turbines and generators and such items as two 220 ton overhead travelling cranes, one house turbine-generator, and auxiliary equipment.

The transormer ha l is to be laid out on the downstream side of the machine hall, with a width of 14 m and length of 101 m. Three banks of 190 MVA main transformers are to be provided in this hall.

(3) Main Circuit and 380 kV Switchyard

The main single line diagram for this project is indicated in Fig. III-6-4.

The so-called unit system is adopted for the main circuits, and generators and main transformers are directly connected by metal-enclosed buses.

The electricity produced stepped up to 380 kV by main transformers is to be conducted by oil-filled (OF) cables to the OF cable yard provided outdoors, from where it is to be conducted by overhead bus lines to the 380 kV switchyard.

The switchyard, for which the double-bus single-breaker scheme is adopted, is to consist of three transmission banks, three generator banks and one bus-tie bank.

Since the switchyard cannot be located adjacent to the powerhouse for the reason described in 6.1.1, it is to be provided at a saddle at EL. 580 m on the downstream left-bank side approximately 600 m from the powerhouse.

The switchyard has a layout in which SF_6 circuit breakers are adopted. It is also planned for a service building to be set up within the same compounds.

The building will consist of rooms such as the control room and some office rooms. The 3 main units in the powerhouse are to be remotely controlled and supervised from this control room.

The outline of the switchyard layout is indicated in Fig. III-6-5.

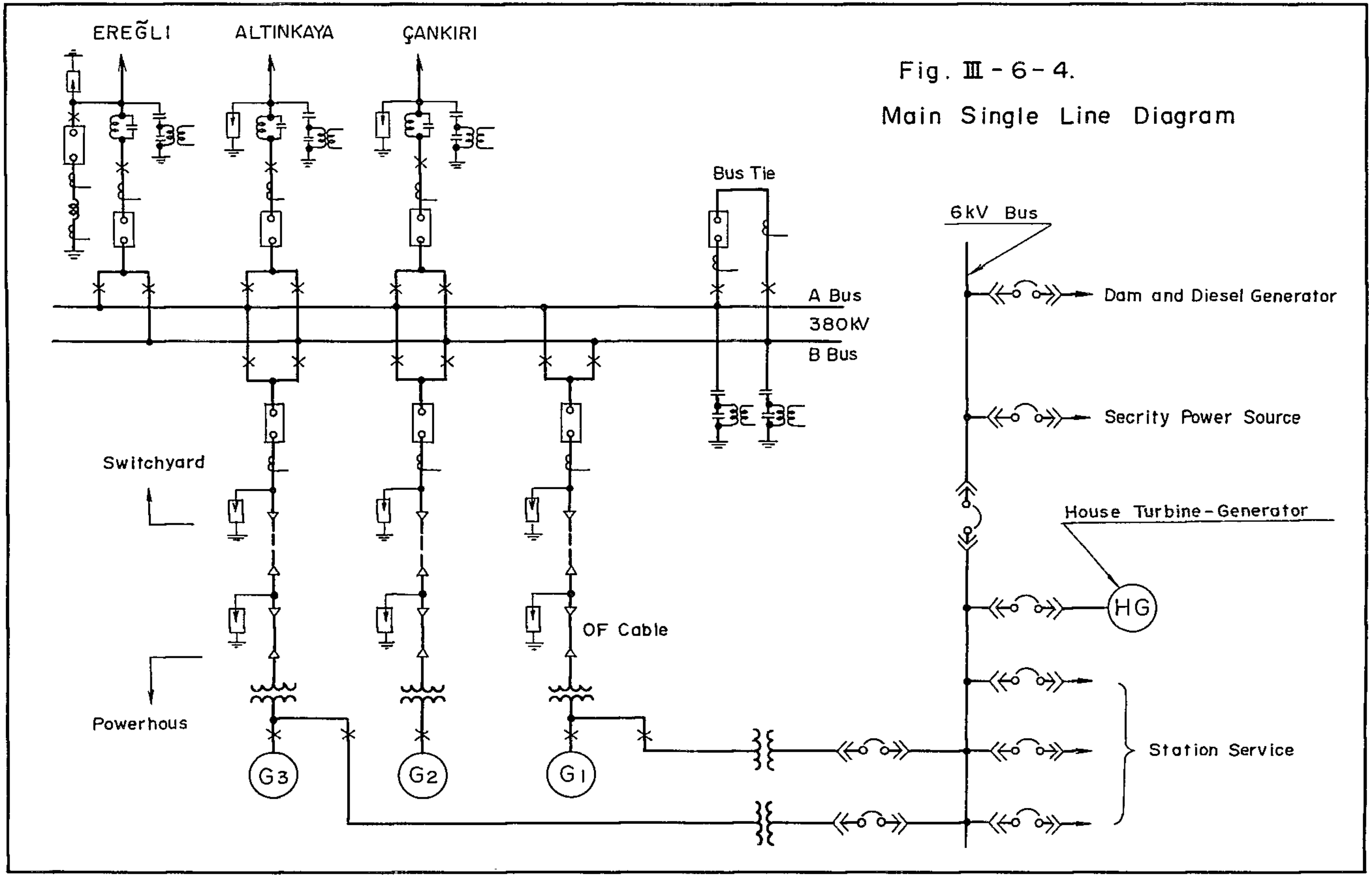
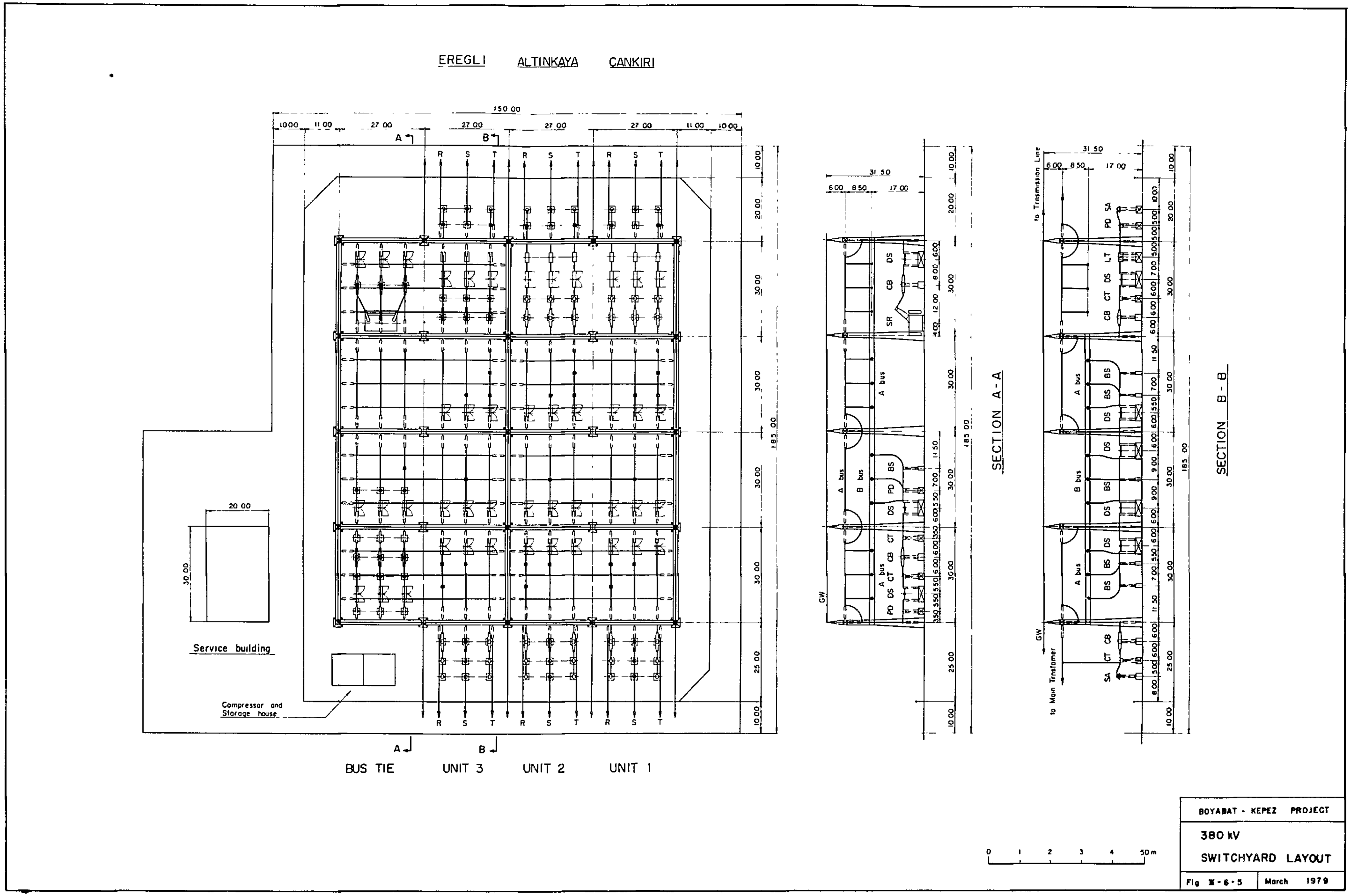


Fig. III-6-4.
Main Single Line Diagram



BOYABAT - KEPEZ PROJECT	
380 kV SWITCHYARD LAYOUT	
Fig III-6-5	March 1979

6.1.3 Planning for Transmission Line and Interconnection

The power transmission plan related with this Project is as indicated below:

Nominal Voltage : 380 kV

Number of Circuits : Three (3)

to Altınkaya-Çankırı Line : Two (2) cct/25 km

to Ereğlı Substation : One (1) cct/330 km

Altınkaya Power Station (700 MW) will already be in operation around the time this project is completed. Moreover, the transmission line linking Altınkaya Power Station and Çankırı Switchyard will also be in operation.

This Altınkaya-Çankırı Line has a total length of 200 km with a line capacity of approximately 790 MW, and has the role of transmitting not only the electricity produced at Altınkaya Power Station, but also simultaneously the electricity produced by the group of power plants such as Hasan Uğurlu (500 MW) located at the Black Sea coast to the Western Region which is the area of large power consumption.

This transmission line is planned to run past a point 25 km southeast of this project site 50 km upstream from Altınkaya Power Station. Therefore, it was planned for π-connecting between the two transmission line circuits outgoing from Kepez Power Station and Altınkaya-Çankırı Line.

However, line capacity and stability are insufficient with just the above-mentioned network, and not all of the electricity produced by this project can be transmitted with stability.

Accordingly, another transmission line will be necessary and in order to satisfy this requirement it was planned in this project for a single-circuit transmission line of 330 km to be constructed to Ereğlı Substation located on the Black Sea coast in the northwest part of the Republic of Turkey.

Since this Kepez-Ereğlı Line will be a fairly long-distant one it is certain that it will adversely affect the economic evaluation of the project alone. However, construction of this transmission line will contribute to improvement in the power flow and stability of the entire power system of the country, and improvement in the reliability of the system can be expected.

