REPUBLIC OF TURKEY

MINISTRY OF ENERGY AND NATURAL RESOURCES
GENERAL DIRECTORATE OF STATE HYDRAULIC WORKS

FEASIBILITY STUDY OF THE KÜRTÜN PROJECT WITH COMPREHENSIVE DEVELOPMENT OF THE HARSIT RIVER BASIN

(VOLUME I)

SEPTEMBER 1969

GOVERNMENT OF JAPAN

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GOVERNMENT OF JAPAN

PREFACE

In accordance with a request from the Government of Republic of Turkey, the Government of Japan entrusted the Overseas Technical Cooperation Agency (OTCA) with the task of conducting a feasibility survey for the Harsit River, the Kurtun Hydroelectric Power Project in Turkey.

OTCA, fully realizing the significance of the mission assigned to it, organized a survey team consisting of six experts from the Ministry of International Trade and Industry and the Electric Power Development Company headed by Mr. Akihiro Irie and dispatched the team to Turkey on March 1, 1969 for about one month. The team made a survey for the feasibility study of the project, studied and discussed with engineers of the Turkish State Hydraulic Works (DSI) various problems relating to the project.

After the return of the team to Japan, the preliminary design work was carried out and the results are herewith submitted to the General Directorate of the State Hydraulic Works as the "Feasibility study of Kurtun Hydroelectric Power Project."

It is my sincere hope that this report which is the outcome of the cooperation of the people of the Republic of Turkey and Japan, will prove to be useful in some way or other for the future development of Turkey as well as for the promotion of friendship and economic cooperation between the two countries.

On behalf of OTCA, I would like to take this opportunity to express my deepest appreciation to the Government of Republic of Turkey, the Embassy of Japan and other competent Authorities concerned for their unlimited cooperation, assistance and warm hospitality extended to the team during their stay in Turkey.

September, 1969

Keiichi Tatsuke
Director General
Overseas Technical Cooperation
Agency

LETTER OF TRANSMITTAL

September, 1969

Keiichi Tatsuke, Director General
Overseas Technical Cooperation Agency
Tokyo, Japan.

Dear Sir:

Presented herewith is a Report on the Feasibility Studies of the Kurtun Project with the Comprehensive development of the Harsit River Basin in the Republic of Turkey. The study, at your request, was carried out by the Electric Power Development Company (EPDC) as a survey team organized by the Overseas Technical Cooperation Agency (OTCA). OTCA dispatched the survey team consisting of six experts for the purpose of conducting a feasibility survey of the said project.

The team conducted investigations on topography, geology, materials, hydrology, etc. and surveys of the project area based on "the Harsit River Reconnaissance Report" prepared by the Seventh Regional Construction Office of DSI, while gathering other relevant data necessary for preparation of the plan.

Upon its return to Japan, the Electric Power Development Company prepared this report based on the results of the field investigations and information obtained in Turkey, along with analysis of hydrological data, load forecast, preliminary design, construction cost estimation, economic evaluation, etc. The work was performed by engineering staff of EPDC under the direction of its Chief Engineer. The purpose of the Kurtun Project is to develop an economical hydroelectric power development by constructing a dam on the middlestream of the Harsit River and to produce a total output of 61 MW utilizing an effective head of 103 m. The catchment area at the proposed dam site is 2,753 sq.km with an annual runoff of approximately 900 million cu.m. The runoff of the river will be regulated by a reservoir having an effective capacity of 73 million cu.m. The annual available energy is estimated at 200 x 10^6 kWh. This energy will be sent to the Central system and the Eastern Black Sea system through a 380-kV transmission line that is planned to be constructed along the Harsit River to enhance the dependability of the Keban Power Station. This project enables the Dogankent power station, which is now being under construction, to extend its installed capacity, and effectuates, together with the Akkoy reservoir which will serve the Kurtun Power Station as a re-regulating pond, the potential energy of the Harsit River.

For the execution of this project, a construction period of around four years and a construction expenditure of approximately 396.4 million Turkish Lira will be required.

The benefit-cost ratio of this project including the incidental downstream benefit at the two power stations, Akkoy and Dogankent, is 1.07, and approximately 3.3 million Turkish Liras of surplus benefit are obtainable. (Therefore, this project is considered appropriate from both the technical and economical viewpoints.)

In recent years, a power demand in Turkey has been remarkably growing, and it is, accordingly, deemed necessary to complete this project by the end of 1982 at the latest.

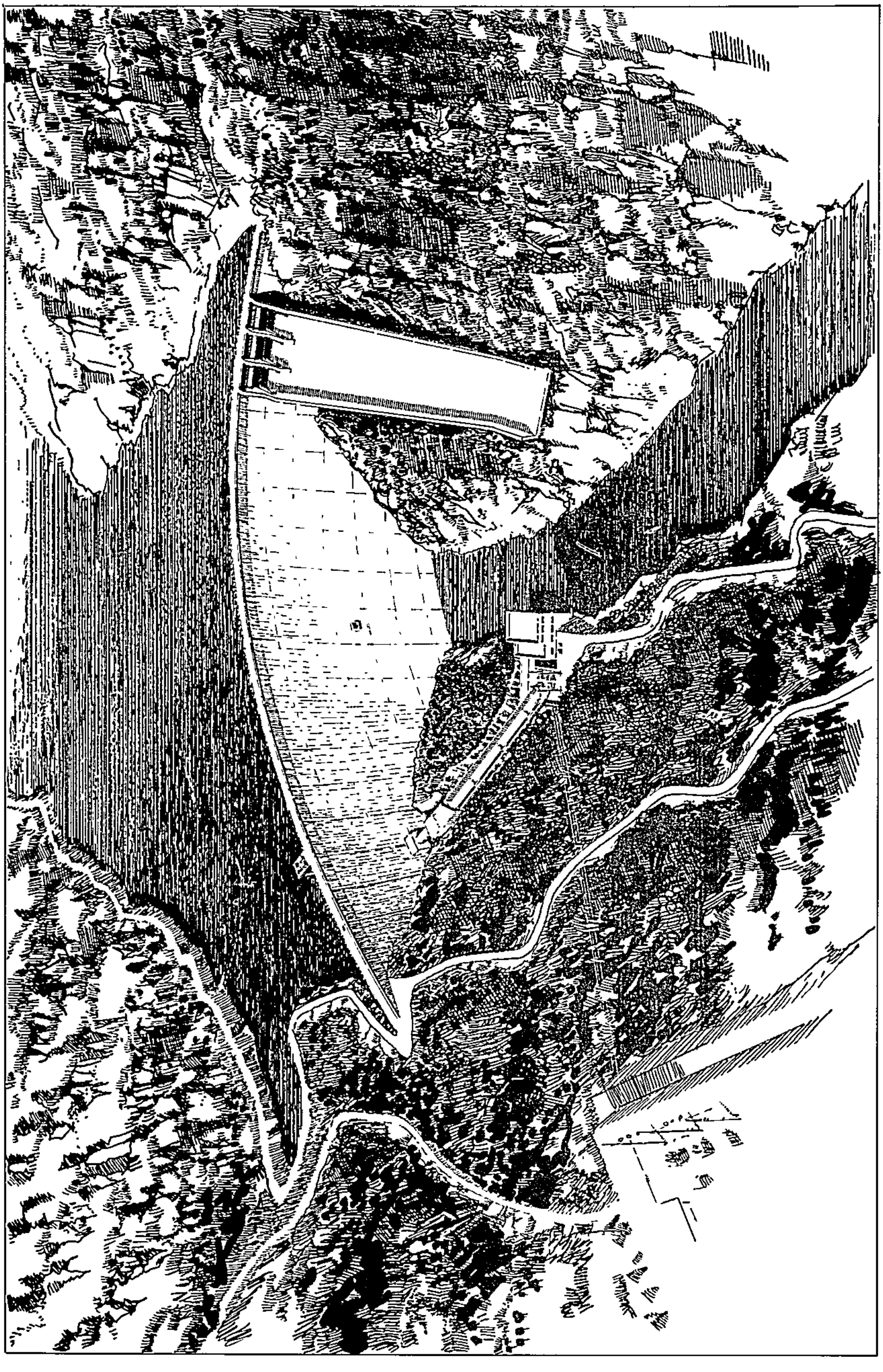
In view of the above mentioned fact, it is advisable to conduct additional surveys and studies described in the Chapter 2 of this report in order to secure the realization of the project.

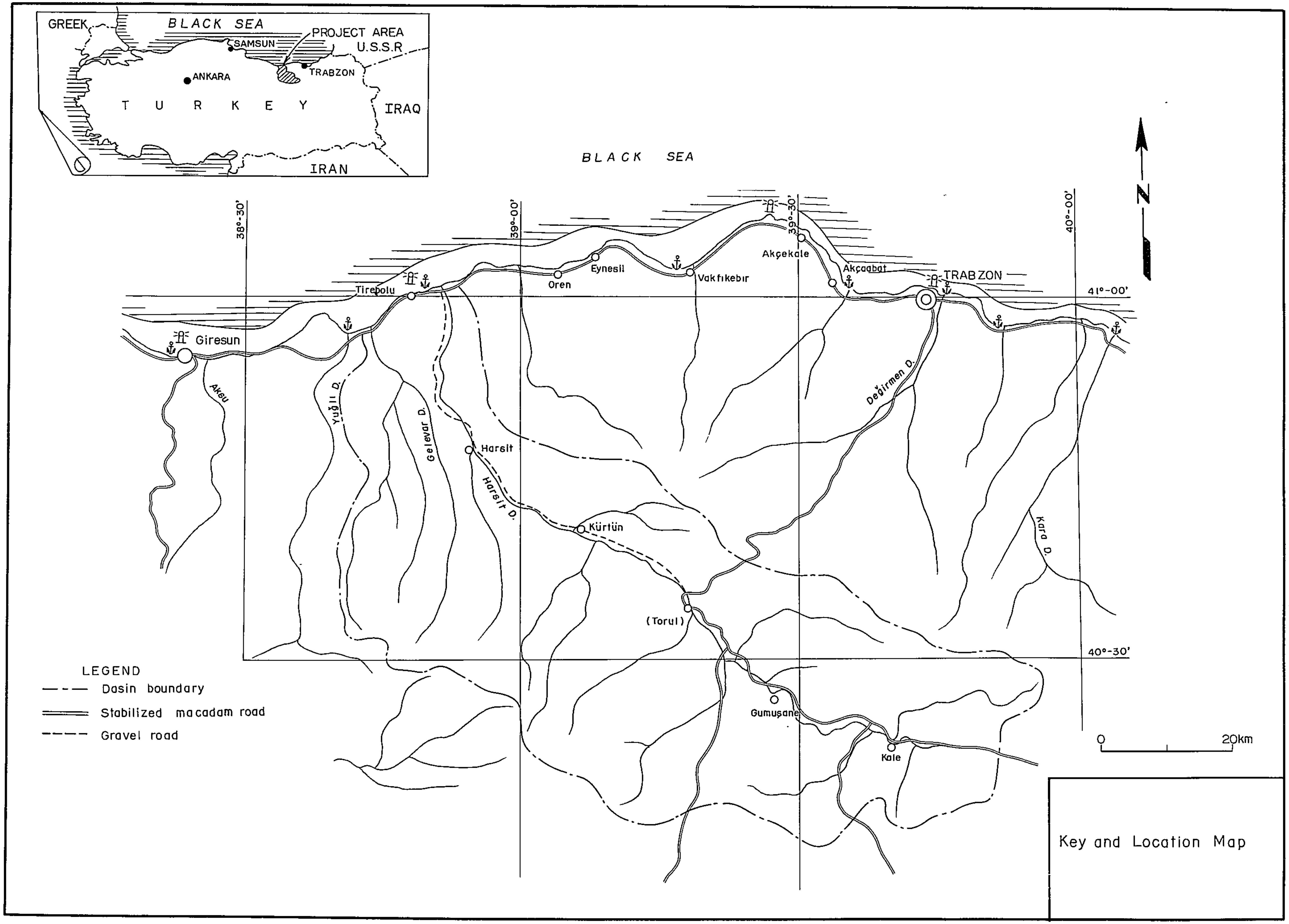
On behalf of the team members, I would like to take this opportunity to express our sincere appreciation and gratitude to Mr. Hazim Tütüncüoğlu, the General Director of the StatesHydraulic Works (DSI), and engineers of DSI and Eti Bank for their generous assistance and cooperation, as well as for the Embassy of Japan for its warmful hospitality extended to the team during its stay in Turkey.