The approximate construction costs of the transmission lines were computed using the unit construction costs below:

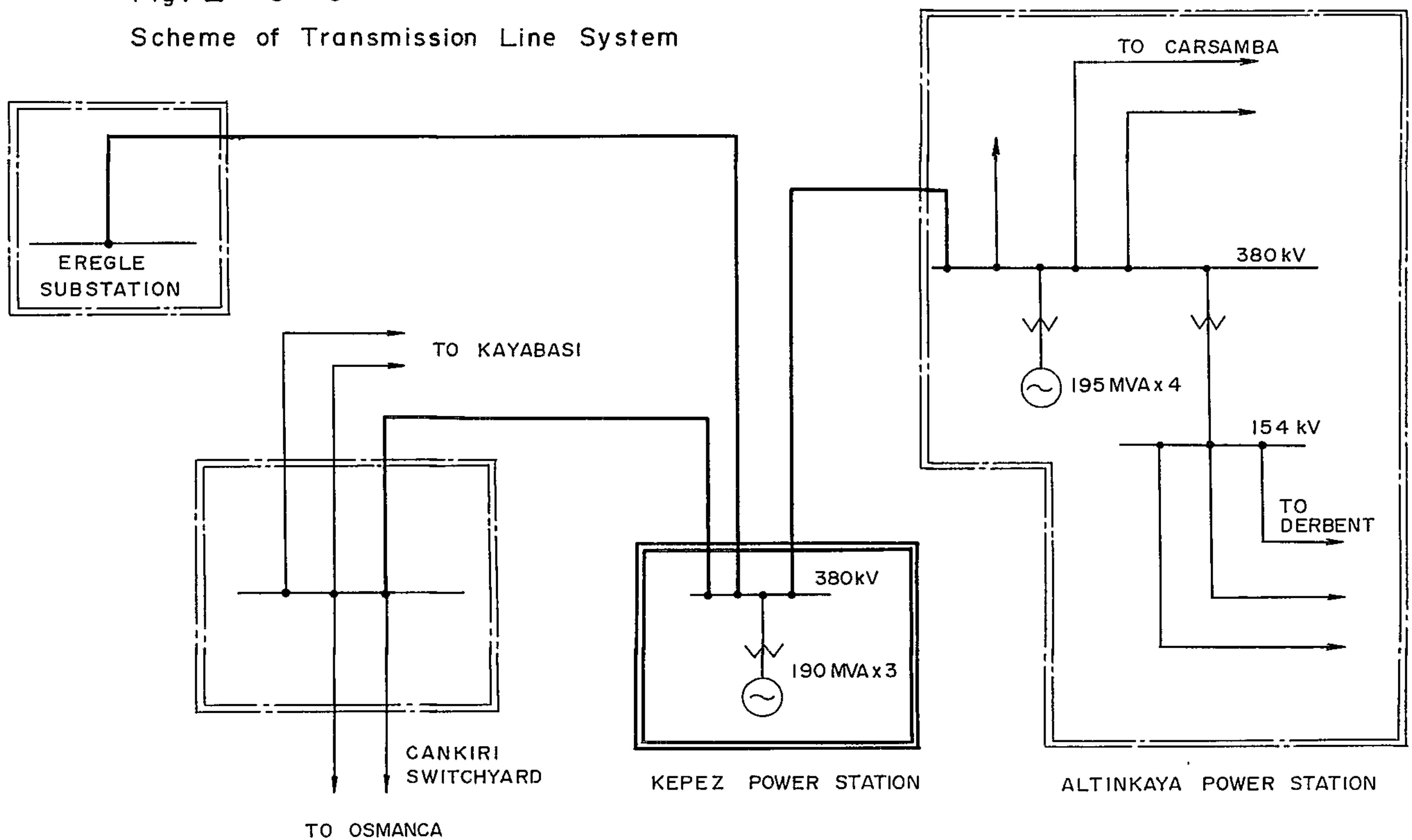
Two-circuit tower line (25 km) : 3.5×10^6 TL/km

One-circuit tower line (330 km) : 2.5×10^6 TL/km

The scheme of the transmission line system is indicated in Fig. III-6-6, and a conceptual passing route of the transmission line in Fig. III-6-7.

Fig. III - 6 - 6

Scheme of Transmission Line System



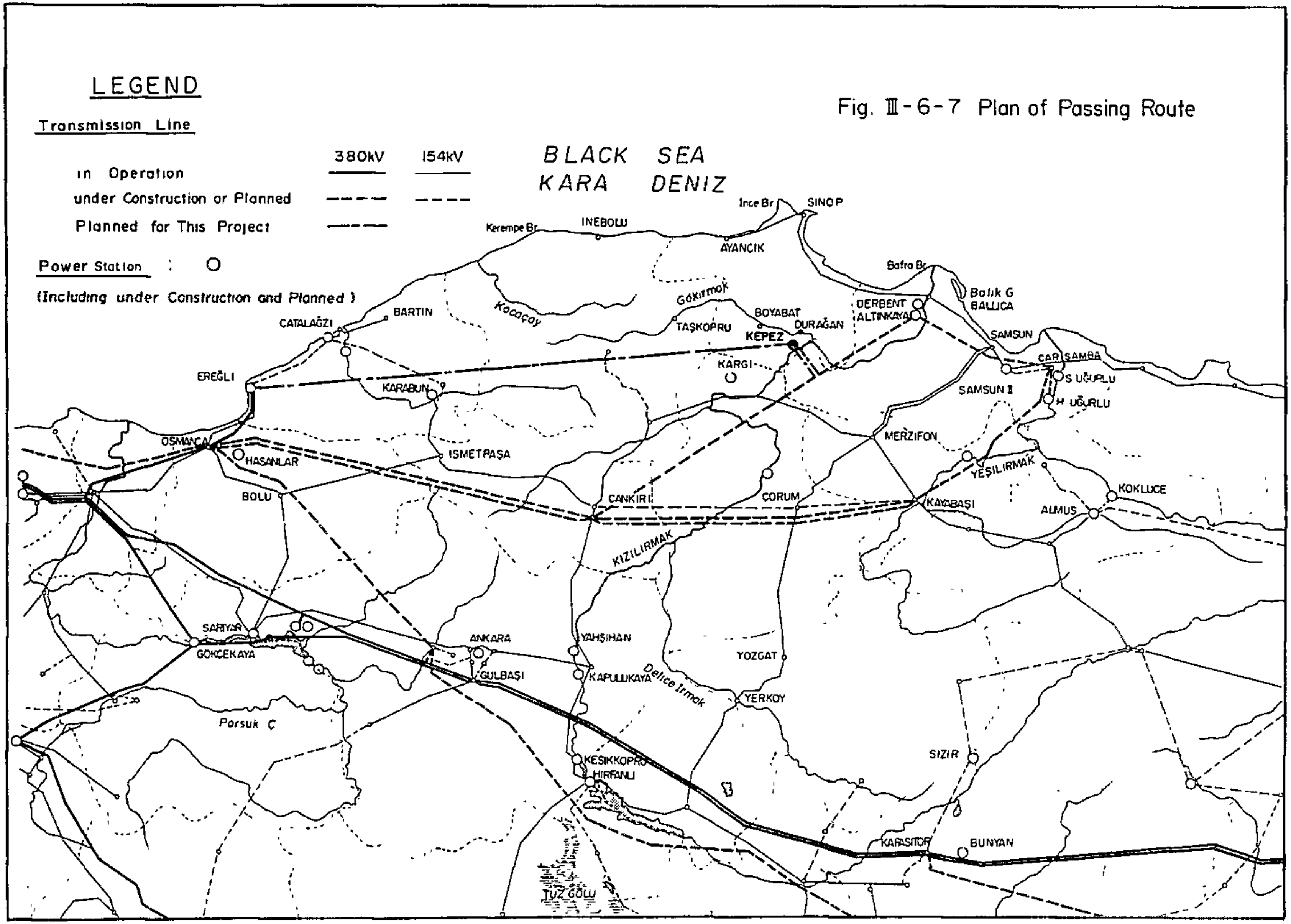


Fig. III-6-7 Plan of Passing Route

6. 1. 4 Power System Analyses and Design of Transmission Line

(1) Power System Analyses

The power system in the Republic of Turkey is fairly complex, while moreover, the power capacity is not small. Consequenly, the amount of time is too short for system analyses to be made during the period of preparation of this Report, so that this will not be possible.

Meanwhile, long-range system analyses were made by TEK in 1978. The scope of that study covered all of the Republic of Turkey, but this Kepez Project was not taken into consideration.

Therefore, it is desirable for a revision of the analyses to be made by TEK of a Kepez Project linked with the network. This revision work can be done by slight returning of the analysis program possessed by TEK.

(2) Design of Transmission Line

As stated in 6.1.3, Kepez Power Station and the Altınkaya-Çankırı Line will be mutually linked by π-connection. The final design for the Altınkaya-Çankırı Line planned by TEK will be completed in 1980. It is desirable for the following items to be taken into account in the final design.

In essence, a site suitable for π-connection of the two-circuit transmission line outgoing from the project should be selected and proper consideration be given to design of structures such as steel towers.

6.2 CONSTRUCTION SCHEDULE AND PROCEDURE

6.2.1 Fundamental Considerations

The structures to be constructed in this project are a concrete gravity dam of a height of 195 m from the foundation rock as the principal structure, a spillway, intake and penstocks provided in the dam body and a powerhouse. The amount of excavation required for construction of these structures will be 1,230,000 m^3, while concrete volumes will be 2,070,000 m^3 for the dam body and 480,000 m^3 for other structures.

The outlines of the items affecting the construction schedule and construction methods for this project are as described below:

(1) Meteorology

The annual mean temperature at the project site is 13°C, and the annual maximum temperatures 40°C (August) and -16°C (January), respectively.

The annual precipitation at the project site is 400 mm.

The meteorological conditions above are comparatively favorable for execution of work such as concrete casting, but the construction schedule is prepared considering that concrete casting will be discontinued during the two winter months, namely, January and February.

(2) Transportation

The accessibility to the project site is very good as stated in 2.3.1. However, in carrying main equipment and materials, it will be necessary for the access road indicated in DWG. III-6-1 to be repaired or newly constructed in part.

The nearest seaport is Samsun, which is the port for landing equipment and materials for the Hasan Uğurlu Project presently under construction, and which will be utilized for landing equipment and materials for the Altınkaya Project also, and there will be adequate landing capacity.

(3) Construction Equipment and Materials

Regarding construction equipment and materials, although it will be necessary to import large-sized construction machinery and some other equipment and materials, others can be procured domestically.

Concerning cement and fly ash for dam construction, moderate-heat portland cement is suitable for this dam. A cement factory being operated in Çorum City (200 km from the City to the site) is designated as the main supply source, with full production capacity and stability for constant supply. If 20 to 30% of the cement is to be substituted by fly ash, it may bring about such advantages as less generation of heat, easier cooling and increase of concrete strength, and fly ash will be available from Çatalagzi Thermal Power Station. However, a study will be needed to be made to confirm availability, stability of supply and quantity of product.

(4) Aggregates

There is distribution of sand-gravel deposits over a wide area of the river bed from 1.5 km upstream of the dam site. The lithology and physical properties of these sand-gravel deposits are as described in 4.4. The quantity of concrete aggregates required is estimated to be as much as 2,750,000 m^3, and the entire amount of aggregates required is to be collected from the section of the mainstream 4.0 to 7.0 km upstream of the dam site and from the confluence with the Mosum Gully which joins the river at the left-bank side 2.0 km upstream of the dam site. Aggregates are to be manufactured providing an aggregate plant at the Mosum confluence point.

(5) Electric Power for Construction

It is considered that about 6 MW will be required as electric power for construction, and this is to be supplied constructing a 34.5 V transmission line for construction of 20 km branching from a transmission line passing the vicinity of Durağan Town.

(6) Construction Facilities

An aggregate plan will be installed on the left-bank 2.0 km upstream as mentioned above in consideration of accessibility to the dam, and the plant capacity will be 700 tons per hour to meet the requirements of concrete volume and construction period.

A batching plant designed for 360 m^3 per hour in nominal capacity will be installed for concrete work and will be located near the dam crest on the left-bank.

Two 28-ton cable cranes will be provided for concrete casting of the dam and two more cable cranes of 10-ton capacity will be used as auxiliaries.

Cement silos and a cooling plant will be provided in addition to the afore-mentioned facilities.

6.2.2 Construction Schedule and Procedure

It is thought that 82 months will be required as the construction period for this project including preparatory works as a result of study considering the construction scale, layout of structures, regional conditions, etc. The target for operation of this power station is set for the autumn of the seventh year after commencement of work. In order to achieve this target successfully, installation of mechanical and electrical equipment must be started at the end of the fourth year and major items of civil works must be performed in accordance with the construction schedule shown in Fig. III-6-8.

This project is a dam type power station, and the feature is that a layout of the major structures such as, spillway, intake, penstock and powerhouse is attached to or embeded in the dam body. Therefore, it is necessary for construction of these structures to be performed in step with progress in work on the dam body which will have a great influence on the construction period.

The outlines of the construction schedule and procedure are described below:

(1) Simultaneous to commencement of work, temporary works including provision of construction roads, construction of the access road, carrying of construction machinery, erection of camp houses and buildings for construction, the batcher plant, cable cranes, and transmission line for construction are to be started. Following this, excavation of the diversion tunnels to be provided at the right-bank for river diversion is to be started from both the upstream and downstream portals.

(2) In the second year, the temporary facilities works and excavation of the diversion tunnels are to be continued, and upon completion of the latter excavation, concrete lining is to be started at the inlets and outlets of the diversion tunnel and immediately below the dam. Upon completion of concrete lining, work on the cofferdam is to be immediately started. Meanwhile, excavation at both banks of the dam is to proceed parallel with the diversion works.

(3) In the third year, upon completion of the cofferdam, the river water is to be diverted to the diversion tunnels and excavation of the river bed at the dam is to be started. Consolidation grouting is to be performed from parts where river bed excavation has been completed and dam concrete casting is to be started in succession.

Contracts for mechanical and electrical equipment are required to be awarded and factory production started at least at the beginning of this year in order to assure start of operation at the time scheduled.

(4) On entering the fourth year, dam concrete casting will reach its zenith. Dam concrete casting will require 30 months in consideration of the lift schedule and capacities of cable cranes. Consolidation grouting is to be done in advance of dam concrete casting, while curtain grouting is to be performed from a gallery to be provided inside the dam body and from curtain grouting galleries to be provided at both banks. Cooling and joint grouting are to be performed in step with

increase in height of dam concrete.

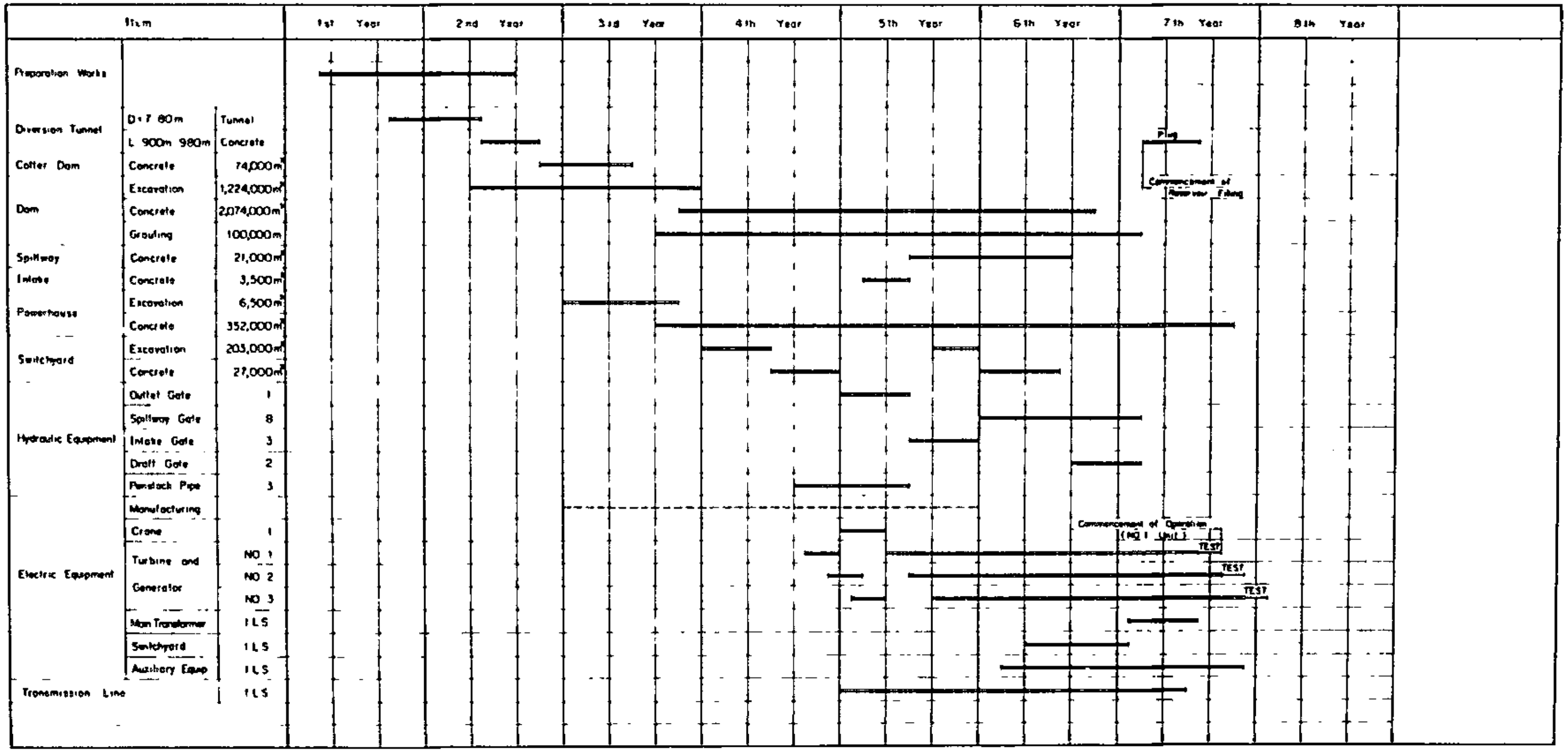
Concrete casting for the powerhouse and installation of penstock pipes are to be carried out in step with the schedule of dam concrete casting, and at the end of the year it will be necessary to install the draft tube of Unit No. 1. As for the switchyard, its construction is not a critical path, so that it will suffice for it to be completed before installation of electrical switchyard facilities.

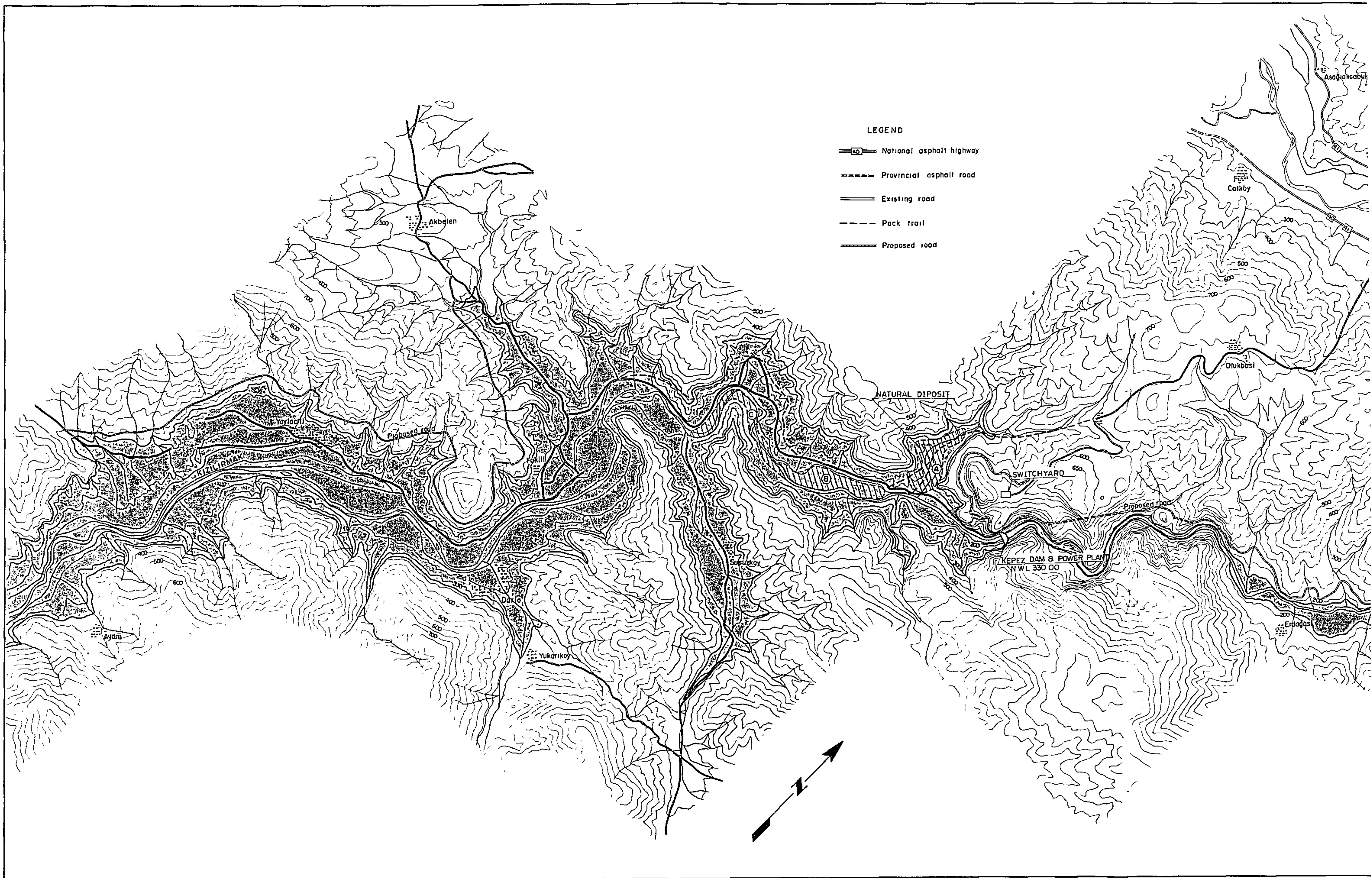
(5) The fifth year will be the year when various works will conflict with each other and it will be necessary for construction schedules to be scrupplously controlled. In dam work, concrete casting and foundation treatment are to be carried out. Concrete casting for the intake, spillway and powerhouse, and installation of gates and penstock pipes are to be carried out, while in the way of mechanical equipment, the overhead travelling crane is to be installed to parallel draft tube installations, and installation of the turbines is started after completion of the overhead travelling crane.