Respectfully yours,

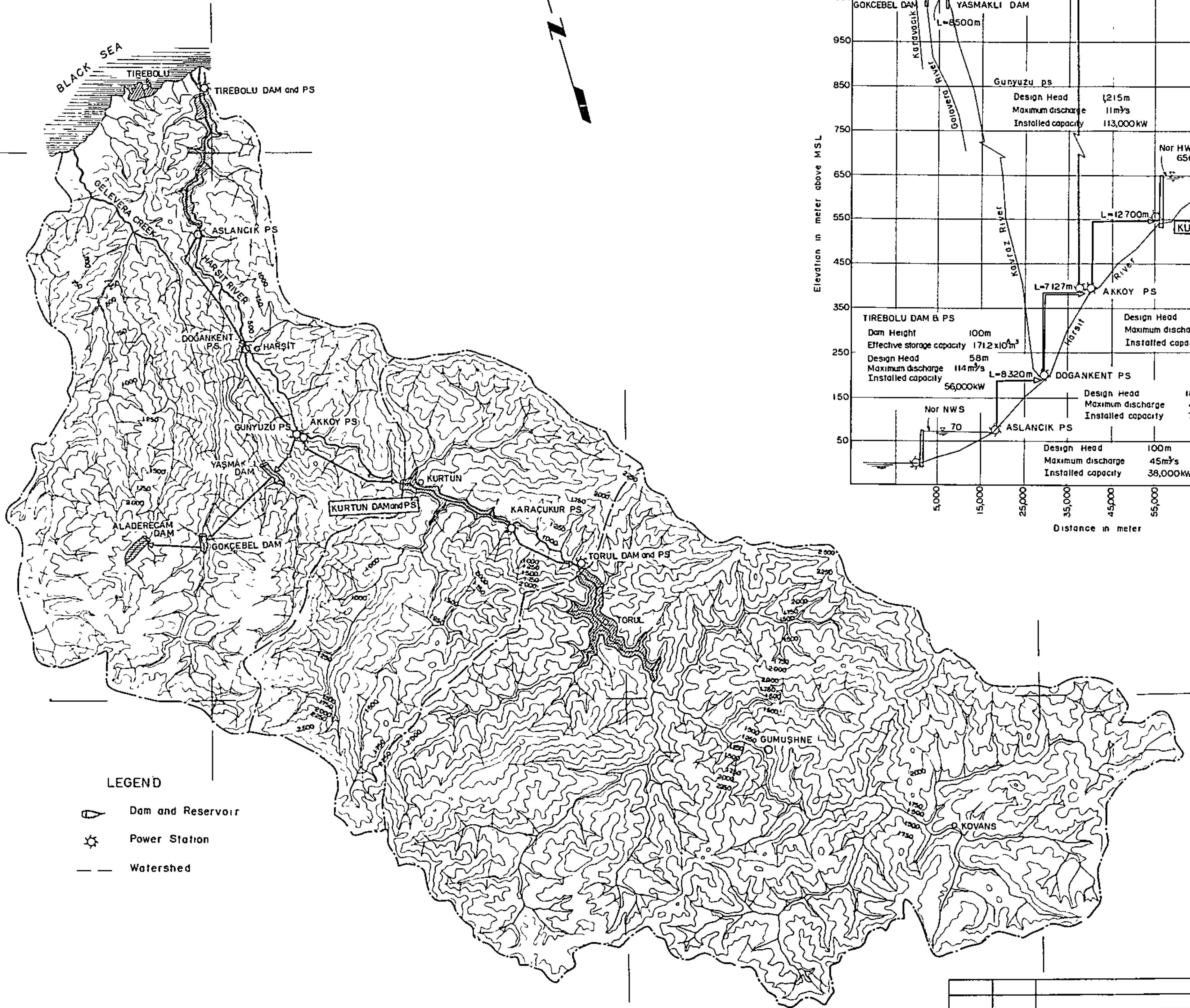
A. Irie

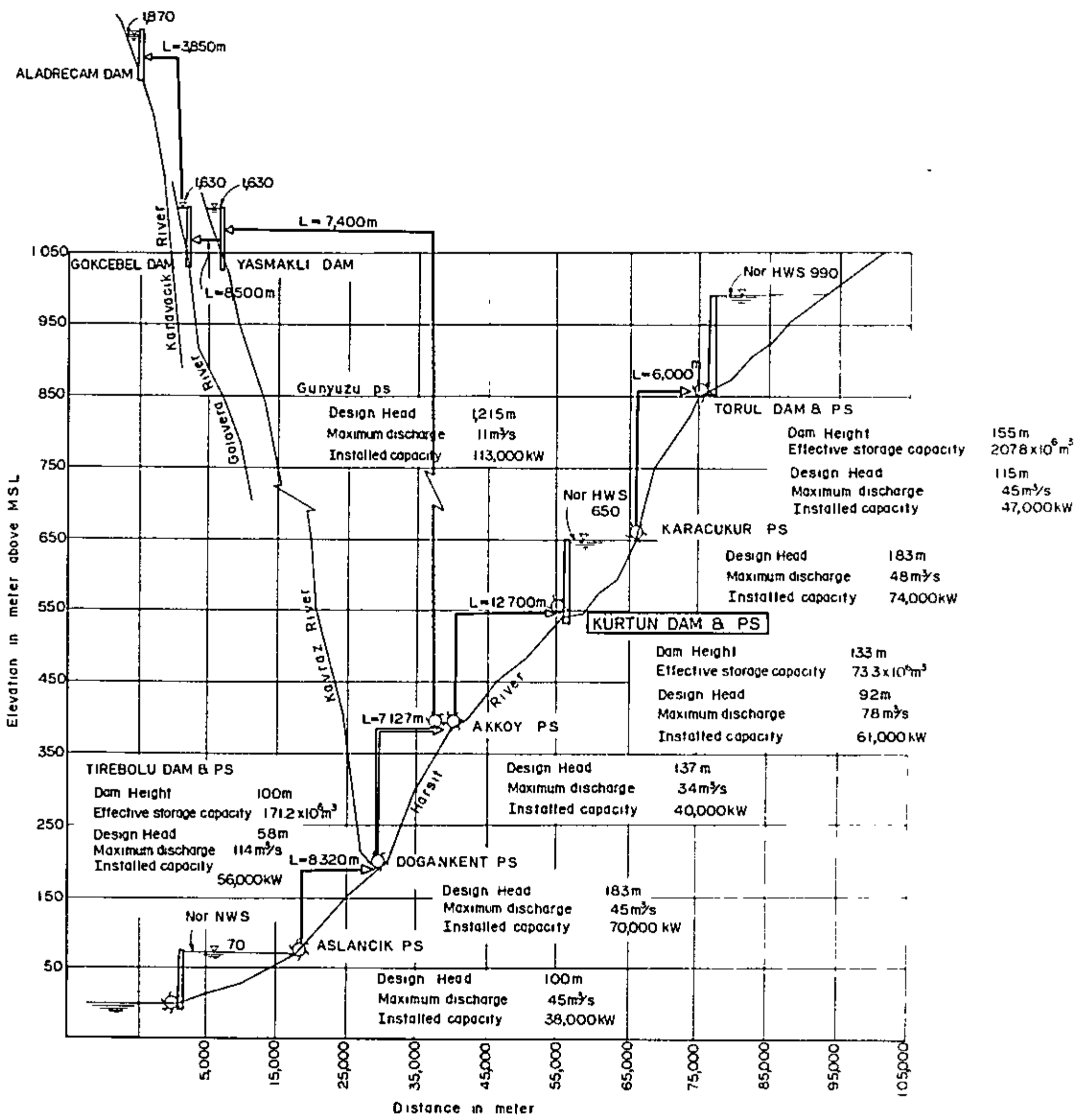
Akihiro Irie
Leader
The Japanese Government Survey Team
for the Kürtün Project





Key and Location Map





LEGEND

- Dam and Reservoir
- Power Station
- Watershed

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

DEVLET SU IŞLERI GENEL MUDURLUGU
ANKARA-TURKEY

KURTUN PROJECT

GENERAL PLAN AND PROFILE

ELECTRIC POWER DEVELOPMENT CO LTD
TOKYO JAPAN

D R	SUBMITTED	
T R	RECOMMENDED	
C K	APPROVED	

LOCATION	DATE	DESCRIPTION	BY
REVISION			

Brief Description of Project

1. Kurtun Power Station

1.1	Location	On the Harsit River
1.2	Catchment Area	2,753 sq. km.
1.3	Annual Inflow	900 million cu. m.
1.4	Flood	2,000 c.m.s. (maximum probable)
1.5	Reservoir	
	Maximum Water Surface	650.00 m
	Normal Water Surface	650.00 m
	Water Surface Area	3.1 sq. km.
	Total Storage Capacity	137 million cu. m.
	Effective Storage Capacity	73.3 million cu. m.
	Available Drawdown	30 m
1.6	Dam	
	Type	Concrete arch
	Elevation of Crest	653.00 m
	Height	133.00 m
	Length	425.00 m
	Volume	458,000 cu. m. (main dam)
1.7	Spillway	
	Type	Channel chute with radial gates
	Capacity	2,000 c.m.s. at flood water level EL. 650.00 m
	Generator	
	Number	2 units
	Type	3-phase, AC, synchronous generator vertical shaft, rotating field, enclosed hood air circulation type with air coolers 34,000 kVA (continuous)
	Rated Output	34,000 kVA (continuous)
	Rated Voltage	13,800 V
	Rated Current	1,422 A
	Rated Power Factor	0.9 (lagging)
	Rated Frequency	50 Hz
	Rated Speed	300 rpm
	Main Transformer	
	Number	1 unit
	Type	Outdoor, 3-phase, oil-immersed, forced-oil-cooled with forced air-cooler (Class FOA)
	Rated Capacity	68,000 kVA (continuous)
	Rated Voltage	Primary 13.8 kV
		Secondary 380 kV

Rated Frequency	50 Hz
Insulation level (BIL)	Primary 110 kV
	Secondary 1,425 kV
	Neutral 110 kV
1.8 Intake	
Type	Attached to the Dam
Control Gate	Roller Gate
1.9 Penstock	
Type	On the Ground, Ring Girder Supported Type
Length	130 m
Diameter	6.50 - 2.80
1.10 Powerhouse	
Type	Outdoor
1.11 Power Generation Facilities	
Unit Capacity	30,500 KW
Number of Units	2
Turbine	
Number	2 units
Type	Vertical shaft, single runner, single discharge, Francis turbine
Normal effective head	92 m
Discharge	39 m^3/s (at nor effective head)
Output	31,600 kW (at nor effective head)
Rated speed	300 rpm
Specific speed	187 m-kW
2 Switchyard Equipment	
Shunt Reactor 120 MVA	1 set
380 kV Circuit Breaker	5 sets
380 kV Disconnecting Switch	13 sets
3 Telecommunication Equipment	
Power Line Carrier Telephone	three channels between Kurtun P.S. and Samsun S.S., two for load dispatching use and one for administrative use
	three channels between Kurtun P.S. and Keban P.S., one for load dispatching use and two for administrative use
4. Construction Period	45 months
5 Start of Operation	April 1982

6. Annual Energy Production

Annual Total Energy	200 million kWh
Annual Firm Energy	77.5 million kWh
Annual Secondary Energy	122.5 million kWh

7. Project Cost

Unit : 1.000 TL

	5% Interest Rate	8% Interest Rate
Generating Facilities	354.366	367.491
Step-up Substation Facilities	42.033	43.901
Total	396.399	411.392

8. Surplus Benefit and Benefit-Cost Ratio

Unit : 1.000 TL

	Kurtun	Akkoy	Additional Dogankent	Total
Annual Benefit	19.520	18.220	12.325	50.065
Annual Cost	27.809	15.672	3.313	46.794
Surplus Benefit	- 8.289	2.548	9.012	3.271
Benefit/Cost				1 07

Note : at 5% interest rate

Unit and Conversion

mm	:	Millimeter
cm	:	Centimeter
m	:	Meter
km	:	Kilometer
sq. mm	:	Square millimeter
sq. cm	:	Square centimeter
sq. m	:	Square meter
sq. km	:	Square Kilometer
ha	:	Hectare
cu. m	:	Cubic meter
gr.	:	Gram
kg	:	Kilogram
ton	:	Metric ton
m/sec.	:	Meter per second
c.m.s.	:	Cubic meter per second
c.m.s. -day	:	Cubic meter per second day
kW	:	Kilowatt
kWh	:	Kilowatt hour
MW	:	Megawatt
kV	:	Kilovolt
kVA	:	Kilovolt - Ampere
MWh	:	Megawatt - hour
rpm	:	Revolutions per minute
EL	:	Height above mean sea level
C	:	Centigrade
p.p.m.	:	Parts per million
%	:	Percentage
$	:	U.S. dollar
TL	:	Turkish lira
1 ha	:	10,000 sq. m.
1 MW	:	1,000 kW
1 GWh	:	1,000,000 kW
1 $	:	100 cents, 360 yen
1 TL	:	9 U.S. dollars

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CHAPTER 1

INTRODUCTION

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Drawing List in Volume I

CHAPTER 1

INTRODUCTION

CONTENTS

CHAPTER 1 INTRODUCTION

1.1 AUTHORIZATION

On February 10, 1969, Mr. Hazim Tütüncüoğlu, the General Director of the State Hydraulic Works (hereinafter called DSI), representing the Government of the Republic of Turkey, visited the Japanese Embassy in Turkey and requested the Government of Japan to conduct a feasibility study of the Kurtun Project on the Harsit River. In response to this request, the Government of Japan assigned the study to the Overseas Technical Cooperation Agency (hereinafter called OTCA). In view of the fact that the purpose of the Project is electric power development on the Harsit River, the actual work of the study was carried out by the Electric Power Development Co. (hereinafter called EPDC) under assignment from OTCA.

1.2 FORMER STUDIES

Studies in regard to this Project have been conducted since 1950 and were mainly conducted by DSI as listed below.

(1) The project area was studied by E.I.E.I. during 1950 - 1960 and a formulation was established for several facilities presently under construction.

(2) In 1963, the Harsit Project Exploratory Report was prepared by the Survey and Planning Department of DSI. The planning report for the facilities currently under construction was also prepared by the Survey and Planning Department of DSI.

(3) In 1966, a report titled "Interesting Power Facilities Combinations for the Eastern Black Sea" was prepared by the Planning Group of DSI Division VII for submittal to the Technical Congress. This report treated diversion works from Harsit Valley and the Coruh River to the Harsit River.

(4) In 1967, reconnaissance studies for the entire Harsit River were carried out. According to the ensuing reconnaissance report, comprehensive development of the Harsit River would consist of 3 reservoir type power stations, 4 run-of-river type power stations, 3 reservoirs on the adjacent Gelevera Creek, tunnels to divert the water stored in these reservoirs to the middle reaches of the Harsit River where the said power plants would be located. A total installed capacity of 654 MW and annual potential energy production of 2,365 x 10^6 kWh will be available at these power stations.

1.3 SCOPE OF REPORT

Of the electric power development projects of the entire Harsit River basin, the Kurtun Project is considered to have the highest priority for development following the Dogankent Power Station presently under construction, and in order to meet the rapidly growing demand for power in Turkey, investigation work cheifly consisting of geological survey of the damsite has been carried out as a part of the DSI planning program of 1968.

Prior to field investigations, the Survey Mission had a meeting with Mr. Mufit Kulen, Director of the Planning Division of DSI on March 3, 1969 in Ankara for discussions regarding the objectives and scope of the investigations.

As a results of the discussions, it was confirmed that the objectives and scope of the studies of the Mission were as follows:

(1) Review of existing preliminary studies.
(2) Formulation of a master plan for the project area.
(3) Making feasibility studies for the Kurtun Project.

Also, it was required by the DSI's Seventh Regional Construction Office that based on formulation of the plans for the two large-scale reservoirs on the Harsit River, Torul and Kurtun, the final plans for the Dogankent Power Station which is under construction for the first stage development of an installed capacity of 32.8 MW, should be established, that is, the size of the cross section of Dogankent Headrace Tunnel should finally be determined between 20 sq.m. and 35 sq.m.

This report, in accordance with the objectives of the Survey Team based on the requests of DSI describes the investigation results of the Survey Team for the Kurtun Project in regard to the technical and economic feasibilities of the Kurtun Project with formulation of a master plan for the entire Harsit River basin as the main theme.

1.4 SURVEY AND STUDIES

1.4.1 Field Survey

The Survey Team stayed in Turkey for approximately one month from March 2 to March 29 and collected data on hydrology, geology, topography, the power market including supply and demand at Ankara and Samsun with the cooperation of the Planning Division of DSI, the Seventh Regional Construction Office and Etibank

Also, for approximately one week from March 18 to March 23, under the guidance of the Seventh Regional Construction Office personnel, a field reconnaissance of the various planned dam sites and powerhouse sites on the Harsit River was made with emphasis on investigations of topography and geology of the Kurtun and Torul damsites.

The names, specialities and organizations of the 6 persons of the Survey Team dispatched from the Ministry of International Trade and Industry and EPDC for the above investigations are as given below.

Team Leader	Akihiro Irie	Civil Engineer EPDC
Member	Yoshito Naito	Economist Ministry of International Trade and Industry
"	Toshio Hayashi	Civil Engineer EPDC
"	Hideharu Kashiwagi	Geologist EPDC
"	Kazuo Ozaki	Electrical Engineer
"	Hitoshi Murayama	Civil Engineer EPDC

1.4.2 Studies in Japan

Upon return of the Survey Team to Japan, studies of the project plans were carried out at EPDC under the direction of the Chief Engineer from April 1, 1969 to September 20, 1969 based on information obtained in Turkey. The studies made included analysis of hydrologic data, load forecasting, detailed study of plans, preliminary design, estimate of construction cost and economic evaluation and others which are all indispensable to verify the feasibility of the project.

1.5 SOURCE OF DATA

Basic data used in the studies were obtained either from DSI or from various organizations concerned through the offices of DSI.

The principal basic data are as follows:

1. Topographical Data

a)	Project Area Map	1/200,000
b)	KÜRTÜN Dam Location Map	1/1,000
c)	KURTUN Dam and Reservoir Map	1/5,000
d)	TORUL Dam Location Map	1/1,000
e)	TORUL Dam and Reservoir Map	1/5,000
f)	Harsit River Topographical Map	1/5,000
g)	Harsit Project Location Map	1/25,000

2. Hydrological Data

a) The map showing the existing gauging station network within and near the catchment area.

b) The map showing the existing precipitation gauging network

c) List of guaging stations and rainfall observation stations with the period of record and size of catchment area, and type of guage.

d) Tables of monthly precipitation and temperature

e) Runoff data (daily and monthly mean discharge and monthly flow) from DSI stations

f) Number of days with less than 5 mm of rainfall in each month at Tirebolu, Harsit and Torul.

g) Rating curves of sediment measurements

3. Geological Data

a)	Geological map of Kurtun Dam	1/1,000
b)	Geological map of Kurtun and Torul Dam Reservoir Area	1/25,000
c)	Core Description prepared by EIEI at KURTUN DAM	
d)	Geological Sketches of additional Exploratory Adits	
e)	Detailed Location Map of additional Exploratory Adits	

4. Load Forecast and Electric Data

a)	Statistics of Electric Power in Turkey 1964	(EIE)
b)	Eighth Annual Electric Power Survey 1965	(EIE)
c)	Annual Electric Power Survey 1966	(EIE)
d)	Annual Electric Power Survey 1967	(EIE)
e)	General Data on Electric Supply Industry in Turkey 1968	(EIE)

f) 1938, 1948 – 1967 National Income
(Total Expenditure and Investment of Turkey)
(Republic of Turkey, Prime Ministry, State Institute of Statistics)

g) First Five Year Development Plan 1963 - 1967

h) (ditto) 1964 Annual Program

i) (ditto) 1965 Annual Program

j) Second Five Year Development Plan 1968 - 1972

k) (ditto) 1968 Annual Program

l) (ditto) 1969 Annual Program

m) Presently owned Generating Capacity and Operation Data of Etibank

o) Power Development PLant of Etibank

p) Load Forecast for the Interconnected System estimated by Etibank

5. Others

a) Dogankent H.P P. Construction Program

b) Design of Dogankent H.P.P.

c) Principal Features of each Project on Harsit River

d) List of Compensation

e) Revised Summary Reconnaissance Report of Harsit Project

f) Construction Cost of Dogankent H.P.P.

g) Core Material Data from Proposed Borrow Area

Note: Among others, 3d) and 5g) were received on 25 of August 1969

CHAPTER 2

CONCLUSIONS AND RECOMMENDATIONS

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CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

2.1 CONCLUSIONS

(1) In recent years there has been a marked increase in power demand in Turkey with the average growth rate in the past several years having been as much as 12%. This growth was due to rapid industrialization and rising of national living standards brought about by enforcement of the First Five-Year Plan started in 1962 and the Second Five-Year Plan started in 1968. The power demand at demand end of entire Turkey in 1967 was 2,030 MW or 5,220 G.W.h. According to the review of load forecast made by Etibank at the beginning of 1969 and also according to the load forecast made by the Survey Team, it is anticipated that the growth of power demand will be even more rapid in the future and it is estimated that the average growth rate for the 4 years from 1970 through 1973 will be 23.3 %, and 8% from 1974 through 1982 and that the demand in 1982 will read 6,000 MW and 30,000 GWh or twice the demand of 1973.