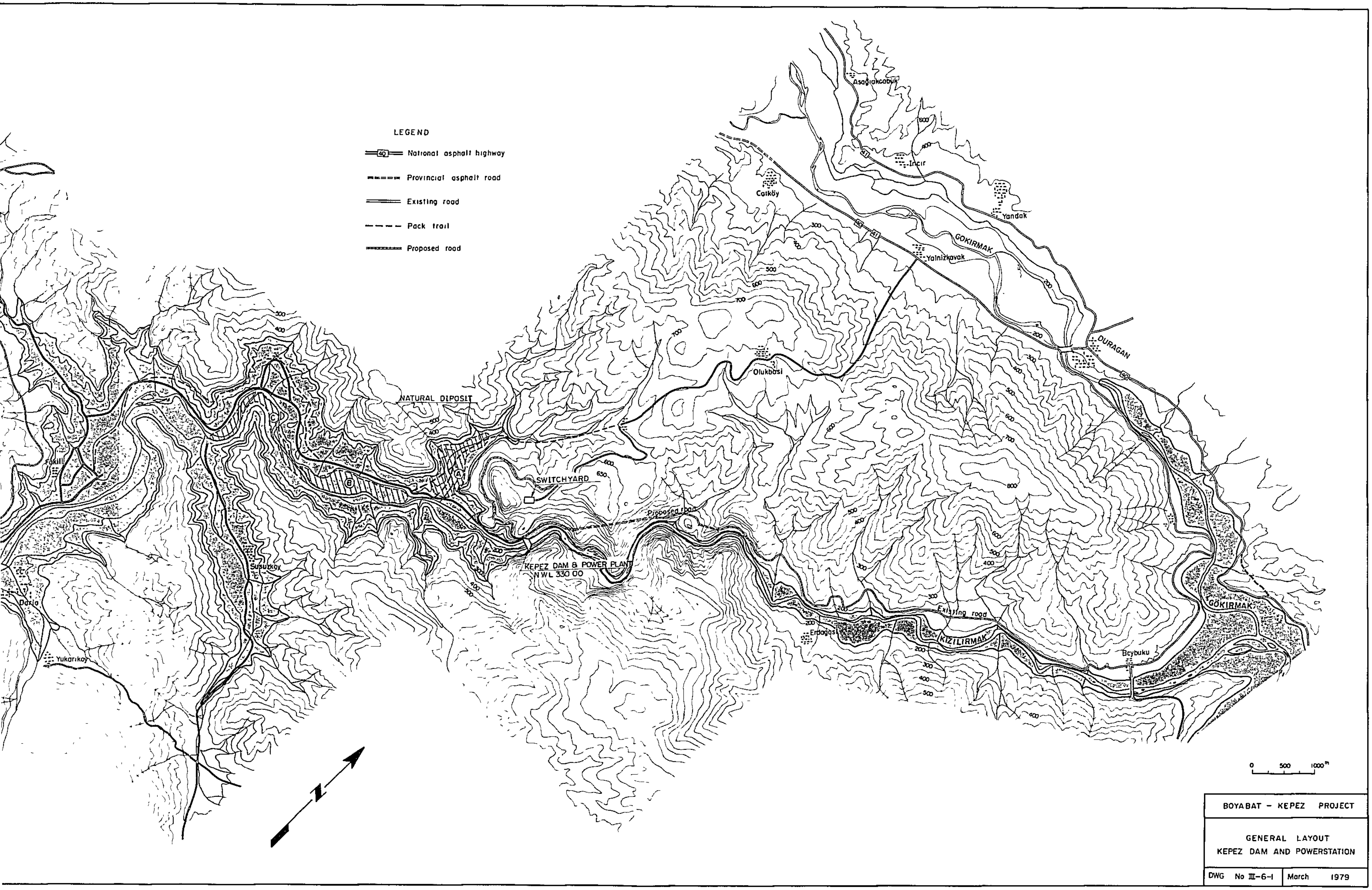
(6) In the sixth year, civil works and the greater part of installation of hydraulic equipment are to be completed, and installation of mechanical and electrical equipment will reach its busiest period.

(7) On entering the seventh year, the river water of the flood season is to be stored in the reservoir to provide for electricity demand in the winter, installation of gates is to be completed during February, and plugging of the diversion tunnels is to be started in March. As for mechanical and electrical equipment, since the schedule is for operation to be started every two months beginning with October, installation of generators, main transformers and auxiliary equipment is to be carried out in the order of units going into operation. Upon the reservoir water level reaching the standard design water level at the beginning of August, test operation of Unit No. 1 is to be started, and with start of operation of Unit No. 1 at the beginning of October as the starting point, Unit No. 2 is to be started up at the beginning of December, and Unit No. 3 at the beginning of January (eighth year).

Fig Ⅲ-6-8 KEPEZ DAM AND POWER PLANT CONSTRUCTION SCHEDULE



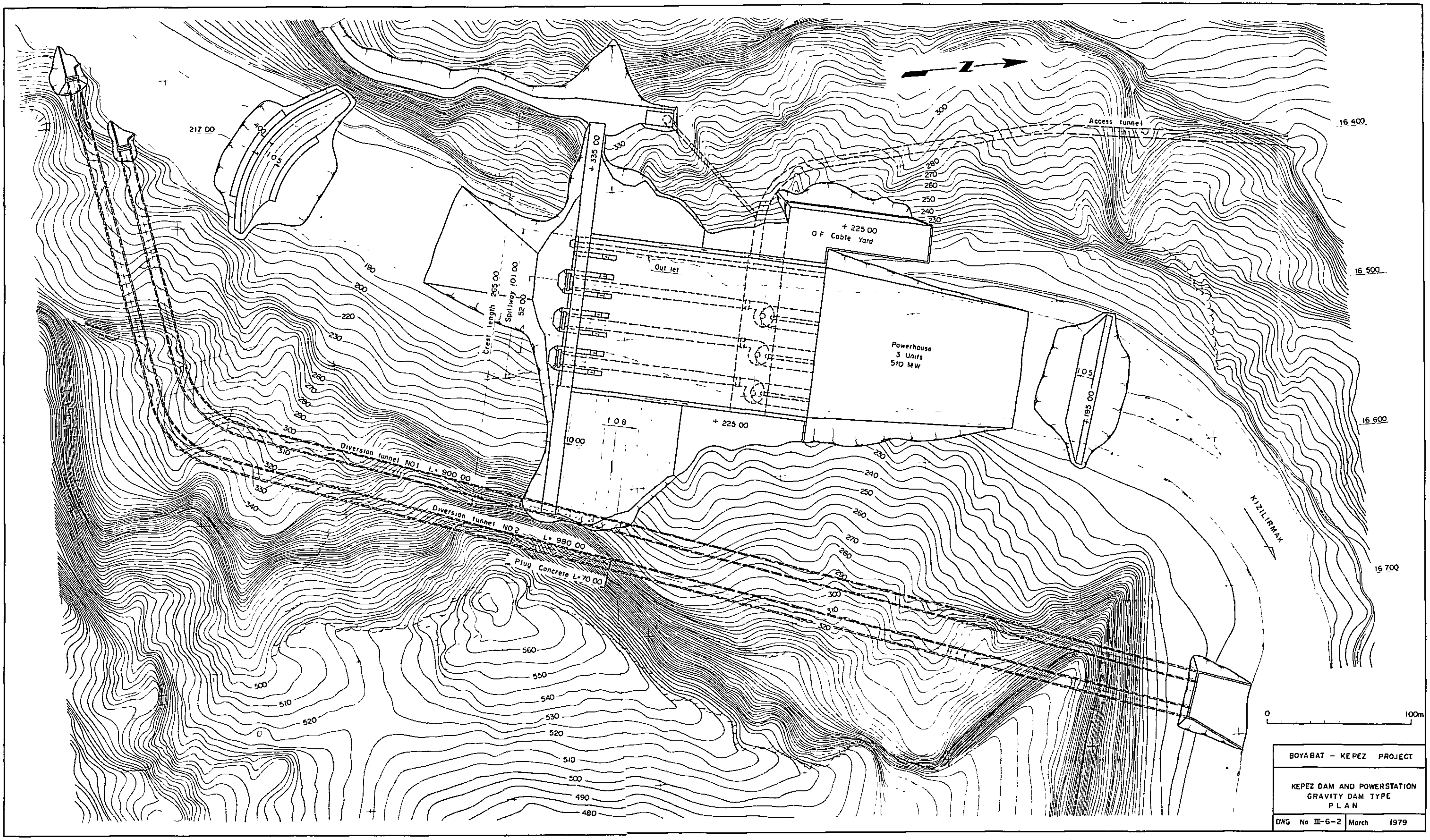

LEGEND
National asphalt highway
Provincial asphalt road
Existing road
Pack trail
Proposed road
Akbelen
Yaylacili
Proposed road
KIZILIRMAK
Fakili
Darja
Aydın
Yukarikoy
Susuzkoy
NATURAL DIPOSIT
SWITCHYARD
KEPEZ DAM & POWER PLANT
N.W.L. 330.00
Proposed road
Catkby
Olukbasi
Erdagasi