In order to meet this demand, DSI and ETI Bank are engaged in increaseing the power generating facilities of the Central System and the Eastern Black Sea System. The Dogankent Power Station located on the downstream of the Harsit River and other large scale hydroelectric power stations such as the Keban and Gokcekaya are now being constructed. In addition, plans for the development of the Ayvacik and Kılickaya Power Stations are being pushed forward. However, after 1982, a shortage of power supply will emerge.

(2) Against this deficiency in supply capacity, the Harsit Project is located at roughly the center of the Eastern Black Sea Coast Region, and therefore, is very advantageous as a supply source for this region. In addition, as a 380-kV transmission line is proposed along the Harsıt River to enhance the dependability of the Keban Power Station, transmission to the Central System will be facilitated when the line is completed. The nucleus of the Harsit Project is a group of runoff the river type power stations. Among the power stations the Dogankent Power Station presently under construction is particularly of advantage which has a waterway of approximately 7,000 m long and utilizes a head of 183 m. However, in order to effectivize the capability of the Power Station and utilize the potential of the Harsıt River to the fullest extent, it is necessary to construct a reservoir in the upstream reaches.

Within the project basin area, there are the Torul and Kurtun Project being planned upstream which have big reservoirs. As geologic survey for the Kurtun Project has more progressed and it is thought that land acquisition is comparatively easier for the Kürtün Project than for the Torul Project, it is desirable that the development of Kürtün Project be promoted to ensure initiation of operation in 1982.

(3) A review of the Comprehensive Harsit River Development Plan formulated by DSI has reached a conclusion that the optimum scale of the Torul and Kürtün Reservoirs which occupy important positions in the basin development program would be as given below.

	Torul Reservoir	Kürtün Reservoir
Normal high water surface	990 m	650 m
Total storage capacity	300×10^6 cu.m.	137×10^6 cu.m
Effective storage capacity	207.8×10^6 cu.m	73.34×10^6 cu.m

(4) From the aspects of topography and geology it will be feasible to build a high dam at the Kürtün site. The dam sould be built in a height of approximately 133 m from foundation bedrock. The output of the power station would be 61,000 kW. The produced power would be transmitted on a 380 kV Keban transmission line, which is under planning independently of this project, to the Eastern Black Sea Region, and the western parts of the country, as well. A step-up substation will be provided adjacent to the powerhouse from which the power will be put into the transmission line in π-connection.

(5) The construction period required for the Kürtün Power Station would be 45 months excluding a detailed design and preparatory works such as road relocation. If commercial operation is to start at the end of April in 1982, the construction schedule would be as follows:

Start of construction	August,	1978
River diversion	July,	1979
Start concrete placement	December,	1979
Start of water impounding reservoir	March,	1982

The construction cost for these works would be roughly as given below.

	at 5 % Interest	at 8 % Interest
Generating facilities	$354,366 \times 10^3$ T.L	$367,491 \times 10^3$ T.L
Step-up Substation facilities	$42,033 \times 10^3$ T.L	$43,901 \times 10^3$ T.L
Total	$396,399 \times 10^3$ T.L	$411,392 \times 10^3$ T.L

(6) The annual energy production and the unit cost per kWh of the Kürtün Project before and after completion of the upstream Torul Reservoir would be as follows:

Before Completion of Torul	
Annual energy production	200×10^6 kWh
Firm energy	77.5×10^6 kWh
Secondary energy	122.5×10^6 kWh
Salable energy	197×10^6 kWh
Unit cost per kWh	
at 5 % interest rate	14.2
at 8 % interest rate	20.2
After Completion of Torul	
Annual energy production	200×10^6 kWh
Firm energy	120×10^6 kWh
Secondary energy	80×10^6 kWh

Salable energy	197 x 10^6 kWh
Unit cost per kWh	
at 5 % interest rate	14.2 kr/kWh
at 8 % interest rate	20.2 kr/kWh

In case the development of the Kürtün Power Station is considered in combination with the Akkoy Power Station which will have a equalizing reservoir for the Kürtün Power Station as a equalizing reservoir and the Degankent Power Station, the annual energy production and unit cost per kWh will be as follows before and after the construction of the Torul Reservoir;

Before Completion of Torul	
Annual energy production	727.0 x 10^6 kWh
Firm energy	381 0 x 10^6 kWh
Secondary energy	346.0 x 10^6 kWh
Salable energy	716.6 x 10^6 kWh
Unit cost per kWh	
at 5 % interest rate	6 5 kr/kWh
at 8 % interest rate	9.4 kr/kWh
After Completion of Torul	
Annual energy production	802 x 10^6 kWh
Firm energy	600 x 10^6 kWh
Secondary nergy	202 x 10^6 kWh
Salable energy	790 x 10^6 kWh
Unit cost per kWh	
at 5% interest rate	5.9 kr/kWh
at 8% interest rate	8 6 kr/kWh

(7) The major purpose of the Kurtun Project is to increase benefit at the run-of-the river type power stations now being constructed or Planned downstream, by its joint effect with the Torul Project planned upstream, rather than to obtain its own benefit directly. Therefore, the benefit will be derived from not only Kurtun's own kW and kWh production but largely from the increase of power production at the Dogankent Power Station which is under construction downstream, and the Akkoy Power Station which will be developed simultaneous with the Kurtun Power Station. The surplus benefit and benefit-cost ratio would be as given below.

(at 5% interest)

	Kurtun	Akkoy	Dogankent Additional	Total
Annual benefit (10^3TL)	19,520	18,220	12,325	50,065
Annual cost (10^3TL)	27,809	15,672	3,313	46,794
Surplus benefit (10^3TL)	- 8,289	2,548	9,012	3,271
Benefit / Cost	–	–	–	1.07

In case 8% interest is assumed the annucal cost exceeds the annual benefit as shown in Chapter 8, and therefore, it is required that construction fund be raised at a relatively low interest rate for development. However, when the entire program is completed, surplus benefit and benefit-cost ratio would be as follows :

(at 5% interest)

		Kürtün	Akkoy	Dogankent Additional	Total
Annual benefit	(10^3TL)	19,520	20,055	14,700	54,275
Annual cost	(10^3TL)	27,809	15,672	3,313	46,794
Surplus benefit	(10^3TL)	- 8,289	4,383	11,387	7,481
Benefit / Cost		–	–	–	1.16

2.2 RECOMMENDATIONS

The Kurtun Project will involve no substantial problems with respect to technical phase, and will be feasible from economic point of view when the development of the project is considered in a entire program for the Harsit River basin including the Gunyuzu Project and Torul Project to be developed in the upstream. However, it would be desirable to conduct investigations and studies which are described bereunder before the commencement of the definite study of the Kurtun Project.

(1) The Kurtun Project by itself would not create much benefit but is expected to increase the capacibility of run-of-the river type power stations in the basin greatly. Therefore, it is considered necessary that the Dogankent Power Station should be enlarged and Akkoy Power Station which has the re-regulating pond of the Kurtun Power Station be developed and completed by the time the Kurtun Power Station starts its operation. For this purpose, geological survey of the tunnel route of the Akkoy Power Station should be conducted by means of surface reconnaissance, in addition to the required geological investigation of the diversion dam.

(2) A fault running almost parallel to the river was seen in LA-6 Test Adit excavated according to an advice of the Survey Team during its field survey.

This fault would not give any adverse influence in particular to the stability of foundation against a thrust of an arch dam with high-water level of 650m. However, it is recommended that in the stage of definite study additional adits be excavated along and downstream side of the dam axis to see whether a fault really exist, and, if exists, to ascertain its scale and dip.

(3) It is estimated that the annual inflow of sediment into the Kurtun Reservoir will be 2.2×10^6 cu.m and 0.98×10^6 cu.m. respectively without and with the Torul Dam. In order to secure

the effective storage capacity of 73.34 x 10^6 cu.m at the Kurtun Reservoir throughout the serviceable life of the Kurtun Power Station, the Torul Dam should be completed within 5 years from start of operation of the Kurtun Power Station. On the other hand, due to the river bed gradient and topography of the reservoir area, the water storage efficiency of the Kurtun Reservoir is not very good If the river bed gradient averaging 1/100 to 1/125 at the proposed reservoir area is taken into consideration, an alternative plan to develop a run-of-the river type power station may be conceivable instead of a reservoir type for the Kurtun Project.

In case the Kurtun project be developed in run-of-the river type, the development scheme for the entire river system will involve construction of a reservoir at Torul in a design to have a high water surface level between EL.1,015m and 970m and development of a series of conduit-type power stations at the downstream. At present, the investigation work for the Kurtun Project is being carried out with an aim to develop power plant in a reservoir-type, and, therefore, geological data are not available for the study of waterway-type development. Accordingly, the study of development of the Kurtun Project in a waterway-type was conducted based simply on topographical maps of scale 1/25,000 to 1/5,000 Details of the studies are as given in Chapter 5 Paragraph 3 and Appendix 4. According to the studies, economic value of the run-of-the river type Kurtun is little different from that in reservoir type. However, in case the Kurtun Project is developed in a reservoir type, it would be necessary that Torul Dam be constructed immediately after the construction of the Kurtun Project as mentioned above. So that geological investigation of the Torul damsite should be carried out as early as possible by exploratory adits and borings While for the study of the run-of-the river type development, geological investigations should also be undertaken of the ground surface along the tunnel route. Final choise on the type of development of the Kurtun should be made after these geological investigations are made and taking into consideration interest on construction funds, difficulty or ease of maintenance related to gate operation and sedimentation, and balance of power demand and supply, etc.

CHAPTER 3

MARKET SURVEY AND LOAD FORECAST

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CHAPTER 3 MARKET SURVEY AND LOAD FORECAST

3.1 MARKET SURVEY

3.1.1 Background

Turkey is a rectangularly shaped land covering an area of 780,576 sq km, approximately 1,800 km in the direction east to west and 750 km north to south. The country faces the Mediterranean Sea to the south and the Black Sea to the north According to the satistics of 1967 the population was 33,044,000, and its growth rate has been 2.6% for the latest several years Approximately 70 % of the nation's population is engaged in agriculture.

The gross national product of Turkey in 1962 was 61,956 x 10^6 TL (at 1965 factor prices) which was 2,125TL per capital. In that year the Government of Turkey prepared the First Five-Year Plan for the years from 1963 through 1967 for industrial development and improvement of the national standard of living As a result, the gross national product in 1967 turned out to be 85,555 x 10^6 TL (at 1965 factor prices) 2,590 TL per capital The Turkish Government is now proceeding along the Second Five-Year Plan (1968 - 1972) and contemplates Third Five-Year Plan (1973 - 1977)

The power demand of Turkey in 1967 totaled 5,220 GWh with the recent annual growth rate having been slightly under 12%. The per capita power consumption in 1967 was 158 kWh with the annual growth rate of the last five years having been 8 to 9% Only slightly under 40% of the entire population is in the areas supplied with electricity, but this percentage is also rising yearly The per capita power consumption in the areas supplied was 429 kWh in 1967, which is still considerably less than in European countries.

Heavy power-consuming areas of the country are located in the western part of the country called Northwest Anatolia and West Anatolia which include such large metropolises and industrial cities as Istanbul, Izmit, Adapazari, Izmir etc. These cities form the nuclei of Turkey's economy and industry The power demands of these two regions hold more than 70% of the entire demand in the country

The trends of power demand from the year 1950 are indicated in Table 3-1 In 1950, 94% of the supply capacity depended on thermal power generation, but as a result of the remarkable development of hydroelectric power generation implemented, the ratio of hydro power against total capacity has enlarged so that in 1967, 63.5% was thermal while hydro counted for 36 5% Presently, large-scale hydroelectric power developments such as Gokcekaya and Keban are being carried out, while further development of the Lower Firat, etc are also being planned and thus it is thought that hydro power capacity will even larger in another 10 years. Turkey is well endowed with hydroelectric power resources, the potential being evaluated at 15,000 MW and 65 x 10^9 kWh according to a survey made in 1968 The greater part of this potential exists in the eastern part of the country, whereas upto 1968, only 4 1% of this had been developed

Thermal power stations have chiefly been built in the major industrial cities on the sea coast in the West with most of the plants such as Seyitomer using abundantly produced lignite as buel,

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CHAPTER 3 MARKET SURVEY AND LOAD FORECAST

3.1 MARKET SURVEY

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Thermal power stations have chiefly been built in the major industrial cities on the sea coast in the West with most of the plants such as Seyitomer using abundantly produced lignite as buel, but recently, oil-fired thermal powr stations such as Ambrali have been built. The power generation according to energy source are given in Table 3-2. In 1967, 61.6% of the entire energy production relied on thermal power generation of which 34.7% used various types of coal and 24.4% used petroleum as fuel. The quantity of petroleum used, following a world-wide trend of conversion from fossil fuels to liquid fuels, is expected to be increased even more in the future and it is throught that in 1980 coal and petroleum will be shoulder to shoulder, while in 1985 petroleum at 21.7%, will exceed coal at 13.7%.

The major power generating facilities of Turkey are indicated in Table 3-3. The supply capability at the end of 1966 consisted of 730 MW from 132 hydro power plants and 1,300 MW from 260 thermal power plants for a total installed capacity of 2,000 MW, but the individual scales of both hydro and thermal were mostly small with only a very few being larger than 50 MW in output. As of 1968 the largest generating capacities of power stations were 160 MW in hydro at Sariyar and 220 MW (110MW x 2) in thermal at Ambarli.

In Northwest Anatolia and West Anatolia, power trnamsission systems with 154-kV transmission lines as trunks are interconnected to form the Central System. At present the power systems of the eastern and middle regions are isolated, but an interconnecting program by 154-kV transmission lines is being aggressively expedited and by the mid-1970s it is scheduled for a nationwide interconnected system to be completed. Further, in 1972, when start-up of comercial survices of large scaled hydroelectric power plants of Keban and Gockcekaya is scheduled, a 380-kV transmission line 900 km long from Keban via Ankara and Gockcekaya to reach Istanbul will be completed, while in the future, it is planned for a trunk system of 380 kV to be formulated based on this transmission line

The area in which the Kurtun Project is located lies at the Eastern Black Sea Coast which is backward in development. Most of the inhabitants of this area depend on agriculture for their livelihoods Recently, there have been seen signs of steps towards industrialization with plans for a copper refining plant and a fertilizer plant to be built near Samsun, a paper mill at Giresun, and lumber mills at Artvin and Erfelek, while copper mines at Murgual are throught to start operation in the near future.

At present, power supply in this region is being undertakn by municipalities, but the facilities are of small scale consisting mainly of diesel engines with power rates being very high at 50 to 100 kr/kWh, which is two to three times the rates of the Central System. On the other hand, the power being supplied from recently built power stations such as Almus Hydro-electric Power Station (27 MW) is less expensive while the supply is stable so that increases in small-scale power generating facilities of high cost are not being held back.

Construction of a 154-kV transmission line is now being pushed forward and it is expected that interconnection will be made with the Central System sometime in 1970. Also, for the late 1970s, consideration is being given to construction of a 380-kV transmission line along the Black Sea Coast from Keban to Adapazarı for the purpose of stabilized power trnamission of the Keban System and the enhancement of realiability in the area along the Black Sea Cost. This transmission line will be interconnected with the 154-kV systems of Samsun and other cities along the Black Sea Coast. This transmission line, while running north to the Black Sea Coast from Keban, is expected to pass the Kurtun site, so that the Kurtun Power Station would be π-connected to this transmission line and the power from the Kurtun would be supplied not only for the demands of the Black Sea Coast, but also for the demands of the Interconnected System.

3.1.2 Pattern of Power Supply in Turkey

The electric power enterprises in Turkey are all operated by government organisations and the DSI, Etibank and EEIM are the main related agencies.

DSI belongs to the Ministry of Energy and Natural Resources and along with irrigation works and others concerned is engaged in construction of hydro-electric power stations.

Etibank also belongs to the Ministry of Energy and Natural Resources and builds and owns the major power transmission lines and thermal power stations throughout the country and is the largest power generation and transmission enterprise in Turkey.

EEIM is an organization belonging to the Etibank and is engaged in operation of the power facilities owned by the Etibank.

In general, power distribution is carried out by the various municipalities.

3.1.3 General Description of DSI

DSI is a governmental organization established in 1953 under Law No. 6,200 which stipulates that its main objectives are flood control, construction and administration of irrigation and drainage facilities and construction of related hydroelectric power plants.

As of 1965, DSI had 14,000 employees and 15 regional offices throughout the country.

At present, the Keban and Gokecekaya Projects are the large-scale hydroelectric power plants under construction by DSI. The Keban Project consists of building a multipurpose dam on the Firat River in the eastern part of Turkey and a power plant to generate an ultimate output of 1,240 MW (155 MW x 8 units) utilizing a large-scale reservoir and facilities to supply irrigation water to downstream areas. The power produced will be transmitted to Istanbul via the capital city Ankara on a 380-kV transmission line approximately 900 km in length which will also be built for this purpose. A plan to interconnect the power systems hitherto operated independently is being promited in connection with construction of this transmission line. If such interconnection be realized, the electric power industry of Turkey will take a great stride forward. The first stage work of the Keban Project, 620 MW,is scheduled to be completed in 1972.

The Gokcekaya Project is located between Izmit and Ankara and consists of a large scale reservoir type power plant with an ultimate output of 300 MW and it is scheduled for the No. 1 and No. 2 units totalling 200 MW to go into operation in 1971 followed by start up of the No. 3 unit, 100 MW, in 1972.

Table 3-1 Total Installed Capacity of Power Plant

(Unit : MW)

Year	1950	1955	1960	1965	1967	(%)
Thermal	390	574	861	989	1,270	(63.5)
Hydro	18	38	412	506	731	(36.5)
Total	408	612	1,273	1,495	2,001	(100.0)

Table 3-2 Gross Energy Production According to Source

(Unit : 10^6 KWh, %)

	1950		1955		1960		1965		1967	
High grade coal	435	55.1	561	35.5	417	14.8	513	10.4	423	6.9
Low grade coal	105	13.4	394	24.9	591	21.0	745	15.1	652	10.6
Lignite	137	17.4	338	21.4	533	18.9	998	20.2	1,063	17.2
Liquid fuel	60	7.5	158	10.0	233	8.3	430	8.7	1,506	24.4
Other fuels	28	2.8	40	2.5	40	1.4	88	1.8	153	2.5
Hydro	31	3.8	89	5.7	1,001	35.6	2,167	43.8	2,370	38.4
Total	789	100.0	1,580	100.0	2,815	100.0	4,942	100.0	6,167	100.0

Table 3-3 Major Generating Power Plant

Hydro:

Name of Plant	Location	Installed Capacity (MW)	Energy Production (GWh)	Year of Completion
Sariyar	Ankara	160	400	1956
Hirfanli	Ankara	96	400	1960
Kesikkopru	Ankara	76	175	1967
Demirkopru	Manisa	69	192	1960
Seyhan	Adana	54	285	1956

Thermal:

Name of Plant	Location	Installed Capacity (MW)	Energy Production (GWh)	Year of Completion
Ambarle	Istanbul	220	1,640	1966
Tuncbilek	Kutahya	129	858	1966
Silahtaraga	Istanbul	120	706	1913
Catalagzi	Zonguldak	120	858	1948
Mersin	Mersin	50	380	1966

3.2 LOAD FORECAST

3.2.1 Supply Territory

The Kurtun site is located roughly in the central part of the Eastern Black Sea Region and is extremely suited to serve for the area.

As mentioned previously, it is scheduled that the Black Sea Coast System and most of the other isolated power systems will be interconnected with the Central System in 1970 and in the mid-1970s, respectively. While further, in the late 1970s, a 380-kV transmission line will be constructed along the Black Sea Coast from Keban to Adapazari and will be interconnected with the 154-kV system along the Black Sea Coast at Samsun or somewhere suitable.

In this way, really all demand sites will be receiving power from the Interconnected System by the year 1980.

The Kurtun Power Station is scheduled for start of operation in 1982, and if a π-connection is made with the beforementioned 380-kV transmission line, it will be possible to transmit the power generated not only to the Eastern Black Sea Region, but also to the western areas.

Therefore, in preparing a load forecast, all of Turkey will be considered as the supply territory of Kurtun.

3.2.2. Period of Demand Estimation

The period of load forecast will be the 15 years from 1969 through 1983.

For examination of the scale, timing of development, and effectivation of supply capability of the Kurtun Power Station, it is thought a load forecast of 15 years will be adequate.

3.2.3 Available Data

At the beginning of 1969, a demand forecast was made by the Etibank. Based on the forecast the facilities expansion program and the demand and supply balance have been studied.

The supply territory assumed in the load forecast is included in the projected Interconnected System, but since there is a plan to interconnect the presently isolated systems with the Central System by the mid-1970s, it may be considered that after 1975, the load forecast would cover the whole of Turkey.

The method of the load forecast applied by the Etibank is so-called analytical method, and the forecast was made for respective districts in such categories as "Municipality , Industry , Irrigation, Others", etc. Transmission and distribution loses and consumption at plant auxiliaries have also been taken into account. "Municipality" may be broken down into subdivisions such as "Domestic and Commercial", "Offices" and "Street Lighting", while in "Industry", "Traction" is also included. "Others" mainly consists of "villages" and "Small Customers".

The load forecast prepared by the Etibank are indicated in Table 3-4. According to the forecast, the demand in the Interconnected System will increase sharply from 1970 through 1973 with the average rate of growth at 23.3%. From 1974 through 1982 annual growth rate will vary between 5.7% and 12.6% with an average for the period being at 8%, and the demand in 1982 will double the demand in 1973. Although the average growth rate is 12.9% for the period from 1970 through 1982, this does not indicate the growth rate for entire Turkey.

3.2.4 Demand Estimation

For estimating power demand, there will be two typical approaches: one is the microscopic approach in which estimation will first be made of each component element of power demand and total demand will be given as their cumulative results, and the other is the macroscopic approach in which some rules governing the overall demand will be first sought and estimation will be made according to the rules found. Since the load forecast by the Etibank was based on the former method, macroscopic methods are used here to check the load forecast by the Etibank.

The following three methods are adopted.

(1) A method of forecasting on the basis of actual trend of power demand in the past (Trend Method).

(2) A method of forecasting on the basis of correlation between GNP and power demand (GNP Method).

(3) A method of forecasting based on per capita energy consumption assumed (Per Capita Method).

In view of the fact that the actual power demand of Turkey in the past has recorded a steady annual growth rate, it would be reasonable to make recourse to the abovementioned three methods for load forecasting.

As it is thought that the records of 1967 are more reliable than those of 1968, the records of 1967 were used for all items.

(1) Estimation by Trend Method

The past energy consumption of Turkey is shown in Table 3-5. According to the Table, the average annual rate of growth was 11.5% for the 10 years from 1958 through 1967, 11.8% for the 7 years from 1961 through 1967 and 11.3% for the 5 years from 1963 through 1967. These figures show that the power demand is fairly steadily growing and it was assumed that energy consumption would grow yearly at a rate of 11.5% in the future.

Transmission and distribution losses have been at about 12.4%of total energy consumption, while they are 7% to 10% in the highly developed countries of the world. The losses are naturally governed by regional characteristis, and in a country like Turkey where transmission of power has to be effectuated over distance, it is thought difficult to reduce the losses substantially. However, in consideration of power system alignment and possible advance of technology in future it was assumed that the losses would be decreased to the present level in developed nations by the year 1980. Accordingly, in the forcast losses have been calculated on a yearly decreasing basis to be finally lowerd to 10% of energy production at transmission end or 11.1% of total energy consumption.

The ratio of consumption at plant auxiliaries to overall energy consumption was 5.7%in 1967. This figure will vary depending on the ratio of hydro to thermal, and since it is considered that the ratio of hydro power will increase in the future, it is thought the figure will be lowered year by year. However, since it is difficult to estimate the reduction, a ratio of 5.7% has been adopted for the study from the view-point of safety.

The results of estimation are given in Table 3-6

(2) Estimation by GNP Method

The GNP of Turkey based on actual performance from 1951 through 1968 is given in Table 3.7. All values in the Table are in real terms at 1965 price level. As seen in the Table, the average annual rate of growth was 5.0% for the 10 years from 1958 through 1967, 5.4% for the 7 years from 1961 through 1967 and 6.7% for the 5 years from 1963 through 1967. These figures show that the annual growth rate has been increasing yearly. The Turkish Government has set an annual rate of growth of 7%, as a target for GNP in the Second Five-Year Plan, and whose rate is thought to be attainable in consideration of the past performance. Therefore, annual growth rate of 7% was assumed for the study.

The ratio of energy consumption to GNP, was 61.0 kWh/10^3 TL in 1967 as shown in Table 3-7. Average annual growth rate was 6.2% for the 10 years from 1958 through 1967, 4.8% for the 7 years from 1961 through 1967 and 4.3% for the 5 years from 1963 through 1967 indicating a trend of gradual reduction. Therefore, the annual growth rate of kWh/GNP was estimated at 4.3% for the future.

Transmission and distribution losses and energy consumption at plant auxiliaries were assumed at the same level as described in the foregoing paragraph (1).

The results of estimation are given in Table 3-8.

(3) Estimation by Per Capita Method

As seen in Table 3-9, the population of Turkey in 1967 was 33,044,000 with the average annual rate of growth being 2.63% for the 10 years from 1958 through 1967, 2.53% for the 7 years from 1961 through 1967, and 2.53% for the 5 years from 1963 through 1967. These figures indicate a slightly decreasing trend, but these are still fairly high when compared with the annual growth rates which are experienced in various countries. Since problems of population are highly associated with economic and social conditions, it is very difficult to estimate its future growth. However, for the present study it was assumed that intentional control policies would be taken in the future in view of the present high growth rate and, accordingly that the annual growth rate would be slackened gradually from 2.55% to 2.30% as shown in Table 3-10.

The average annual rate of growth per capita energy consumption was 8.7% for the 10 years from 1958 through 1967, 9.0% for the 7 years from 1961 through 1967, and 8.6% for the 5 years from 1963 through 1967. In consideration of this relatively steady growth, an annual growth rate of 8.7% was adopted for the study. (Re : Table 3-9)

The transmission and distribution losses and energy consumption at plant auxiliaries were considered to be the same as those previously described in the paragraph (1).

The results of estimation are given in Table 3-10

3.2.5 Comparison of Demand Estimation Results

Results of demand for power estimated according to the above three methods are given in Table 3-11 together with the estimation by the Etibank.

Of the forecast values obtained based on the three methods in the present study, the one obtained on the basis of GNP Method is the largest while the result by the Per Capita Method is the smallest. However, the difference between the two is only 2.6% in 1983, showing that no substantial difference will be presented whichever of the methods may be resorted to. Further, the average value of estimations based on three methods agree well with the estimated value obtained by the Trend Method.

For the period upto 1970, the estimates of the Etibank are smaller than those obtained in the present study. This is due to the forecast of Etibank being limited to the Interconnected System which is quite different from the supply territory assumed in the present study. After 1970, from 1971 through 1981, the estimates of the Etibank are larger, while after 1981 they again become smaller than the estimates obtained in the present study.

Through the First and Second Five Year Plans the economy of Turkey has been shifting from dependency on agriculture to industrialization and this economic metamorphosis would continue in the future.

The demand forecast by the Etibank shows a fair amount of growth from 1970 through 1973. This would be largely due to the method of forecast adopted: total demand was taken as sum of individual demand forecasted based on the plans for each categorized demand items as described before.

While the macroscopic approach made recourse in the present study is not well sensitive to the fluctuation of demand in individual demand categories. Therefore, if any increase or decrease of demand be intentionally caused in some demand categories, such as sudden increases in factory loads due to promotion of industrialization through the Second Five-Year Plan, the fluctuation would not necessarily be reflected in the forecast obtainable.

Therefore, it is unavoidable for some degree of difference to occur between the forecasts made by the Etibank and that by the macroscopic method. However, around 1980, the difference between the two is considerably lessened and in 1982 there is almost complete agreement.

Although there is a fair amount of difference between the estimation of the Etibank and that obtained in the present study in the interim years, since the difference becomes extremely small

Table 3-4 Load Forecast of Interconnected System by Etibank

Year	Energy Demand (10^6 kWh)	Peak Demand (MW)
1969	6,700	1,180
1970	7,600	1,400
1971	10,300	1,910
1972	12,200	2,260
1973	15,500	2,800
1974	16,600	3,040
1975	18,700	3,430
1976	19,900	3,650
1977	21,400	3,960
1978	23,000	4,250
1979	24,600	4,560
1980	26,000	4,815
1981	29,200	5,400
1982	31,000	5,740

Table 3-5 Historical Energy Consumption in Turkey

Year	Net Energy Consumption (GWh)	Network Losses (GWh)	Plant Auxiliaries (GWh)	Gross Energy Production (GWh)
1950	679	49	61	790
1951	764	56	68	888
1952	879	61	81	1,020
1953	1,012	101	87	1,200
1954	1,192	113	98	1,402
1955	1,347	123	110	1,580
1956	1,545	147	128	1,819
1957	1,757	165	134	2,057
1958	1,962	202	140	2,303
1959	2,170	264	159	2,587
1960	2,396	279	140	2,815
1961	2,585	283	143	3,011
1962	3,059	329	171	3,560
1963	3,406	422	155	3,983
1964	3,767	470	215	4,451
1965	4,202	521	219	4,942
1966	4,700	580	255	5,535
1967	5,220	648	299	6,167
1968	5,821	724	334	6,879

Table 3-6 Load Forecast (Trend Method)

Year	Net Energy Consumption		Network Losses		Plant Auxiliaries		Gross Energy Production
	Increase (%)	GWh	Ratio to Net Energy Consumption (%)	GWh	Ratio to Net Energy Consumption (%)	GWh	GWh
1967	11.5	5,220	12.4	648	5.7	299	6,167
1968	11.5	5,820	12.3	720	5.7	330	6,900
1969	11.5	6,490	12.2	790	5.7	370	7,700
1970	11.5	7,240	12.1	880	5.7	410	8,500
1971	11.5	8,070	12.0	970	5.7	460	9,500
1972	11.5	9,000	11.9	1,070	5.7	510	10,600
1973	11.5	10,040	11.8	1,190	5.7	570	11,800
1974	11.5	11,190	11.7	1,310	5.7	640	13,100
1975	11.5	12,480	11.6	1,450	5.7	710	14,600
1976	11.5	13,920	11.5	1,600	5.7	790	16,300
1977	11.5	15,520	11.4	1,770	5.7	890	18,200
1978	11.5	17,300	11.3	1,960	5.7	990	20,300
1979	11.5	19,290	11.2	2,160	5.7	1,100	22,600
1980	11.5	21,510	11.1	2,390	5.7	1,230	25,100
1981	11.5	23,980	11.0	2,640	5.7	1,370	28,000
1982	11.5	26,740	10.9	2,920	5.7	1,520	31,200
1983	11.5	29,820	10.8	3,220	5.7	1,700	34,700

Table 3-7 Gross National Product of Turkey (1950 - 1968)

Year	Gross National Product at 1965 Factor Prices 10^6 TL	Net Energy Consumption GWh	kWh/GNP	
			$kWh/10^3$ TL	Increase %
1950	33,933	679	20.0	-
1951	39,026	764	19.6	-0.2
1952	42,390	879	20.7	5.6
1953	47,129	1,012	21.5	3.9
1954	42,939	1,192	27.8	29.3
1955	46,142	1,342	29.1	4.7
1956	49,285	1,545	31.3	7.6
1957	52,433	1,757	33.5	7.0
1958	55,121	1,962	35.6	6.3
1959	57,342	2,170	37.8	6.2
1960	59,480	2,396	40.3	6.6
1961	58,613	2,585	44.1	9.4
1962	61,956	3,059	49.4	12.0
1963	66,728	3,406	51.0	3.2
1964	69,994	3,767	53.8	5.5
1965	73,217	4,202	57.4	6.7
1966	80,445	4,700	58.4	1.7
1967	85,555	5,220	61.0	4.5
1968	91,337	5,821	63.7	4.4