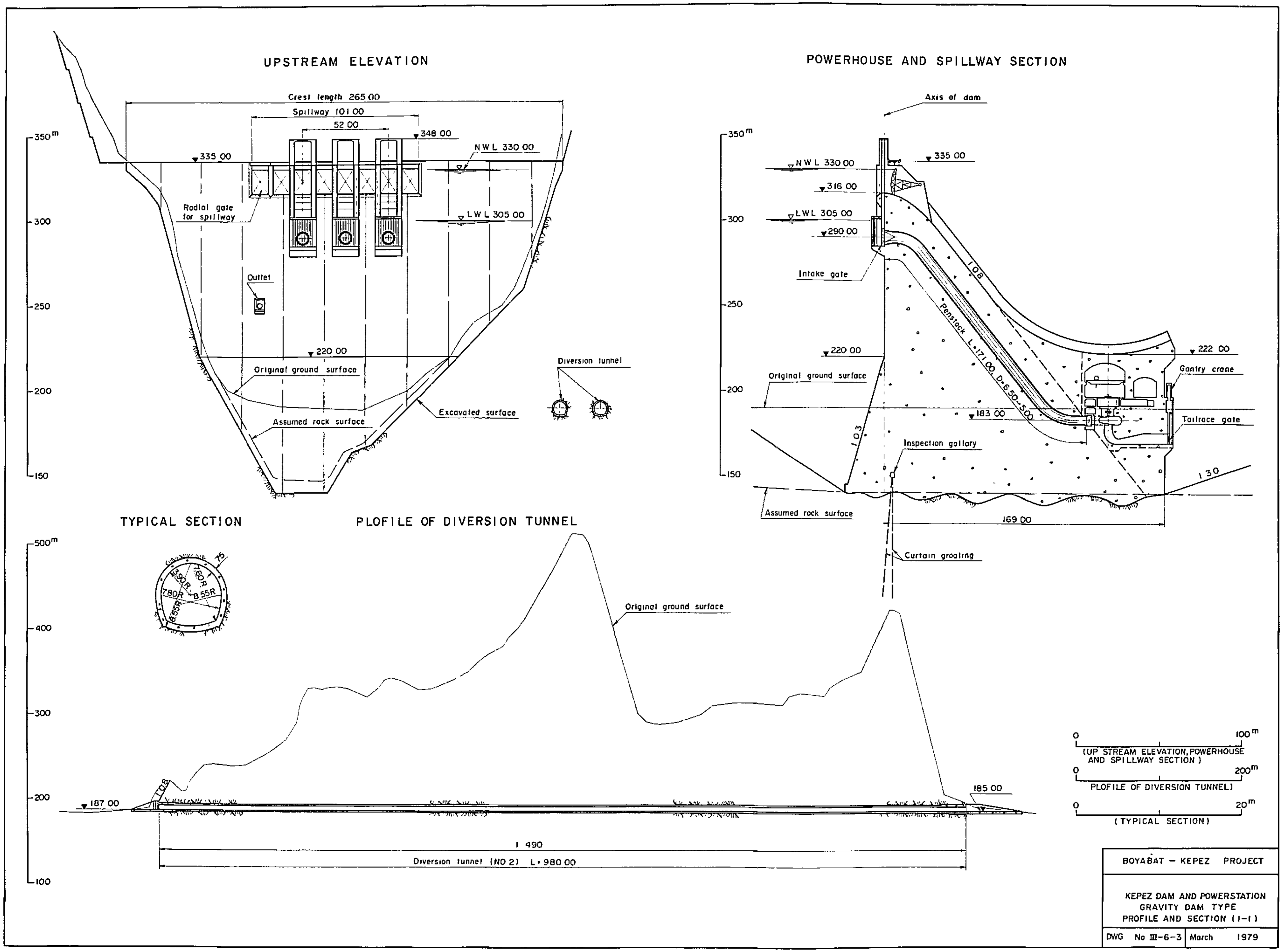


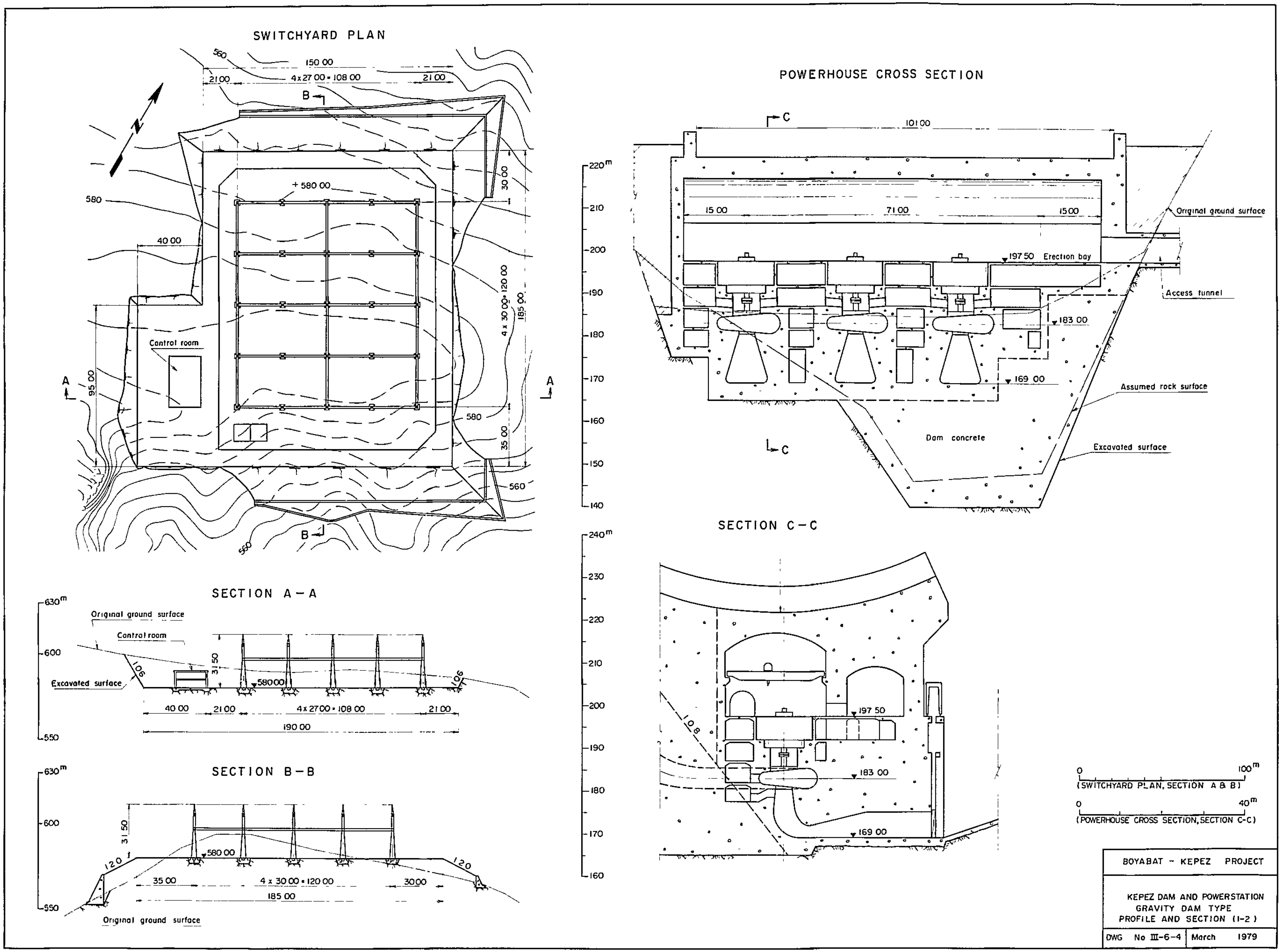
BOYABAT - KEPEZ PROJECT

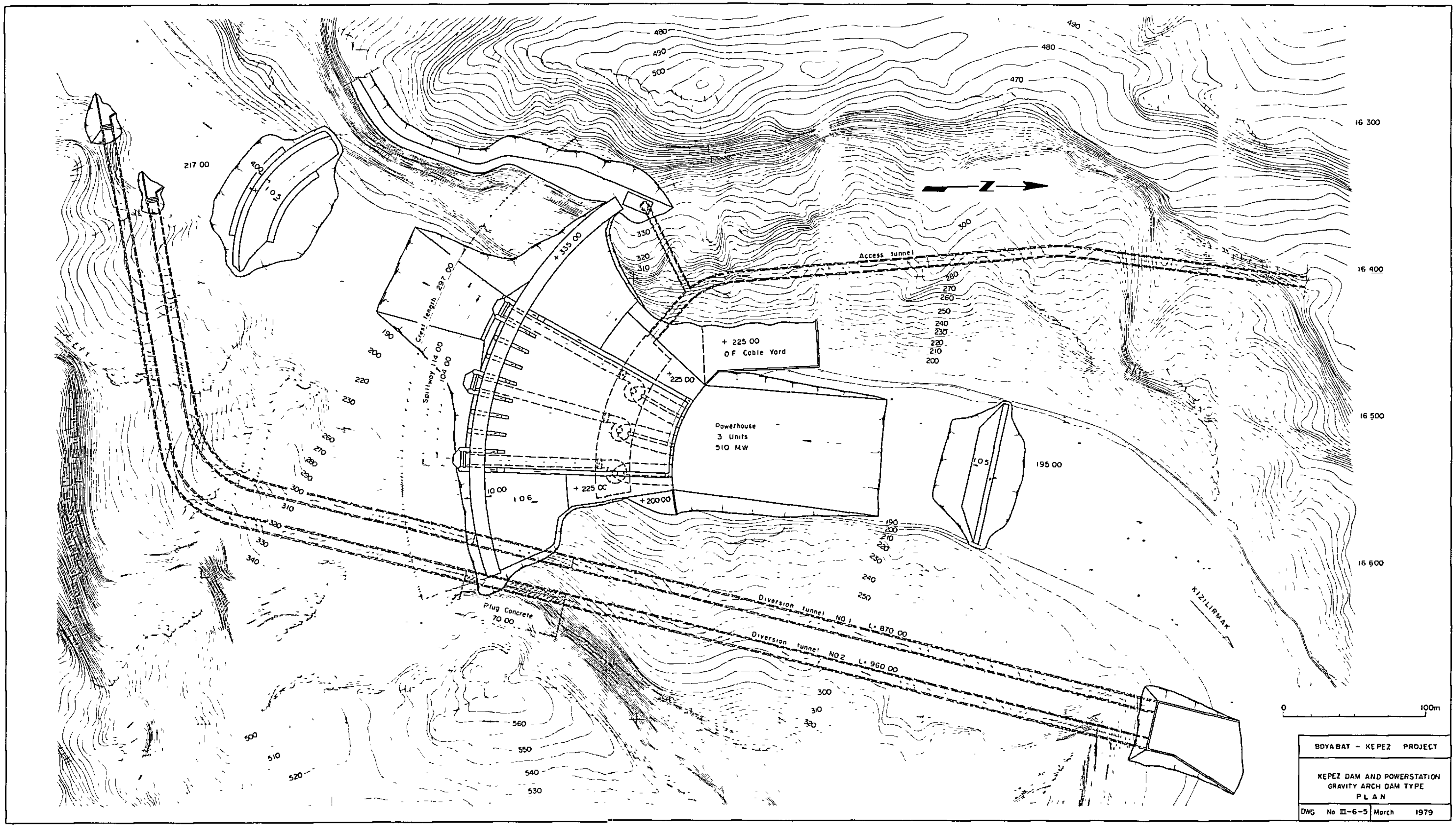
GENERAL LAYOUT
KEPEZ DAM AND POWERSTATION

DWG No III-6-1 | March 1979

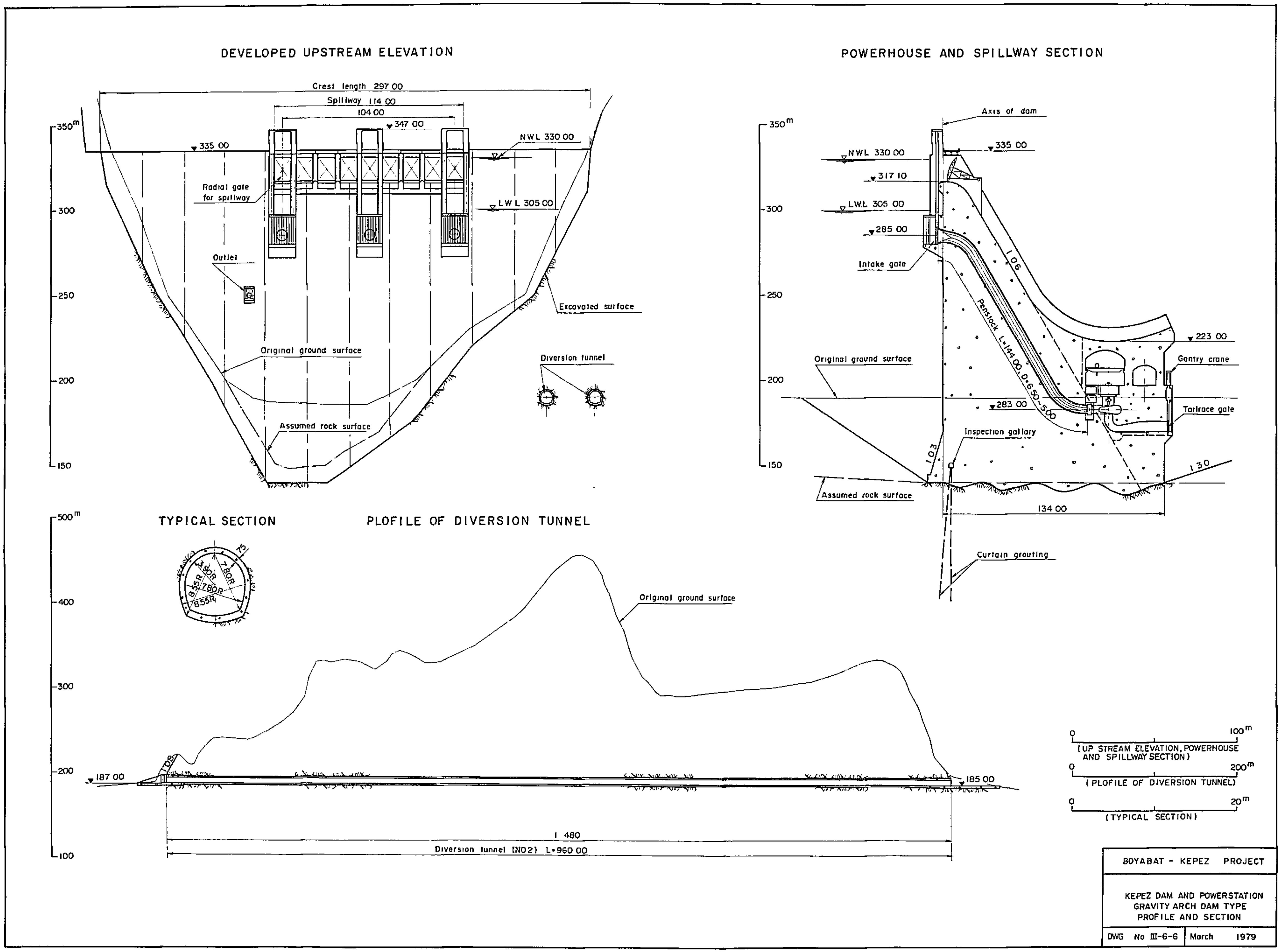

Access tunnel
+ 335 00
+ 225 00
O F Cable Yard
Out let
Crest length 265 00
Spillway 101 00
52 00
Powerhouse
3 Units
510 MW
+ 195 00
105
108
10 00
+ 225 00
Diversion tunnel NO 1 L= 900 00
Diversion tunnel NO 2 L= 980 00
Plug Concrete L= 70 00
KIZILIRMAK
Z
16 400
16 500
16 600
16 700
217 00
0
100m
BOYABAT – KEPEZ PROJECT
KEPEZ DAM AND POWERSTATION
GRAVITY DAM TYPE
PLAN
DWG No III-6-2
March 1979


UPSTREAM ELEVATION
Crest length 265.00
Spillway 101.00
52.00
348.00
335.00
NWL 330.00
LWL 305.00
Radial gate for spillway
Outlet
220.00
Original ground surface
Assumed rock surface
Excavated surface
Diversion tunnel
350m
300
250
200
150
POWERHOUSE AND SPILLWAY SECTION
Axis of dam
NWL 330.00
335.00
316.00
LWL 305.00
290.00
Intake gate
1.08
Penstock L=171.00 D=6.50~5.00
220.00
222.00
Original ground surface
Gantry crane
183.00
Tailrace gate
Inspection gallery
1.03
1.30
Assumed rock surface
169.00
Curtain grouting
TYPICAL SECTION
75
7.80R
7.90R
8.55R
7.80R
8.55R
PLOFILE OF DIVERSION TUNNEL
500m
400
300
200
100
Original ground surface
1.08
187.00
185.00
1 490
Diversion tunnel (NO 2) L=980.00
0
100m
(UP STREAM ELEVATION, POWERHOUSE AND SPILLWAY SECTION)
0
200m
PLOFILE OF DIVERSION TUNNEL)
0
20m
(TYPICAL SECTION)
BOYABAT – KEPEZ PROJECT
KEPEZ DAM AND POWERSTATION
GRAVITY DAM TYPE
PROFILE AND SECTION (1-1)
DWG No III-6-3
March 1979


SWITCHYARD PLAN
150 00
21 00
4x27 00 = 108 00
21 00
580
560
+580 00
40 00
Control room
95 00
30 00
4 x 30 00 = 120 00
185 00
35 00
POWERHOUSE CROSS SECTION
101 00
15 00
71 00
15 00
197 50 Erection bay
183 00
169 00
Original ground surface
Access tunnel
Assumed rock surface
Dam concrete
Excavated surface
SECTION C-C
197 50
183 00
169 00
SECTION A-A
Original ground surface
Control room
Excavated surface
31 50
580 00
40 00
21 00
4x27 00 = 108 00
21 00
190 00
SECTION B-B
31 50
580 00
35 00
4 x 30 00 = 120 00
30 00
185 00
Original ground surface
(SWITCHYARD PLAN, SECTION A & B)
(POWERHOUSE CROSS SECTION, SECTION C-C)
BOYABAT - KEPEZ PROJECT
KEPEZ DAM AND POWERSTATION
GRAVITY DAM TYPE
PROFILE AND SECTION (1-2)
DWG No III-6-4
March 1979



Access tunnel
+ 225 00
OF Cable Yard
Powerhouse
3 Units
510 MW
Crest length 297 00
Spillway 14 00
104 00
+ 335 00
Plug Concrete
70 00
Diversion tunnel NO 1 L= 870 00
Diversion tunnel NO 2 L= 960 00
KIZILIRMAK
Z
16 300
16 400
16 500
16 600
0
100m
BOYABAT - KEPEZ PROJECT
KEPEZ DAM AND POWERSTATION
GRAVITY ARCH DAM TYPE
PLAN
DWG No III-6-5
March 1979


DEVELOPED UPSTREAM ELEVATION
Crest length 297 00
Spillway 114 00
104 00
347 00
335 00
NWL 330 00
LWL 305 00
Radial gate for spillway
Outlet
Excavated surface
Original ground surface
Diversion tunnel
Assumed rock surface
350m
300
250
200
150
POWERHOUSE AND SPILLWAY SECTION
Axis of dam
335 00
NWL 330 00
317 10
LWL 305 00
285 00
Intake gate
1:0.6
Penstock L=144 00, D=6 50-5 00
223 00
Gantry crane
Original ground surface
283 00
Tailrace gate
Inspection gallary
1:0.3
1:3.0
Assumed rock surface
134 00
Curtain grouting
TYPICAL SECTION
PLOFILE OF DIVERSION TUNNEL
75
8 55R
7 80R
Original ground surface
500m
400
300
200
100
187 00
185 00
1 480
Diversion tunnel (NO2) L=960 00
0
100m
(UP STREAM ELEVATION, POWERHOUSE AND SPILLWAY SECTION)
200m
(PLOFILE OF DIVERSION TUNNEL)
20m
(TYPICAL SECTION)
BOYABAT - KEPEZ PROJECT
KEPEZ DAM AND POWERSTATION
GRAVITY ARCH DAM TYPE
PROFILE AND SECTION
DWG No III-6-6
March 1979

CHAPTER 7

CONSTRUCTION COST

CHAPTER 7 CONSTRUCTION COST

LIST OF TABLES

CHAPTER 7 CONSTRUCTION COST

Estimation of the construction cost is done based on the criteria applied for the definite study of the Kılıçkaya Project, and taking account of construction methods according to the engineering level which can be expected as of the present, the geological and natural conditions at the project site, regional conditions, project scale, etc. The point of time of estimation is taken to be April 1978 for which data necessary for estimation of labor and materials and equipment costs for construction are most complete.

7.1 ITEMS OF CONSTRUCTION COST ESTIMATION

The items of construction cost estimation are the dam, spillway, intake, penstock, powerhouse, switchyard, hydraulic equipment, mechanical and electrical equipment and power transmission facilities. In this construction cost, all costs necessary for execution of the work such as planning and investigation costs, preparatory works costs (access road, camp house, etc.), supervision and management costs, compensation costs (land acquisition, relocation of road, etc.), interest during construction period, etc. are included. Construction machinery and major equipment are assumed to be brought in from Japan and the U.S.A. and their import duties are considered to be 10% of purchase prices.

(1) Cost of Civil Works

Quantities of the various works are calculated from the preliminary drawings mentioned in Chapter 6. The prices of construction equipment are based on F.O.B. values plus ocean and domestic overland transportation costs to the project site.

(2) Cost of Equipment

Cost of mechanical and electrical equipment such as turbines, generators and transformers are all estimated on importation from foreign manufacturers plus costs of transportation to the project site and installation.

(3) Contingency Cost

Contingency costs are to be 15% for civil works, and 10% for mechanical and electrical equipment works.

(4) Planning and Investigation, and Supervision and Management Costs

Based on discussions with DSİ, these costs are to be 15% of the construction cost including contingency costs.

(5) Compensation Costs

For costs of land acquisition, relocation of road, etc., the amount indicated

Table III-7-1 Estimated Construction Costs

(Unit: 1000 TL)

Item	Cost
Civil Works	
Cofferdam	182,000
Diversion Tunnel	490,000
Dam	2,496,000
Spillway	62,000
Outlet Works	200
Intake	10,600
Powerhouse	611,000
Switchyard	125,000
Access Road	184,000
Cement	413,000
Subtotal	4,573,800
Contingency (15%)	685,500
Total	5,259,300
Hydraulic Works	472,700
Mechanical and Electrical Equipment	2,020,000
Transmission Line	1,000,000
Camp Facility	60,000
Relocation of Road	150,000
Project Controlling	1,344,000
Land Acquisition	850,000
Total	11,156,000
Interest during Construction Period (9.5%)	2,968,000
Grand Total	14,124,000

Table III-7-2 Estimated Foreign and Domestic Currencies

Unit : 1000 TL

Item	Total	Domestic	Foreign
Civil Works	5,259,300	3,383,500	1,875,800
Hydraulic Works	472,700	94,500	378,200
Mechanical and Electrical Equipment	2,020,000	202,000	1,818,000
Transmission Line	1,000,000	100,000	900,000
Camp Facility	60,000	60,000	-
Relocation of Road	150,000	150,000	-
Project Controlling	1,344,000	598,000	746,000
Land Acquisition	850,000	850,000	-
Total	11,156,000	5,438,000	5,718,000
Interest during Construction Period (9.5%)	2,968,000	1,392,000	1,576,000
Grand Total	14,124,000	6,830,000	7,294,000

Table III-7-3 Fund Requirement in Each Year

(Unit : 1000 TL)

Description	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	Total
Preparation Works	151,500	134,700					150,000	436,200
Civil Works	103,200	638,300	586,700	1,249,000	1,192,400	1,088,700	174,800	5,033,100
Hydraulic Works	-	-	-	91,200	226,400	128,800	26,300	472,700
Mechanical and Electrical Equipment	-	-	580,000	307,600	408,300	236,300	487,800	2,020,000
Transmission Line	-	-	-	-	400,000	400,000	200,000	1,000,000
Project Controlling	37,900	116,000	175,000	247,200	334,000	278,100	155,800	1,344,000
Land Acquisition	340,000	-	-	-	-	-	510,000	850,000
Total								11,156,000
Interesting during Construction Period	25,400	89,600	187,900	335,300	544,700	781,800	1,003,300	2,968,000
Grand Total	658,000	978,600	1,529,600	2,230,300	3,105,800	2,913,700	2,708,000	14,124,000

CHAPTER 8

ECONOMIC EVALUATION

CHAPTER 8 ECONOMIC EVALUATION

LIST OF TABLES

LIST OF FIGURE

CHAPTER 8 ECONOMIC EVALUATION

8.1 METHOD OF ECONOMIC EVALUATION

The examination of the economic effects of the Kepez Project is to be done by consideration of a standard-type oil-fueled thermal power plant which would be constructed as the alternative facility in case there were no Kepez Project, and with the fixed costs and variable costs of this power plant as the criteria, the kW benefit and kWh benefit are calculated and the effective power and effective electric energy of the Kepez Project are to be multiplied by these, and comparisons made with the costs of the power generation facilities.

8.2 ANNUAL COST OF ALTERNATIVE THERMAL POWER PLANT

It is assumed that a standard-type oil-fueled thermal power plant will be constructed at the load center in the West Anatolia Region and the construction cost and general features are indicated in Table III-8-1.

Table III-8-1 Alternative Thermal Power Plant

Item	Unit	Description
Installed Capacity	MW	600 (300 MW x 2)
Annual Utilization Factor	%	73
Thermal Efficiency	%	35
Annual Energy Production	GWh	3,840
Construction Cost	10^6TL	9,000
Economic Life	year	25
Station Service Use	%	kW 2.5, kWh 2.8

The construction cost of the alternative thermal power plant is estimated at 9,000 x 10^6 TL. The annual cost of the alternative thermal power plant is broken down into fixed costs and variable costs.