Table 3-8 Load Forecast (GNP Method)

Year	Gross National Product		kWh/GNP		Net Energy Consumption GWh	Network Losses		Plant Auxiliaries		Gross Energy Production GWh
	Increase (%)	10^6 TL	Increase (%)	kWh/10^3 TL		Ratio to N.E.C. (%)	GWh	Ratio to N.E.C. (%)	GWh	
1967	-	85,555	-	61.0	5,220	12.4	648	5.7	299	6,167
1968	7.0	91,540	4.3	63.6	5,820	12.3	720	5.7	330	6,900
1969	7.0	97,950	4.3	66.3	6,490	12.2	790	5.7	370	7,700
1970	7.0	104,810	4.3	69.2	7,250	12.1	880	5.7	410	8,500
1971	7.0	112,150	4.3	72.2	8,100	12.0	970	5.7	460	9,500
1972	7.0	120,000	4.3	75.3	9,040	11.9	1,080	5.7	520	10,600
1973	7.0	128,400	4.3	78.5	10,080	11.8	1,190	5.7	570	11,800
1974	7.0	137,390	4.3	81.9	11,250	11.7	1,320	5.7	640	13,200
1975	7.0	147,010	4.3	85.4	12,550	11.6	1,460	5.7	720	14,700
1976	7.0	157,300	4.3	89.1	14,020	11.5	1,610	5.7	800	16,400
1977	7.0	168,310	4.3	92.9	15,640	11.4	1,780	5.7	890	18,300
1978	7.0	180,090	4.3	96.9	17,450	11.3	1,970	5.7	990	20,400
1979	7.0	192,700	4.3	101.1	19,480	11.2	2,180	5.7	1,110	22,800
1980	7.0	206,190	4.3	105.4	21,730	11.1	2,410	5.7	1,240	25,400
1981	7.0	220,620	4.3	109.9	24,250	11.0	2,670	5.7	1,380	28,300
1982	7.0	236,060	4.3	114.6	27,050	10.9	2,950	5.7	1,540	31,500
1983	7.0	252,580	4.3	119.5	30,180	10.8	3,260	5.7	1,720	35,200

Note: N.E.C. = Net Energy Consumption

Table 3-9 Population and Net Energy Consumption per Capita in Turkey (1950 - 1967)

Year	Population x 10^3	Net Energy Consumption GWh	Net Energy Consumption per Capita	
			kWh/capita	Increase %
1950	20,947	679	32.4	-
1951	21,634	764	35.3	9.0
1952	22,219	879	39.6	12.2
1953	22,818	1,012	44.4	12.1
1954	23,433	1,192	50.9	14.6
1955	24,065	1,342	55.8	9.6
1956	24,771	1,545	62.4	11.8
1957	25,498	1,757	68.9	10.4
1958	26,247	1,962	74.8	8.6
1959	27,017	2,170	80.3	7.4
1960	27,755	2,396	86.3	7.5
1961	28,446	2,585	90.9	5.3
1962	29,154	3,059	104.9	15.4
1963	29,880	3,406	114.0	8.7
1964	30,623	3,767	123.0	7.9
1965	31,391	4,202	133.9	8.9
1966	32,207	4,700	145.9	9.0
1967	33,044	5,220	158.0	8.3

Table 3-10 Load Forecast (kWh/capita Method)

Year	Population		Net Energy Consumption per Capita		Net Energy	Network Losses		Plant Auxiliaries		Gross Energy
	Increase (%)	x 10^3	Increase (%)	kWh/capita	Consumption GWh	Ratio to N.E.C. (%)	GWh	Ratio to N.E.C (%)	GWh	Production GWh
1967	-	33,044	-	158	5,220	12.4	648	5.7	299	6,167
1968	2.55	33,890	8.7	172	5,830	12.3	720	5.7	330	6,900
1969	2.55	34,750	8.7	187	6,500	12.2	790	5.7	370	7,700
1970	2.55	35,640	8.7	203	7,230	12.1	870	5.7	410	8,500
1971	2.53	36,540	8.7	221	8,080	12.0	970	5.7	460	9,500
1972	2.53	37,460	8.7	240	8,990	11.9	1,070	5.7	510	10,600
1973	2.53	38,410	8.7	261	10,030	11.8	1,180	5.7	570	11,800
1974	2.50	39,370	8.7	284	11,180	11.7	1,310	5.7	640	13,100
1975	2.50	40,350	8.7	309	12,470	11.6	1,450	5.7	710	14,600
1976	2.50	41,360	8.7	336	13,900	11.5	1,600	5.7	790	16,300
1977	2.45	42,370	8.7	365	15,470	11.4	1,760	5.7	880	18,100
1978	2.45	43,410	8.7	397	17,230	11.3	1,950	5.7	980	20,200
1979	2.45	44,470	8.7	432	19,210	11.2	2,150	5.7	1,090	22,500
1980	2.40	45,540	8.7	470	21,400	11.1	2,380	5.7	1,220	25,000
1981	2.40	46,630	8.7	511	23,830	11.0	2,620	5.7	1,360	27,800
1982	2.40	47,750	8.7	555	26,500	10.9	2,890	5.7	1,510	30,900
1983	2.30	48,850	8.7	603	29,460	10.8	3,180	5.7	1,680	34,300

Table 3-11 Comparison of Load Forecast

Year	Whole Country Estimate by Survey Team			Interconnected System Estimated by Etibank
	Trend Method	GNP Method	kWh/capita Method	
1969	7,700	7,700	7,700	6,700
1970	8,500	8,500	8,500	7,600
1971	9,500	9,500	9,500	10,300
1972	10,600	10,600	10,600	12,200
1973	11,800	11,800	11,800	15,500
1974	13,100	13,200	13,100	16,600
1975	14,600	14,700	14,600	18,700
1976	16,300	16,400	16,300	19,900
1977	18,200	18,300	18,100	21,400
1978	20,300	20,400	20,200	23,000
1979	22,600	22,800	22,500	24,600
1980	25,100	25,400	25,000	26,000
1981	28,000	28,300	27,800	29,200
1982	31,200	31,500	30,900	31,000
1983	34,700	35,200	34,300	-

in later years, the load forecast of the Etibank has been adopted for the study of the Kurtun Project.

3.2.6 Forecast of Load Curve

In Turkey peak demand appears in either November or December, and since these two months are in the dry season, power supply condition is most critical in the month. Judging from the river discharge condition, it may be said that the situation is more severe in December. Therefore, for the study of the daily balance of demand and supply, the daily load curve of the day of the maximum load in December was adopted.

The annual load factor of the Interconnected System is 10% higher than that of entire Turkey which was 63.6% in 1964 and 62.1% in 1966. The daily load factor of the Interconnected System is about 75%. However, when the development program is carried out in the future and areas of sparse demand are absorbed into the Interconnected System, the daily load factor will be lowered. In the present study, annual load factor has been assumed at 62.3% to 61.6% throughout the period of load forecast and daily load factor was assumed to be constant at 73%.

The shape of the daily duration curve (Re: Table 3-12) was modelled referring to the actual records of the daily load of the Interconnected System, for convenience of study of the balance of demand and supply.

Table 3-12 Shape of Daily Duration Curve

Hour	%
0 - 3 (3)	100
3 - 7 (4)	85
7 - 11 (4)	80
11 - 14 (3)	75
14 - 17 (3)	70
17 - 24 (7)	51.5

3.2.7 Balance of Demand and Supply

In order to meet the anticipated demand as forecast above, it is necessary to develop new supply capacity. For this purpose, the most rational and economical methods must be used to arrive at suitable combinations of hydro and thermal power and to determine the timing of start-ups.

Based on the data and advice made available by the Etibank, as well as on the kW and kWh balances and generating cost of new hydroelectric power, etc., a development program as shown in Table 3-13 has been established.

The basic considerations applied in the preparation of the development program are as follows:

(1) The development program should be established for the period up to 1983 covering the period of load forecast.

(2) As it is thought that construction of power stations scheduled to start commercial operation by 1972 have already been started, only those stations scheduled for start of operation after 1973 should be included in the study. However, as the demand in 1973 could adequately be met with the supply capacity put into operation by 1972, there will be no necessity for new development in 1973, while in 1974, it will be sufficed by the extension of Units No. 5 and 6 of the Keban Power Station, accordingly emphasis should be placed on the period after 1975.

(3) In building up the supply capability, medium and small scaled hydro should be arranged in combination with large scale hydro and thermal power stations.

(4) Taking into account that hydro power would comprise two thirds of the total supply capability in the 1970s, and that the supply capability would accordingly be governed substantially by river discharge conditions, the December output should be considered for kW balance and firm energy for kWh balance. A reserve capacity should be provided in a size equivalent to 5% of firm energy supply capability. If reserve capacity is so provided, the kW supply capability would be of sufficient size.

(5) Start-up of all hydro and thermal power stations should be aimed at in July every year. Therefore, in the year of start-up, the energy available would be one half of total energy production in a normal year. As thermal power stations can unlike hydro be started up in any month, it will be possible to adjust the month of start-up if desired.

(6) It will be advantageous to develop the Kurtun Project in step with the Akkoy Project and the Dogankent Project (extension only). However, since the Ayvacik Project and Kilickaya Project will precede it to satisfy the demand of the Black Sea Coast Region for the latter 1970s, Kurtun should be developed several years later for start up in 1982 to constitute a part of the supply sources for the Black Sea Coast Region, as well as for the Interconnected System.

(7) Retirement of existing thermal power stations should be taken into account. Obsolete capacity will reach 100 MW in 1980 and 200 MW in 1982.

3.2.8 Execution of Development

By 1982, when the Kurtun Power Station will go into initial operation, the entire territory of Turkey should be covered by the Interconnected System. Since this power station is planned to be led into the 380-kV transmission line, the power from the station will partly be transmitted to the western areas, but will also be supplied to the Black Sea Coast Region through the Samsun Substation. Further, when 380 kV substations are completed at Giresun or Trabzon to be connected with the 380-kV transmission line from Kurtun, almost all of the power output of the Kurtun would be consumed within the Black Sea Coast Region. Therefore, it may be said that Kurtun, while being one of the power stations of the Interconnected System, is a Black Sea Coast Region power station, that is, a power station for meeting the demand of the Black Sea Coast Region.

From the view point of balance of demand and supply, Kurtun would of course be one of the power stations within the Interconnected System, but from the standpoint of the quality of the power produced, it is thought Kurtun should rather be a Black Sea Coast Region power station.

Therefore, the plant factor of the Kurtun Power Station would best be adapted to the conditions of the Black Sea Coast Region. However, at present, as the power for towns and villages of the area is supplied by individually generating facilities, it is difficult to grasp the load curve of the region as a whole, and thus, the plant factor of the Kurtun Power Station was simply assumed at around 25%, which is common for dam-type hydro plants, as described in Chapter 5.

The study of daily balance of demand and supply in December 1982 to make clear the significance of the Kurtun Power Station in the Interconnected System has reached the results as shown in Fig. 3-1 and Fig. 3-2.

The daily duration curve assumed in Chapter 3-2-6 was used for this study. In order to see the influence of discharge conditions, studies were made on average years and dry years, with December output and dependable capacity taken as the hydro supply capability for average year and dry year, respectively. However, whenever dependable capacity were unknown, December output was substituted. Regarding energy, daily energy output was adopted for the average year and firm daily output for the dry year. Since almost all reservoirs of power stations in Turkey are of large storage capacity, no substantial errors would be invited if such assumptions be made. Further, it was assumed that hydro power supply capacity would feed the peak portion of the daily load curve with hydro stations being mobilized in the order of start up. However, in the cases of Keban and Karakaya, since these two power stations will produce very large amounts of energy, and are designed to be operated at high plant factors, they will supply the base portion of the daily load curve in combination with thermal power stations. The summarized data of the hydro and thermal power stations used in the studies are indicated in Table 3-14 and Table 3-15.

As a result, the entire output of the Kurtun Power Station will be made effective from 1982, the year of start of operation, if the year falls on a year of a average discharge, but it is falls on a dry year, it would not be until 2 or 3 years after start-up of the operation that the output of the project is entirely made effective.

In consideration of the schedule of filling reservoir, the commencement of the commercial operation of the Kurtun Power Station would be suitable in April 1982.

Table 3-13 Interconnected System Capability and Demand

Year	Plant	Plant Capability			System Capability			Demand	
		MW (Dec)	GWh (Av)	GWh (Dry)	MW (Dec)	GWh (Av)	GWh (Dry)	MW	GWh
1974		-	-	-	3,663	20,063	18,522	3,040	16,600
1975	Ayvacık 1.2	250 (200)	900	640					
	Oymapınar	220	1,440	750					
	Aslantas	85	606	355					
	-	-	-	-	4,218	21,536	19,395	3,430	18,700
1976	Nuclear	400	3,000	3,000					
	Ayvacık 3	125	158	90					
	-	-	-	-	4,743	24,588	21,812	3,650	19,900
1977	Balahor	46	227	136					
	Kılickaya	120	337	281					
	Ayvacık 4	125	159	90					
	-	-	-	-	5,034	26,529	23,611	3,960	21,400
1978	Cıldir	15	30	30					
	Cavizlık	50	310	160					
	Adıguzel	85	488	335					
	-	-	-	-	5,184	27,304	24,127	4,250	23,000
1979	Elbıstan 1.2	300	1,840	1,840					
	-	-	-	-	5,484	28,638	25,309	4,560	24,600
1980	Karakaya 1.2.3	600	4,100	4,100					
	Retirement	-100	-500	-500					
	-	-	-	-	5,984	31,358	28,029	4,815	26,000
1981	Elbıstan 3.4	300	1,840	1,840					
		-	-	-	6,284	34,078	30,749	5,400	29,200
1982	Zonguldak	300	1,840	1,840					
	Kurtun	61	202	127					
	Akkoy	40	196	158					
	Dogankent (ext.)	37	100	81					
	Karakaya 4.5	400	2,200	1,520					
	Retirement	-200	-1,000	-1,000					
		-	-	-	6,922	36,767	33,032	5,740	31,000
1983	Karababa 1.2.3	600	3,500	3,500					
		-	-	-	7,592	40,286	36,145	(6,200)	(33,500)

Table 3-14 Hydroelectric Power Plants

Power Plant	Year of Start of Operation	Installed Capacity (MW)	December Output (MW)	Annual Energy Average Year (GWh)	Dry Year (GWh)
Almus	1966	27	27	87	35
Sariyar	1956	160	180	400	310
Kesikkopru	1967	76	76	175	160
Demırkopru	1960	69	72	192	130
Kemır	1958	48	48	145	80
Gokcekaya	1971	300	300	570	500
Hırfanlı	1959	96	93	400	200
Seyhan	1958	54	50	285	243
Kadincık	1970	127	120	565	340
Keban 1-4	1972	620	600	4,600	4,600
Keban 5-6	1974	310	300	1,000	550
Ayvacık 1,2	1975	250	250	900	640
Ayvacik 3	1976	125	125	159	90
Ayvacık 4	1977	125	125	158	90
Aslantas	1975	127	85	606	355
Oymapinar	1975	270	220	1,440	750
Kılıckaya	1977	120	120	337	281
Balahor	1977	46	46	227	136
Cevizlık	1978	50	50	310	160
Adıguzel	1978	106	85	488	335
Karakaya 1,2,3	1980	600	600	4,100	4,100
Kurtun	1982	61	61	202	127
Akkoy	1982	40	40	196	158
Dogankent (ext.)	1982	37	37	100	81
Miscellaneous dam type hydro	-	76	58	348	257
Miscellaneous run of river type hydro *	-	204	160	1,110	835

Note: * Contains Existing Dogankent (32.8 MW)