Fixed Cost :

$$9{,}000 \times 10^6 \text{ TL} \times 0.1533^* = 1{,}380 \times 10^6 \text{ TL}$$

*Note :	Capital Recovery Factor	10.6% (Interest Rate : 9.5%)
	Operation and Maintenance	4.23%
	Administration	0.50%
	Total	15.33%

Variable Cost :

The variable cost per kWh is to be calculated by the equation below with fuel cost as the criterion.

$$\frac{0.86 \times \text{Calorie Cost}}{\text{Thermal Efficiency} \times (1 - \text{Station Service Use})}$$

$$= \frac{0.86 \times 22.5}{0.35 \times (1-0.028)} = 57 \text{ kurus/kWh}$$

Note :

$$\text{Calorie Cost} : \frac{\text{Fuel Cost}}{\text{Fuel Calorie}} = 22.5 \text{ kurus/1,000 kcal}$$

Fuel Cost : 2,160 TL/ton

Fuel Calorie : 9,600 kcal/kg

Thermal Efficiency : 0.35

Station Service Use : 0.028

8.3 ANNUAL BENEFIT

8.3.1 Method of Benefit Calculation

The benefit of the Kepez Project is to be based on the various figures for the above-mentioned alternative thermal power station divided into kW benefit and kWh benefit which are respectively calculated by the methods described below, with the sum total being the benefit.

8.3.2 Calculation of kW Benefit

The kW benefit is to be the effective power (output as a rule capable of more than 6 hours operation with firm power as the criterion) of the Kepez Project con- multiplied by the unit kW benefit.

The unit kW benefit is computed based on the standard fixed costs of the alternative thermal power plant, but in this case, in order for the reliabilities of supply capability of hydro and thermal to be compared under identical conditions, it is decided to consider output reduction due to periodic repairs and faulting of the thermal, while to make the standpoint of comparison between hydro and thermal the same, transmission losses and transmission costs to the primary substation entrance are to be considered.

The kW benefit is obtained by the equation below.

(kW Benefit) Effective Power

$$\times \frac{\text{Fixed Cost of Alternative Thermal Power Plant}}{\text{(Installed Capacity of Alternative Thermal Power)} \times (1 - \text{Station Service Ratio})(1 - \text{Fault Ratio})(1 - \text{Repair Ratio})(1 - \text{Transmission Loss Ratio})}$$

+ (Transmission Cost per kW from Thermal Power Station to Entrance of Primary Substation)

Note :

Fixed Cost of Alternative Thermal Power : 1,380 x 10^6 TL

Installed Capacity of Alternative Thermal Power : 600,000 kW

Station Service Use : 0.025

Fault Ratio : 0.05

$$\text{Repair Ratio :} \frac{\text{Standard Number of Days of Repair}}{365 \times \text{Stacking Ratio}}$$

$$= \frac{40}{365 \times 0.90} \doteq 0.122$$

With regard to the transmission loss ratio and transmission cost, these are omitted assuming that the alternative thermal plant will be constructed near the load center.

8.3.3 Calculation of kWh Benefit

The kWh benefit is to be the effective electric energy of the Kepez Project multiplied by unit kWh benefit. The kWh benefit is determined by the equation below with the variable cost of the alternative thermal power plant as the basis.

(kWh Benefit) = Effective Electric Energy

$$\times \frac{\text{Variable Cost of Alternative Thermal Power Plant}}{\text{(Annual Energy Production of Alternative Thermal Power Plant)} \times (1 - \text{Station Service Use}) \times (1 - \text{Average Transmission Loss Ratio})}$$

Note :

Variable Cost of Alternative Thermal Power Plant : 2,123 x 10^6 TL

Annual Energy Production of Alternative Thermal Power Plant :
3,840 x 10^6 kWh

Station Service Use : 0.028

With regard to the average transmission loss ratio, it is omitted assuming that the alternative thermal power plant will be constructed near the load center.

8.4 ANNUAL COST

The annual cost is to be the annual cost of the Kepez Project plus the transmission cost to the entrance of the primary substation. The annual cost ratio is to be 11.5%*.

* Capital Recovery Factor		9.66%
Interest		9.5%
Economic Life		
Civil Works, 50 years	70%	
Electro-Mechanical, 25 years	30%	
Overall economic life	45 yr	
Operation and Maintenance Expense		1.54%
Administration Cost		0.30%
Total		11.5%

8.5 RESULTS OF ECONOMIC EVALUATION

The results of calculation of benefit-cost ratio (B/C) for the Kepez Project taking account of the additional benefit at Altınkaya Power Station is indicated in Table III-8-2.

Table III-8-2 Estimation of Economic Evaluation

Item	Unit	Description
Firm Peak Output	MW	449.4
Losses	%	7.8
Effective Output	MW	414.3
Unit Price per kW	TL/kW	2,830
kW Value	10^6 TL	1,172
Annual Energy	10^6 kWh	1,468.4
Losses	%	7.8
Effective Energy	10^6 kWh	1,353.9
Unit Price per kWh	TL/kWh	0.57
kWh Value		772
Annual Benefit (B)	10^6 TL	1,944
Construction Cost	10^6 TL	14,124
Annual Cost (C)	"	1,624
Surplus Benefit (B-C)	10^6 TL	320
Benefit-Cost Ratio (B/C)		1.197

8.6 INTERNAL RATE OF RETURN

A thermal power station having a capacity equal to the effective output and effective energy of Kepez Power Station is considered as being constructed as the alternative facility, and the cost required for construction and operation and maintenance of this alternative power station is assumed to be the benefit of Kepez Power Station. Therefore, the costs of construction and the annual costs of operation and maintenance of Kepez Power Station and the alternative thermal power station are converted to present worths assuming an interest rate, and the interest rate at which the present worths of the two become equal is the internal rate of return.

The preconditions necessary for computation of the internal rate of return are given below.

(1) The economic life of Kepez Power Station is considered to be 50 years from start of operation with all electrical equipment to be replaced after 25 years from the start of operation. Operation and maintenance costs are considered to be

disbursed in equal annual amounts throughout the economic life.

(2) It is considered that an alternative thermal power station will be in operation for the economic life of Kepez Power Station, that is 50 years. However, the economic life of the alternative thermal power station is to be 25 years and it is considered that a facility with equal capacity will have been newly constructed in the neighborhood by the time the economic life of the first comes to an end. Operation and maintenance costs and fuel costs are considered to be disbursed in equal annual amounts during the economic life of Kepez Power Station.

(3) The firm peak output (including the increase of the firm peak out put of Altınkaya Power Station of 27 MW) and the annual energy generation of Kepez Power Station are considered as 449.3 MW and 1,468 GWh, respectively. The operation and maintenance cost is taken to be 1.84% of the construction cost.

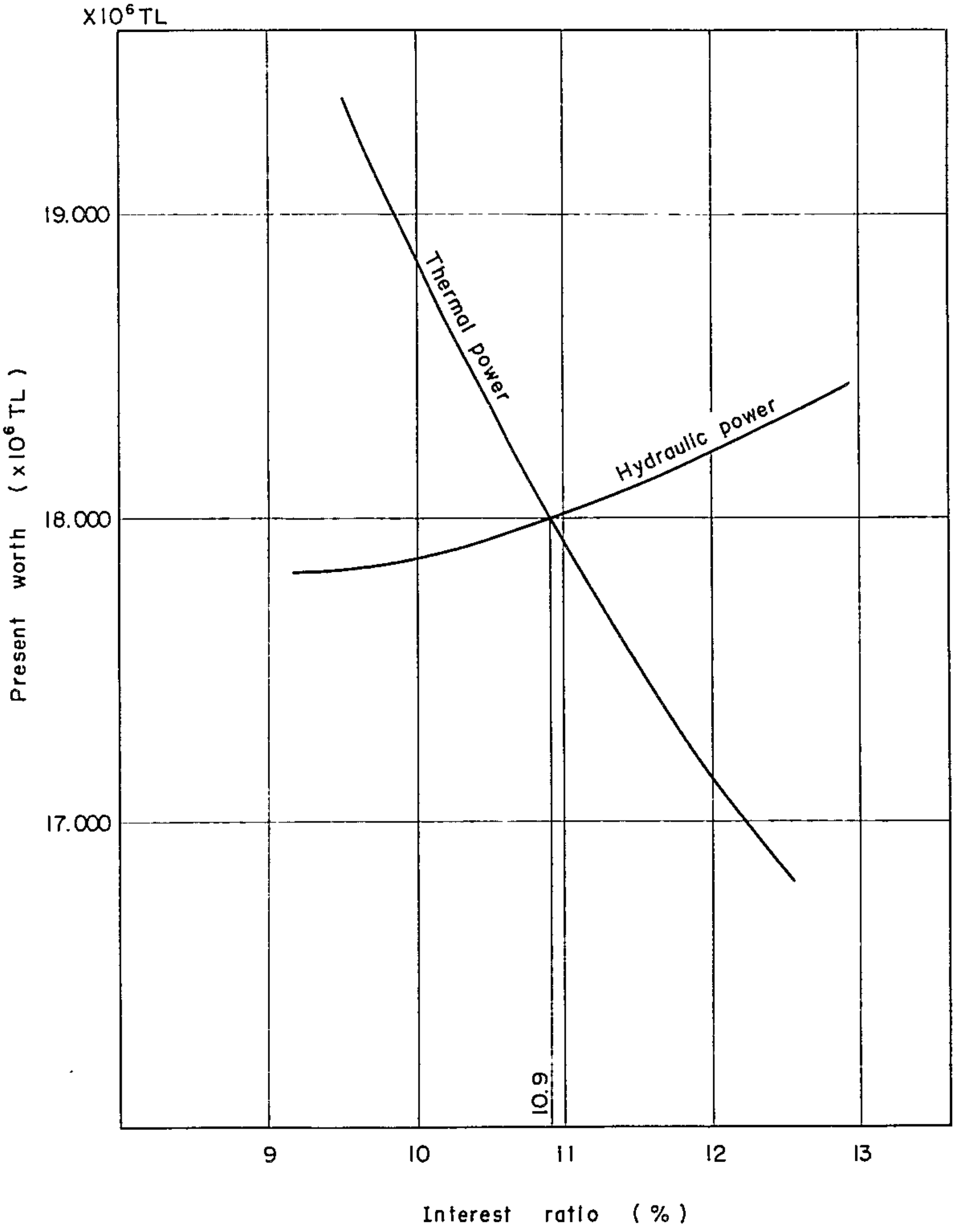
(4) The installed capacity of the alternative thermal power station is to be 512.2 MW with annual energy generation 1,395 GWh, and the operation and maintenance cost is to be 4.73% of the construction cost, while the fuel cost is to be 0.57 TL/kWh. The construction cost of the alternative thermal power station, as mentioned previously, is to be 15,000 TL/kW (construction period, 4 years; interest rate, 9.5%).

The results of calculation of the internal rate of return are indicated in Table III-8-3 and Fig. III-8-1, with internal rate of return computed to be 10.9%.