Table 3-15 Thermal Power Plants

Power Plant	Year of Start of Operation	Installed Capacity (MW)	Maximum Continuous Rating(MW)	Annual Energy (GWh)
Catalagzı	1948	6 x 20	120	775
Tuncbilek	1956	2 x 32 + 60	120	830
Ambarli	1967	2 x 110	230	1,610
Silahtar	1913	120	80	500
Mersin	1963	4 x 25	100	700
Ambarli 3	1970	1 x 110	115	800
Ambarli 4,5	1970	2 x 150	300	2,100
Hopa	1970	2 x 25	50	350
Miscellaneous	-	193	165	825
Seyitomer 1	1971	1 x 150	150	1,120
Seyitomer 2	1972	1 x 150	150	1,120
Nuclear	1976	1 x 400	400	3,000
Elbistan 1,2	1979	2 x 150	300	1,840
Elbistan 3,4	1981	2 x 150	300	1,840
Zonguldak	1982	1 x 300	300	1,840

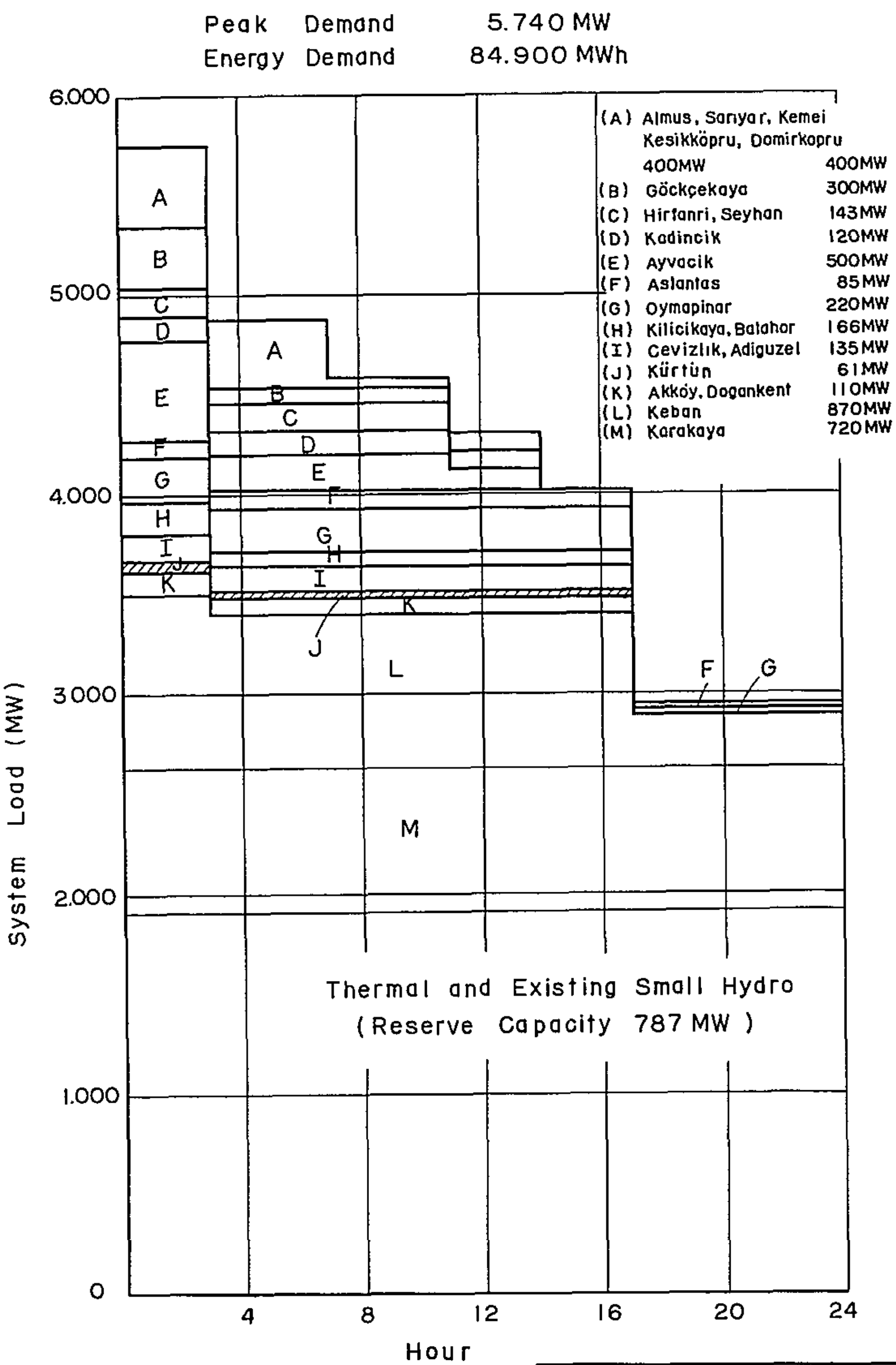

Fig. 3 – 1

Operation Pattern of Interconnected System Anticipated in December 1982

(Average Hydro Year)

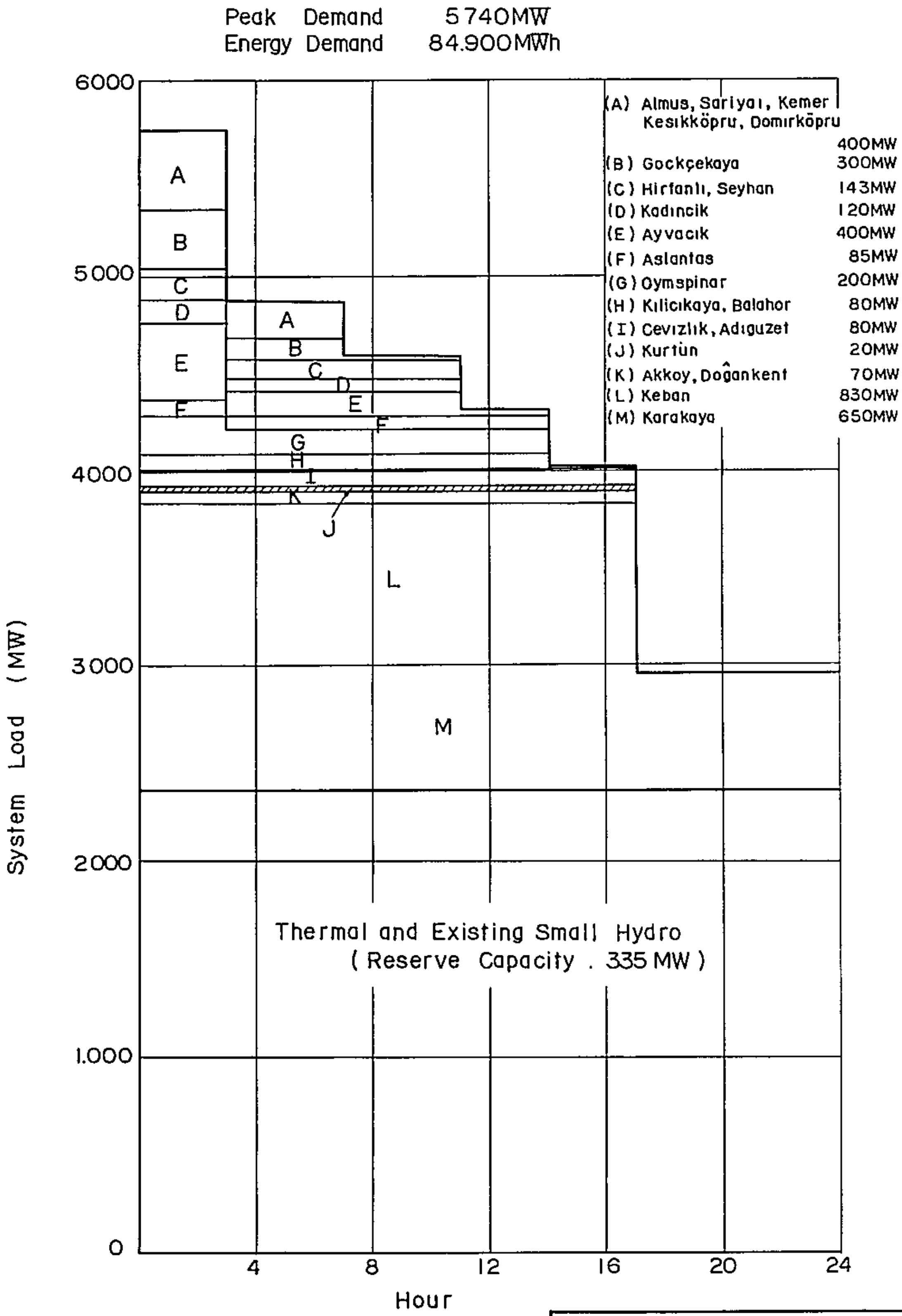

Fig. 3 – 2

Operation Pattern of Interconnected System Anticipated in December 1982
(Dry Year)

CHAPTER 4

SCHEME OF DEVELOPMENT

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CHAPTER 4 SCHEME OF DEVELOPMENT

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The project area is located in the northern part of Turkey between latitude 40° 15' and 41° 00' N and longitude 38° 40' and 39°55' W. The major rivers and streams within the area which would be subject to development are the Harsit River and Gelevela Creek. The Harsit River originates in the mountain range of elevation of 2,500 m to 3,000 m running parallel to the Black Sea Coast and flows down roughly in a south to north direction entering the Black Sea at a point 5 km east of Tirebolu. Gelevela Creek is adjacent to and flows parallel with the Harsit River on the western side entering the Black Sea at a point 13 km west of the mouth of the Harsit

The more prominent mountains surrounding the river basins are Abdalmusa (EL. 3,332 m) to the south, Zülfe (EL. 2,750 m) to the east, Cakırgöl (EL. 3,060 m) to the northeast and Alacadag (EL. 2,180 m) to the west, which separate the Harsit and Gelevera from other catchment areas. The major tributaries of the Harsit River are Ikısu and Cıt Creeks which join the main stream between Gümüshane and Torul, Manastır and Erikbeli Creeks which merge with the Harsit between Torul and Kürtün and Kavraz Creek which has its confluence at the town of Harsit.

The catchment area of the Harstı River is 3,270 sq.km and that of Gelevera Creek is 788 sq km

The Harsit River, which is the main object of development in the project area, has an average river gradient of 1/100 and has rather swift stream.

The upstream part of the Harsit River flows through an inland area typical of Turkey, but downstream of the Torul damsite, the conditions change and the river passes through the so-called Eastern Black Sea Coastal Area.

Consequently, the discharge conditions of the river differ considerably between the upstream and downstream parts, a comparison of the runoff per unit area of drainage of the respective representative runoff gaging stations, Torul (DSI) and Giris (DSI), being as follows

Torul Gaging Station	253,000 c m /sq.km
Giris Gaging Station	330,000 c m/sq km

The rainy season is for 4 months from March to June, the discharge during this period amounting to 70% of the annual discharge Construction of Torul and Kürtün Dams is being planned to regulate this fluctuation in annual runoff From ancient times basin area was a important hub of caravan travel connecting the inland regions and the Black Sea Coast, and because of this, although not necessary in good maintenance, roads are well developed along the Harsit River.

As one link of the Harsit Electric Power Development Program, the first stage work of Dogankent Power Station has been going on at the dowstream of the Harsit River since 1968, start

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As one link of the Harsit Electric Power Development Program, the first stage work of Dogankent Power Station has been going on at the dowstream of the Harsit River since 1968, start of operation of which is scheduled for 1970.

Dogankent Power Station is a run-of-river power station with a tunnel of 7,127 m. The power produced will be transmitted to Trabson by a 154 kV transmission line.

As the first stage work, 2,000 m of the 7,127 m length of the tunnel is being constructed with a cross-sectional area of 35 sq.n tor the purpose of daily regulation while the remaining 5,127 m has a cross-sectional area of 20 sq.m, and the installed capacity will be 32.8 MW(8.2 MW x 4). After completion of Torul and Kürtün Reservoirs being planned for the upatream area, the tunnel can be enlarged for maximum capacity of 45 c.m.s. and it will be possible to make extension of facilities to an ultimate installed capacity of 70,000 kW.

The Torul and Kürtün projects would involve large-scale reservoir-type power plants on the Harsit River. The reservoirs will regulate river discharge an annual basis to enable effective power generation at the power plants under an effective head of as much as 1,000 m available on the Harsit River. The major purpose of the Project is to cope with the rapidly growing power demand of the Black Sea Coast and the western parts of Turkey.

4.1.2 Geology

Formations belonging to the Upper Cretaceous Period are most widely distributed in the Harsit River Basin. The rocks belonging to this period are conglomerate, sandstone, marly shale, limestone, flysch and tuff, besides which there are also volcanic rocks such as andesite, basalt, agglomerate and rhyolite, and rather, along the Harsit River, the distribution of volcanic rocks is the wider. Intruded through these Upper Cretaceous strata are igneous rocks, granite and granodiorite, of eocene or later origin. At Torul and the area southwest of Torul, there are fairly wide distributions of eocene volcanic rocks and flysch elements (sandstone, conglomerate, shale, marl and occasionally limestone) covering the Upper Cretaceous formations. At Gümüsane and points southwest, there are distributions of Paleozoic quartzite and granite.

(1) Tirebolu Dam Site

The width of the river is fairly large and the left bank slope comprises a steep cliff, but the right bank is in a fairly gentle slope. The basal rock on both left and right banks is rhyolite and columnar joints are well developed with a fairly large number of fissures, but the rock is sound. The left bank has a great number of cracks, but sound rhyolite is widely exposed. The right bank is covered widely with topsoil and talus and it is thought weathering of the bedrock extends slightly deeper than on the left bank. Sand and gravel is widely deposited in the river bed and the thickness according to electrical exploration by DSI is 37 m. It is thought the river bed sand and gravel widely distributed upstream and downstream of the dam can be used as concrete aggregate.

(2) Aslancik Power Station and Tunnel

Volcanic rocks of the Upper cretaceous Period are distributed along the tunnel and penstock route. These are basalt, andesite and rhyolite which have been subjected to considerable metamorphism and are silicified. The rock is generally sound, but there are portions which have become soft and weak due to faults. The rock in the vicinity of the powerhouse site is rhyolite with columnar joints developed almost horizontally, but it is sound while topsoil and talus deposits are thin. Coarse sand and gravel is widely deposited at the river bed, the thickness of which is estimated to be 25 to 30m. For concrete aggregates, it is believed the sand and gravel widely deposited in the Harsit River can be used.

(3) Akköy Power Station and Tunnel

Volcanic rocks of the Upper Cretaceous Period are predominant at the tunnel and penstock routes with granodiorite distributed in parts. These rocks are hard, but abound in cracks. The bedrock at the powerhouse site is basalt covered with thin topsoil and talus deposits. The deposit of sand and gravel in the Harsit River is fairly thick being estimated to be 15 to 20 m. Although it is thought this sand and gravel deposit can be used as concrete aggregate, there are places in the vicinity which would provide good quarry sites.

(4) Kürtün Damsite

The width of the river is 30 to 40 m at the dam axis with the left bank inclined about 40° while the right bank is a slightly more gentle slope roughly about 35° up to EL. 710m above which it is a very gentle slope of around 10°. The basal rock is predominantly granodiorite besides which there are andesite, porphyrite and crystalline limestone. The granodiorite carries a great variety of different species of rock captive to form an assemblage and since these are not completely assimilated with the granodiorite, the geological map is extremely complex.

The river bed is widely deposited with sand and gravel about 20 m thick

(5) Karacukur Power Station and Tunnel

The tunnel and penstock routes are comprised of volcanic rocks of the Upper Cretaceous Period. These rocks consist of basalt and agglomerate which are sound but are abundant in fissures. The bedrock at the powerhouse location is sound basalt with thin topsoil and talus and there are outcrops over the entire area. Since the inclination of the slope is steep and the width of the river is small, it will be unavoidable for the powerhouse to be made an underground type. It is estimated that the thickness of the river bed gravel is about 5 to 6 m. For concrete aggregate there is bedrock in the vicinity which would provide a good quality quarry.

(6) Torul Dam

The bedrock is granodiorite or basalt which is sound, but there is a great number of fine cracks The part of the left bank at higher elevations has outcrops of bedrock, but the lower parts are covered fairly widely with talus which is estimated to be 6 to 7 m at the thickest portions. The river bed portion is deposited with coarse gravel and the thickness is estimated to be about 15 m. Bedrock is exposed over almost the entire surface of the right bank with hardly any talus and the slope is extremely roughly pitted.

There is a considerable quantity of water springing at the slope of the left bank road approximately 200 m upstream of the damsite and because of this travertine has been formed. There are countless suitable sites with good bedrock for quarries for concrete aggregate in the vicinity.

(7) Günyüzü Power Station, Intake Dam and Tunnel

According to a report of DSI, the intake damsite and the headrace tunnel route is distributed with volcanic rocks of the Upper Cretaceous Period such as andesite, basalt, dacite and agglomerate. The abovementioned volcanic rocks and granite are distributed at the powerhouse and penstock route while the topsoil and talus deposits are thin and there are outcrops of sound bedrock. Both banks are steeply sloped immediately from the edges of the water of the Harsit River.

4.1.3 Climate and Precipitation

The climate of the project area belong to a transition between Eastern Black Sea climate and that of the Middle Anatolia.

The four seasons are as follows: spring from March through May, summer from June through August, and autumn from September through November , winter from December through February. The precipitation in this zone is caused by the frontal action of the Black Sea. It is poor along the valley but rich in the surrounding mountains.

Fig. 4-6 shows the distribution of monthly precipitation at observatories in the project area and the vicinity. This figure shows that the principal precipitation in the inland is in spring and it is in autum and winter along the Black Sea.

An isohyetal map of the annual precipitation in the project area based on data of EIE is shown in Fig. 4-7. According to this map, the annual precipitation of the Harsit River Basin are about 500 mm in the Torul Basin, 550 mm in the Kürtün Basin, 600 mm in the Giris (Dogankent) Basin and averaging about 700 mm in the whole basin and it's distribution is generally heavy in Black Sea Coastal and poor in the inland.

Fig. 4-8 shows the fluctuation of annual precipitation at several observatories in the project area. According to this figure, although the cycle of annual precipitation (a period from wet year to wet year) is about 10 years, the variation of annual precipitation is not conspicuous.

In general, the temperature along the sea coast is mild, but in the inland where the moderating influence of the Black Sea is lost, the temperature is low and in winter drops to -10°C to -15°C. The mean monthly maximum, average and minimum temperature based on data of Giresun is shown in Fig. 4-9. Based on a lapse rate of 0.6°C per 100 meters of increase in elevation, the temperature at the proposed Kürtün dam site can be estimated by deducting 3.5°C from the temperature of Giresun.

4.2 COMPREHENSIVE DEVELOPMENT OF HARSIT RIVER BASIN

The Harsit Project was conceived as an independent electric power development program from as early as 1950 in order to meet the rapidly growing power demand, and later, after various studies, a reconnaissance report of the entire river basin was prepared by DSI in 1967.

Based on the above investigations, the first stage development of Dogankent Power Station was started in 1968 upon condition that the final design of the Dogankent would be determined after the scale of Torul and Kürtün Reservoirs, which are proposed at the upstream, is established.

On one hand, adjacent and parallel to the Harsit River, there is Gelevela Creek which enters the Black Sea at a point 13 km west of the mouth of the Harsit. The results of studies show that it would be economical to provide a reservoir on the upstream stretches of Gelevela Creek and divert the stored water to the Harsit River immediately upstream of Dogankent. Thus, comprehensive development of the Harsit River Basin would include both the Harsit River and Gelevela Creek.

In order to regulate the runoff of the streams which fluctuate sharply by season, high dams would be constructed. As the damsites, DSI had selected the Kürtün and Torul sites, to which the present Survey Team found the selection appropriate for the purpose after it conducted field investigations

In regard to Kürtün Dam, geological investigations are presently being made of the vicinity of the damsite through exploratory adits and borings As for the Torul damsite, geological investigations are at the stage of surface reconnaissance.

In formulation of the development scheme the following points were taken into consideration:

(1) The power of the river basin will first be developed to meet the load of the Black Sea Coast only. However, ultimately, power will be put in π-connection into the 380-kV transmission line connecting Keban, the Black Sea Coast, Ankara and Istanbul which is scheduled to be constructed along the Harsit River.

(2) Therefore, the development of the basin should be taken up against the whole demand in Turkey including the Black Sea Coastal Area.

(3) The development will be materialized in 1982 in consideration of the growth of demand and of other sites scheduled to be developed. It is estimated the power requirements of all systems will be 6,000 MW in 1982. Accordingly 499 MW of power obtainable in this basin will be consumed effectively even if any additional load is not created. Therefore, in establishing a development plan it will be more important to aim to extract maximum energy in an economical manner than to consider operation of reservoirs according to fluctuation of load.

(4) The development scheme should be formulated giving due consideration to the progress of the Harsit River Development Program already prepared by DSI and to the scale of Dogankent Power Station already under construction

This Project will comprise construction of arch dams at the Torul and Kürtün sites with respective heights of 155 m and 133 m above bedrock to form reservoirs with total storage capacities of 300 x 10^6 cu.m and 137.2 x 10^6 cu.m. (as regards details, refer to Chapter 5) The fluctuations of annual discharge will be controlled through these reservoirs. Torul and Kürtün Power Stations appurtenant to the two dams and a series of conduit-type power stations, namely, Karacukur, Akköy, Dogankent and Aslancik, and a dam-type Tirebolu Power Station at the extreme downstream will be constructed for effective utilization of the water stored at the two reservoirs. Further, the runoff of the tributaries of Gelevela Creek will be diverted to the Harsit River immediately upstream of Dogankent Intake Dam to produce 113,000 kW of power under a head of 1,215 m. By the diversion energy increase will also be ensured at the various power plants farther downstream of the Dogankent Power Station.

The power obtainable at these power stations will be a total of 499 MW, and the annual energy production will total 2147.4 x 10^6 kWh.

The summarized data of the various projects within the river basin are as given in Table 4-1.

4.3 SCHEME OF DEVELOPMENT FOR KURTUN PROJECT

4.3.1 Power Plant

The overall scheme of the Harsit Program is as described in the preceding paragraph. The Kurtun Project, which is located on the middle reaches of the basin and is scheduled to be developed following Dogankent Power Station presently under construction, will be a dam-type power station. The dam with a height of 133 m above the foundation rock and a crest length of 425 m will be a dome-type arch dam, the drawdown of the reservoir will be 30 m.

The intake water level of the intake provided appurtenant to the dam on the right bank of the dam will vary from a high water level of 650 m to a low water level of 320 m according to season, while the discharge water level of the power plant will be at EL. 545 m which is equivalent to the high water level of the downstream Akköy equalizing pond.

The powerhouse will be provided at the right bank 100 m downstream of the dam. Design head of turbines will be 92 m in consideration of fluctuation of the water level of reservoir. Maximum available discharge will be 78 c.m/sec taking into account firm available discharge after completion of Torul Power Station. Therefore, the installed capacity will be 61,000 kW. The annual energy production will be 200 x 10^6 kWh and after completion of Torul the firm energy production will be increased by 55 %.

4.3.2 Transmission and Communications Systems

(1) Power Systems around Kurtun Site

In the vicinity of the Kurtun site, there are 154-kV, 1-cct transmission line from the Dogankent Power Station now under construction to Tirebolu Substation and 154-kV transmission line under construction along the Black Sea Coast (1 cct between Trabzon and Ordu, and 2 cct between Ordu and Samsun). In addition to these transmission lines, construction of a 380-kV transmission line is scheduled to be completed by 1980 from Keban Power Station to the Black Sea Coast and to Adapazari by way of Samsun and Zonguldak along the coast. (Re· Fig. 4-10)

(2) Method of Power Trasmission

The power generation scheme of the Harsit River involves 8 sites for a total of 499 MW of which 32.8 MW are presently under construction at Dogankent Power Station.

The power transmission system of Kurtun Power Station has been proposed in a way which would preclude duplication of investment in transmission facilities which might otherwise be caused if all of the power stations projected on the Harsit River are put into operation independently of each other. It is thought the capacity of the transmission line presently being built from Dogankent Power Station to Tirebolu Substation will be about 140 MW, therefore if the power of Aslancik Power Station is put into this transmission line in the future in addition to the output of Dogankent Power Station after expansion, the transmission line would have no more capacity to convey power obtainable at other power stations, such as Akkoy, Gunyuzu, etc. Therefore, the transmission of the power obtainable at the power stations upstream of the Gunyuzu would be best effectuated by the 380-kV transmission line which, as described before, is proposed for construction by 1980 from Keban Power Station through the vicinity of Kurtun Power Station to the Black Sea Coast. In such case, if the 5 power stations are put on the 380-kV transmission line individually and directly any trouble or failure at any of the power stations would affect the entire system of 380-kV line. In order to avoid such adverse affect, it has been proposed to provide a step-up substation near Kurtun Power Station and to connect the five power stations to the step-up substation. The power will then be put into the 380-kV transmission line after having been stepped up at the substation.

The above transmission system is illustrated in Fig. 4-11.

The results of studies of the voltage and stability of the transmission lines are described in Appendix 4.

(3) Communications System

As communication channels for Kurtun Power Station, one system each of power line carrier telephone for load dispatching and administrative use (3-channel telephone with transmission band for superimposed signals) will be formulated between Kurtun Power Station and Samsun Substation and between Kurtun Step-up Substation and Keban Power Station, while also, one channel each of carrier relay signal transmission channel for protection of the 380-kV transmission line will be provided.

At Kurtun Power Station, a 20-channel private automatic telephone exchange will also be installed.

Table 4-1 Harsıt River Comprehensive Development Plan

Description / Project		Torul	Karacukur	Kurtun	Akkoy	Gunyuzu	Dogankent	Aslancik	Tirebolu	Total
Drainage Area	sq.km	2,026	2,026	2,753	2,753	299	2,912	2,995	3,266	
High Water Surface	m	990	850	650	545	1,630	383	180	70	
Low Water Surface	m	946	840	620	535	1,586	-	-	48	
Effective Storage Capacity	10^6 cu.m	207.8	-	73.34	-	74.8	-	-	-	
Design Head	m	115	183	92	137	1,215	183	100	58	
Firm Discharge	c.m.s	12.2	12.2	19.7	19.7	4.6	24.7	24.8	28.4	
Maximum Discharge	"	48	48	78	34	11	45	45	114	
Dam Height	m	155	-	133	-	-	-	-	95	
Length of Waterway	m	-	6,500	-	12,700	7,400	7,127	8,320	-	
Installed Capacity	kW	47,000	74,000	61,000	40,000	113,000	70,000	38,000	56,000	499,000
December Output	kW	37,600	74,000	48,600	40,000	110,000	70,000	38,000	56,000	474,200
Annual Energy Production	10^6 kWh	143.4	214.4	200.1	229.4	529.6	411.3	228.1	191.1	2,147.4
Project Cost										
at 5% Interest Rate	10^6 TL	544.1	159.8	391.6	228.3	330.0	223.9	162.6	249.8	2,290.1
at 8% Interest Rate	"	571.1	166.9	411.0	238.5	346.5	226.1	169.8	262.2	2,382.1
Unit Price per kWh										7.3