Table III-8-3 Cash Flow for Economic Comparison

Year	Hydraulic-power				Thermal-power			
	Construction (Civil)	Construction (Ele.)	Operation cost	Amount	Construction cost	Operation cost	Fuel & oil cost	Amount
1st	632.6			632.6				
2nd	889.0			889.0				
3rd	674.7	667.0		1,341.7				
4th	1,541.3	353.7		1,895.0	539.2			539.2
5th	1,629.6	929.5		2,559.1	2,156.6			2,156.6
6th	1,402.2	731.7		2,133.9	2,156.6			2,156.6
7th	913.7	791.0		1,704.7	539.2			539.2
8th - 28th			260.0	260.0		363.4	767.3	1,130.7
29th			260.0	260.0	539.2	363.4	767.3	1,669.9
30th			260.0	260.0	2,156.6	363.4	767.3	3,287.3
31st			260.0	260.0	2,156.6	363.4	767.3	3,287.3
32nd		667.0	260.0	927.0	539.2	363.4	767.3	1,669.9
33rd		353.7	260.0	613.7		363.4	767.3	1,130.7
34th		929.5	260.0	1,189.5		363.4	767.3	1,130.7
35th		731.7	260.0	991.7		363.4	767.3	1,130.7
36th		791.0	260.0	1,051.0		363.4	767.3	1,130.7
36th - 57th			260.0	260.0		363.4	767.3	1.130.7

Fig. III-8-1 Comparison of present worth



CHAPTER 9

FUNDING PLAN

CHAPTER 9 FUNDING PLAN

LIST OF TABLES

CHAPTER 9 FUNDING PLAN

9.1 FUND REQUIREMENT AND FUND PROCUREMENT

The total construction cost, as described in Chapter 7, will be the following:

Total Amount	14,124,000,000 TL
Foreign Currency Portion	7,294,000,000 TL
Domestic Currency Portion	6,830,000,000 TL

and the fund requirements by year are indicated in Table III-7-3. It is assumed that procurement of funds will be from an international financing institution for the foreign currency portion and from a domestic financing institution for the domestic currency portion. The interest rates and repayment periods are assumed to be indicated below.

Foreign Currency	
Interest rate	7.25% (commitment charge not considered)
Repayment method	7 years deferment, 15 years repayment of capital and interest in equal instalments
Domestic Currency	
Interest rate	9.5%
Repayment method	7 years deferment, 10 years repayment of capital in equal instalments

9.2 INCOME AND EXPENDITURES

(1) Electricity Charge Revenues

The electric power generated at Kepez Power Station is intended to be supplied to the power system of all of the Republic of Turkey. The prevailing electricity sales charges, as described in Chapter 2, Part II consist of a dual system of tariffs set forth by the government. These electricity sales tariffs are controlled and to compute electricity charge revenues using the above-mentioned tariffs would result in underestimation of income. However, since it is difficult to set electricity tariffs whereby income and expenditure would be balanced, here the sum of effective output benefit and effective energy benefit described in Chapter 8 will be tentatively used. The electricity charge income is indicated in Table III-9-1.

(2) Operation, Maintenance and Administrative Costs

The expenses required for operation, maintenance and administrative costs for Kepez Power Station are indicated below.

Operation and maintenance cost	1.54% of construction cost
Administrative cost	0.30 % of construction cost

(3) Depreciation Cost

The depreciation cost is calculated by the straight-line method with residual value as zero. The economic lives are to be 50 years for civil engineering facilities and 25 years for electrical equipment and power transmission facilities.

(4) Net Profit

Deducting operation and maintenance costs, administrative costs and depreciation costs from the incomes of the various years calculated according to the conditions above, and further deducting interest paid on borrowings, there will be a net profit obtained as shown in Table III-9-1 in the first year after start of operation.

9.3 REPAYMENT PLAN

The sources for repayment of borrowings will consist of the net profit in the balance of current accounts and the depreciation reserves. Calculating the cash balance assuming that repayments of the foreign and domestic currency portions will be made based on the terms indicated in 9.1, the result will be as shown in Table III-9-2. According to this table, recovery of the capital invested will be completed in the 12th year after start of operation.

However, since the funding plan for the Project has been calculated on a trial basis making assumptions of loan terms and electricity charge income, it is desirable for the funding plan to be subjected to further examination.

Table III-9-1 Income Statement

(10^6 TL)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
(A) Income								1944.2	1944.2	1944.2	1944.2	1944.2	1944.2	1944.2	1944.2	1944.2	1944.2	1944.2	1944.2	1944.2	1944.2	1944.2
Effective Output (MW)								414.3	414.3	414.3	414.3	414.3	414.3	414.3	414.3	414.3	414.3	414.3	414.3	414.3	414.3	414.3
Unit Price (TL/kW)								2830.0	2830.0	2830.0	2830.0	2830.0	2830.0	2830.0	2830.0	2830.0	2830.0	2830.0	2830.0	2830.0	2830.0	2830.0
kW Value								1172.5	1172.5	1172.5	1172.5	1172.5	1172.5	1172.5	1172.5	1172.5	1172.5	1172.5	1172.5	1172.5	1172.5	1172.5
Effective Energy (10^6 kWh)								1353.9	1353.9	1353.9	1353.9	1353.9	1353.9	1353.9	1353.9	1353.9	1353.9	1353.9	1353.9	1353.9	1353.9	1353.9
Unit Price (TL/kWh)								0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
kWh Value								771.7	771.7	771.7	771.7	771.7	771.7	771.7	771.7	771.7	771.7	771.7	771.7	771.7	771.7	771.7
(B) Total Operation Cost								639.9	639.9	639.9	639.9	639.9	639.9	639.9	639.9	639.9	639.9	639.9	639.9	639.9	639.9	639.9
Operation & Maintenance								217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5
Administration & Others								42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4
Depreciation								380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0
(C) Operation Income (A) - (B)								1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3
(D) Financial Expenditure (Interest)								1177.7	1092.2	1005.1	916.5	826.1	733.9	639.7	543.5	444.9	343.9	240.2	198.7	154.1	106.3	55.0
Foreign Loan								528.8	508.2	486.0	462.3	436.8	409.5	380.2	348.8	315.1	279.0	240.2	198.7	154.1	106.3	55.0
Domestic Loan								648.9	584.0	519.1	454.2	389.3	321.4	259.5	194.7	129.8	64.9					
(E) Net Income (C) - (D)								126.6	212.1	299.2	387.8	478.2	570.4	664.6	760.8	859.4	960.4	1064.1	1105.6	1150.2	1198.0	1249.3

Table III-9-2 Cash Flow Statement

(10^6 TL)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
(A) Cash Credit	658.0	978.6	1529.6	2230.3	3105.8	2913.7	2708.0	1684.3	1684.3	1684.3	1684.3	1684.3	1684.3	1684.3	1684.3	1681.3	1684.3	1684.3	1684.3	1681.3	1684.3	1684.3
1. Operation Income before Interest								1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3	1304.3
2. Depreciation								380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0	380.0
3. Exterior Borrowing																						
Foreign Fund	66.9	278.3	964.7	1109.5	1893.1	1700.5	1281.0															
Domestic Fund	591.1	700.3	564.9	1120.8	1212.4	1213.2	1427.0															
(B) Cash Disbursement	658.0	978.6	1529.6	2230.3	3105.8	2913.7	2708.0	2145.4	2080.6	2015.6	1950.7	1885.8	1820.9	1756.0	1691.2	1626.3	1561.5	813.5	813.6	813.5	813.6	813.5
1. Construction Expenditure	658.0	978.6	1529.6	2230.3	3105.8	2913.7	2708.0															
2. Interest								1177.7	1092.2	1005.1	916.5	826.1	733.9	639.7	543.5	444.9	343.9	240.2	198.7	154.1	106.3	55.0
3. Amortization of Debit (Principal)								967.7	988.4	1010.5	1034.2	1059.7	1087.0	1116.3	1147.7	1181.4	1217.6	573.3	614.9	659.4	707.3	758.5
Foreign Fund								284.7	305.4	327.5	351.2	376.7	404.0	433.3	464.7	498.4	534.6	573.3	614.9	659.4	707.3	758.5
Domestic Fund								683.0	683.0	683.0	683.0	683.0	683.0	683.0	683.0	683.0	683.0					
(C) Cash Balance (A) - (B)	-	-	-	-	-	-	-	-461.1	-396.3	-331.3	-266.4	-201.5	-136.6	-71.7	-6.9	58.0	122.8	870.8	870.7	870.8	870.7	870.8
(D) Accumulated Total	-	-	-	-	-	-	-	-461.1	-857.4	-1188.7	-1455.1	-1656.6	-1793.2	-1864.9	-1871.8	-1813.8	-1691.0	-820.2	50.5	921.3	1792.0	2662.8

PART Ⅳ

BOYABAT HYDROELECTRIC POWER DEVELOPMENT PROJECT

PART IV

BOYABAT HYDROELECTRIC POWER DEVELOPMENT PROJECT

CHAPTER 1

GENERAL

CHAPTER 1 GENERAL

The two sites of Boyabat and Kepez have been proposed as dam sites for the Project, and making a comparison study of the two sites is a matter of great importance.

The Boyabat site, as indicated in DWG. IV-4-1, is located 6 km upstream of the Kepez site. The river-bed width of the dam site is large at 270 m while the width-height ratio is 1:4 and the topography is in sharp contrast to the Kepez site. Accordingly, dam types other than rockfill are inconceivable for this site. If the spillway and power station are to be located at the right-bank side as indicated in DWG. IV-4-2, the layout of structures as a whole will be ideal from the viewpoint of ease of construction.

However, as stated in Conclusions of Part I, since the dam volume will be excessively large, the total construction cost will be 41% higher than for the Kepez site, while the tailrace water level will be 10.5 m higher, and the annual energy production will be 9% less than for the Kepez site. The benefit-cost ratio will consequently be 0.768 so that it cannot be said to be an economical site.

For the above reason, the Report up to this point has been prepared focusing on the Kepez site, but in this Part, the results of the study on the Boyabat site will be given in outline.

Synopsis

Item	Unit	Description
Location	-	On the Kızılırmak River
Catchment Area	km^2	64,675
Annual Inflow	10^6m^3	4,806
Design Flood	m^3/sec	9,300
Reservoir		
High Water Level	m	330.50
Normal Water Level	m	330.00
Reservoir Area	km^2	58.71
Gross Storage Capacity	10^6m^3	3,040
Effective Storage Capacity	10^6m^3	1,410
Diversion Tunnel		
Diameter	m	8.40
Length	m	990 + 970 = 1,960
Dam		
Type	-	Rockfill Type
Crest Elevation	m	335.00
Dam Height	m	195.00
Crest Length	m	670.00
Volume	10^3m^3	20,600
Spillway		
Type	-	Chute with Roller Bucket
Capacity	-	9,300 m^3/s at high water level
Intake		
Type	-	Vertical Type
Control Gate	-	Roller Gate
Penstock		
Type	-	Exposed
Length	m	380.00
Diameter	m	5.50

Item	Unit	Description
Powerhouse		
Type	-	Semi-underground Type
Power Generation Facilities		
Number of Units	unit	3
Unit Capacity	kW	153,000
Turbine		
Number	unit	3
Type	-	Vertical Shaft Francis Turbine
Normal Effective Head	m	112.90
Maximum Discharge	m^3/sec	157.00
Output	kW	159,000
Rated Speed	rpm	167
Generator		
Number	unit	3
Type	-	Vertical Shaft Synchronous Generator
Rated Output	kVA	170,000
Rated Voltage	kV	16.5
Rated Power Factor	%	90 (lagging)
Rated Frequency	Hz	50
Rated Speed	rpm	167
Main Transformer		
Number	unit	3
Type	-	3-phase, Outdoor-Type
Rated Capacity	kVA	170,000
Rated Voltage	kV	16.5/380
Switchyard		
Nominal Voltage	kV	380
Type of Circuit Breaker	-	SF_6 Circuit Breaker
Transmission Line		
Number of Circuit	unit	3
Nominal Voltage	kV	380

Item	Unit	Description
Annual Energy Production		
Total Energy	GWh	1,342
Firm Energy	GWh	824
Secondary Energy	GWh	518
Project Cost		
Investment (9.5% interest rate)	10^6TL	19,874
Surplus Benefit and Benefit-Cost Ratio		
Annual Benefit (B)	10^6TL	1,756
Annual Cost (C)	10^6TL	2,286
Surplus Benefit (B-C)	10^6TL	- 530
Benefit-Cost Ratio (B/C)	-	0.768