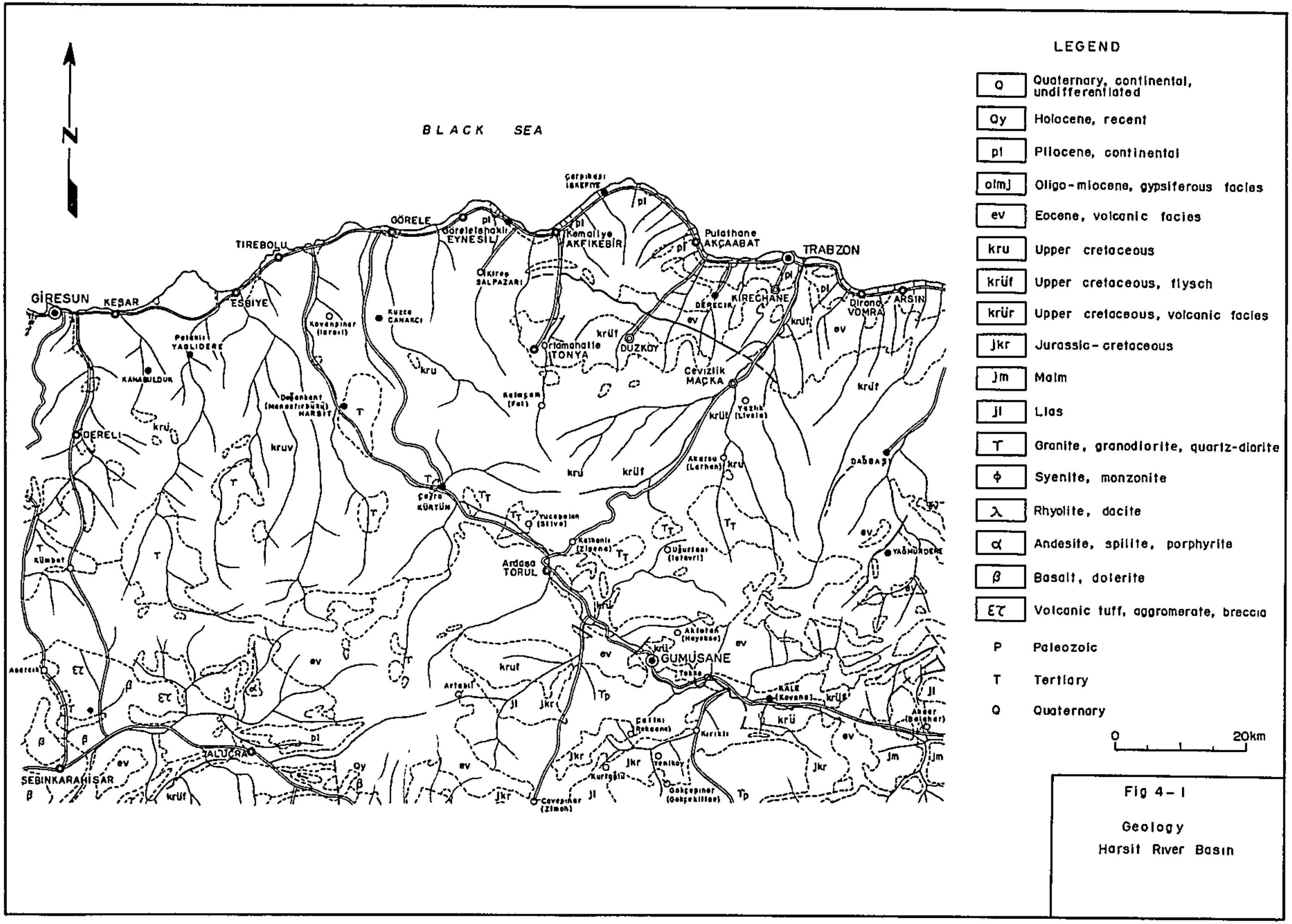


Fig 4-1

Geology
Harsit River Basın

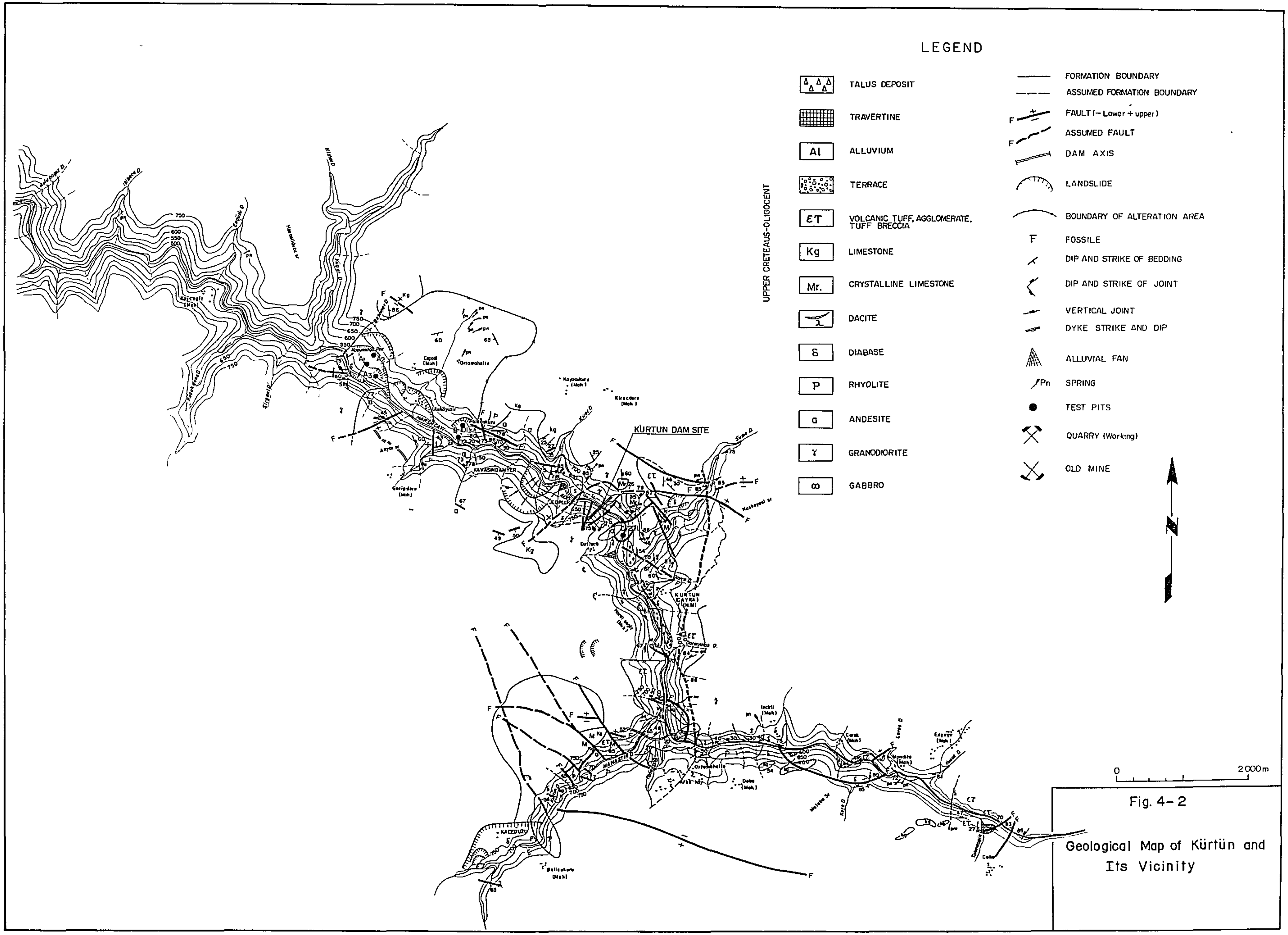


Fig. 4-2

Geological Map of Kürtün and Its Vicinity

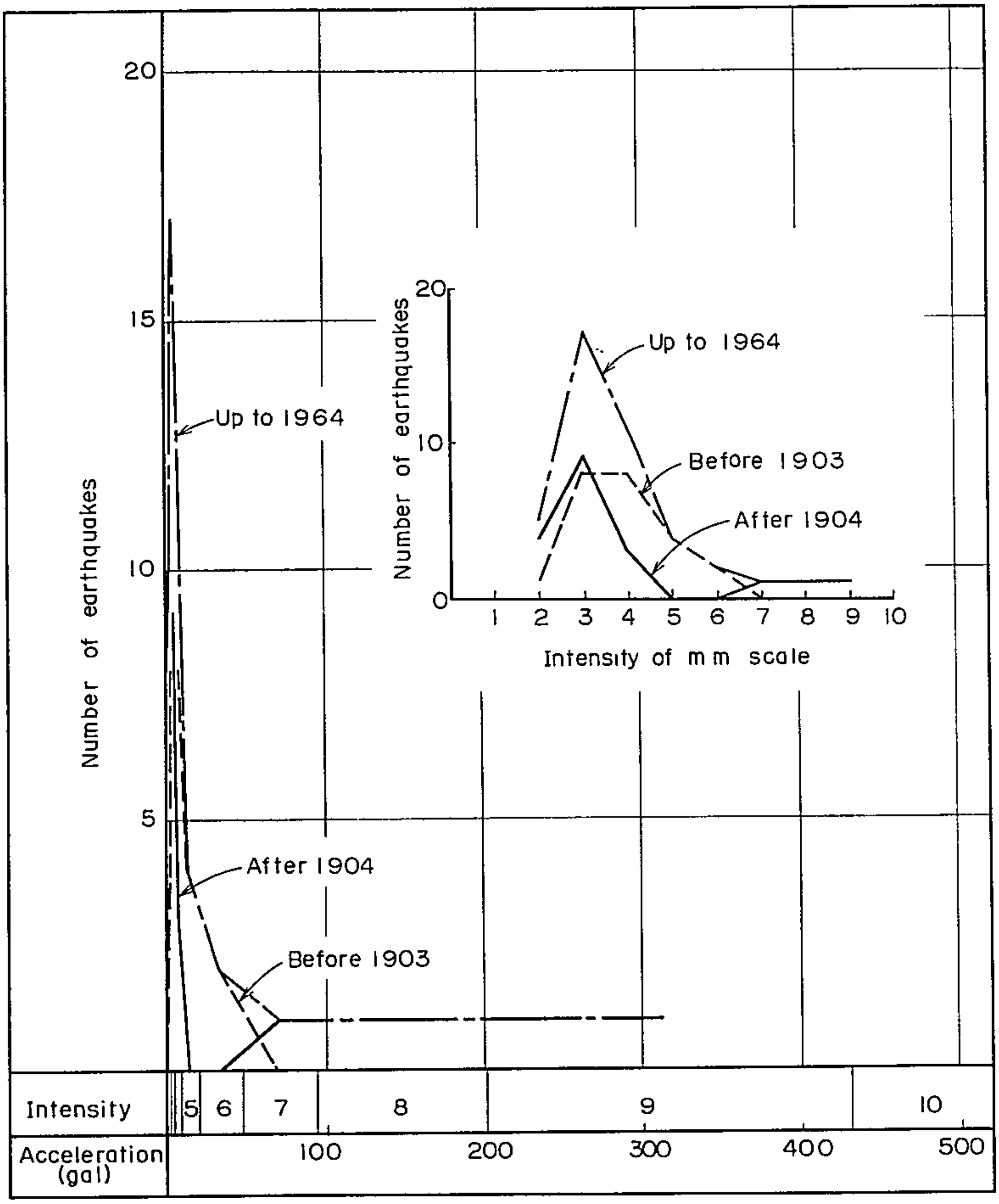
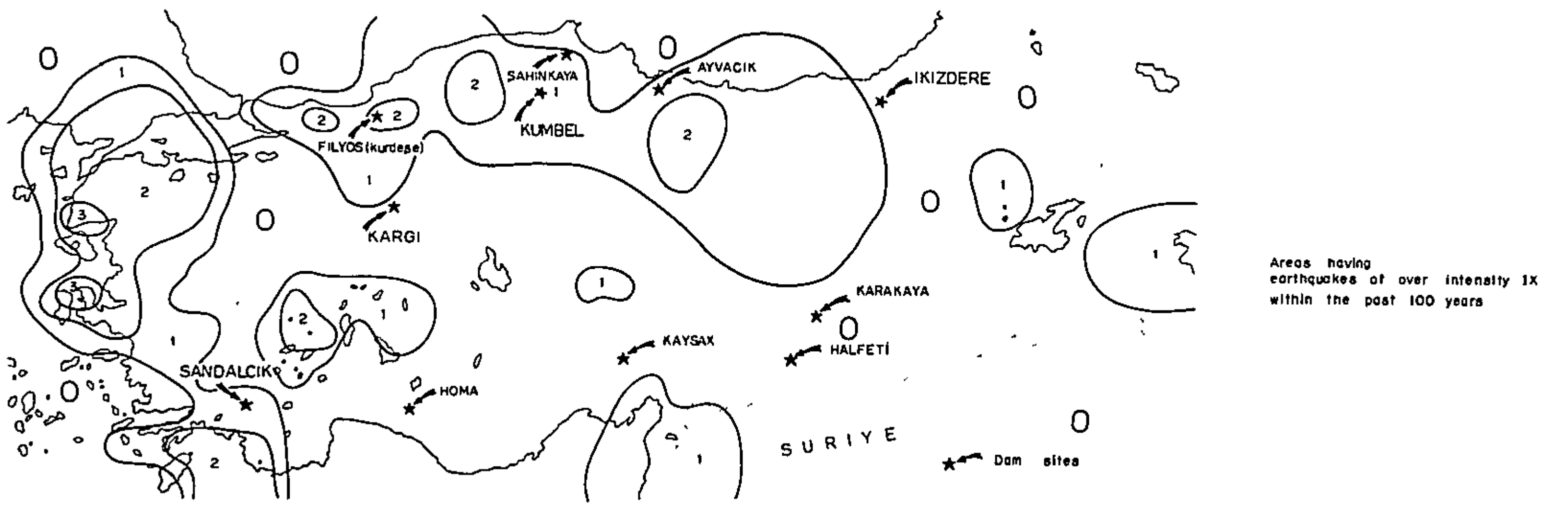


Fig 4-3

Earthquakes Records

ISOSEISMAL MAP (AFTER REFERENCE No 3)



EARTHQUAKE ZONES OF TURKEY (AFTER REFERENCE No 9)

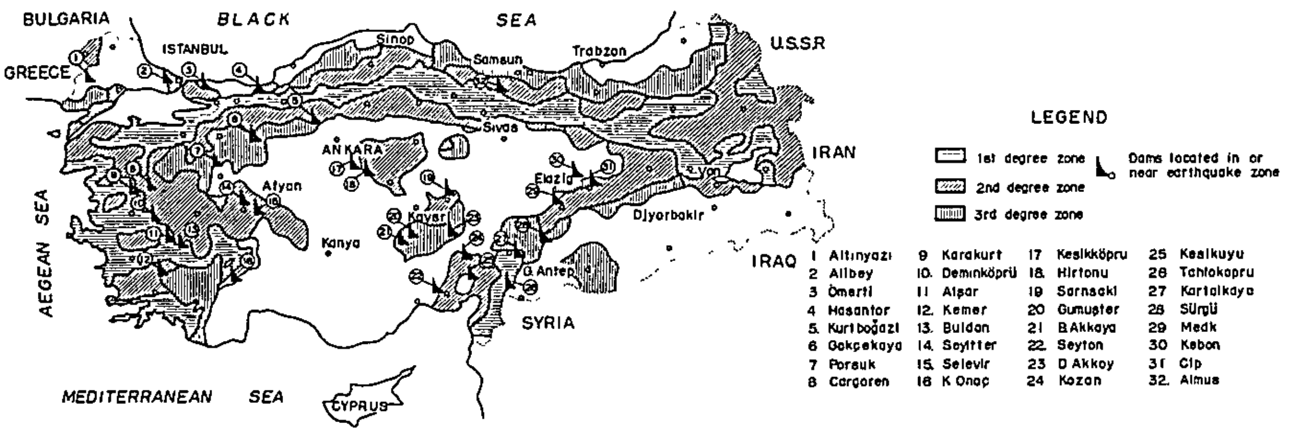


Fig 4 – 4

Tectonic Structure of Turkey and Earthquake Activity 1952 — 1967

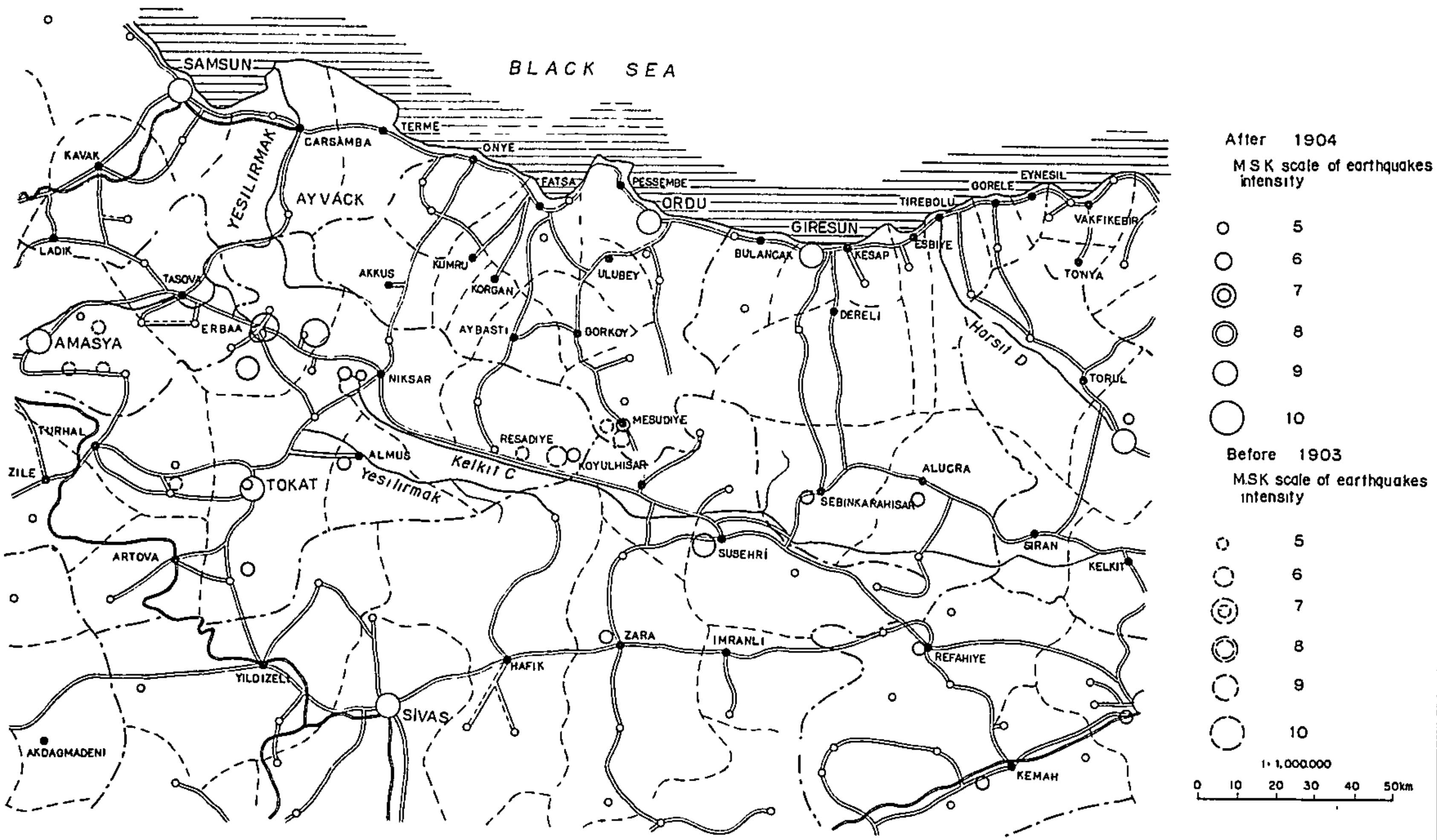


Fig 4 – 5

Past Earthquakes Around Project Area

Fig 4-6

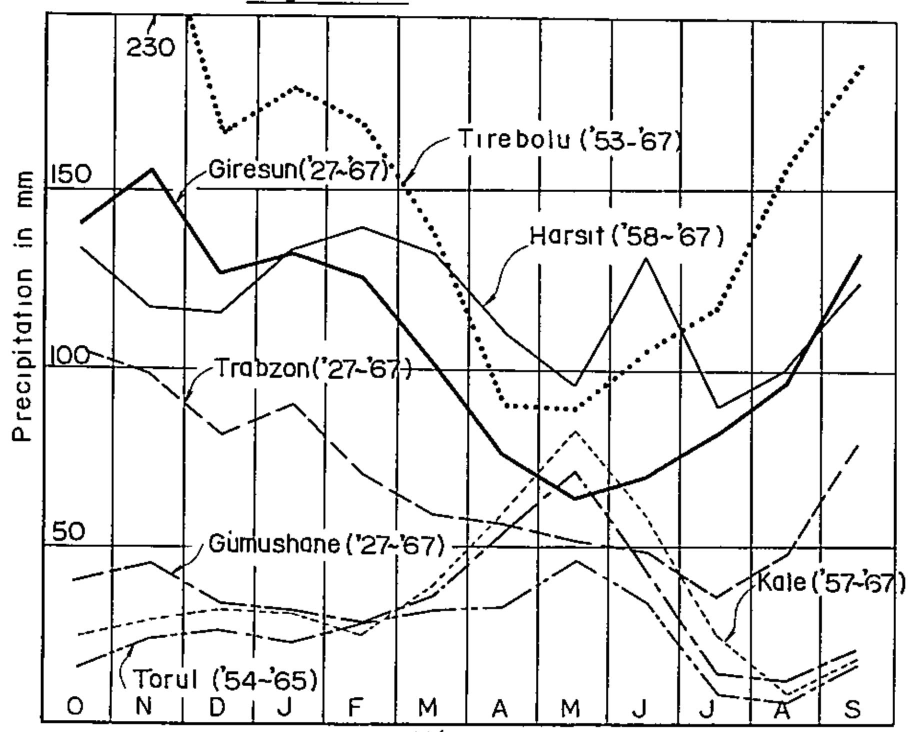
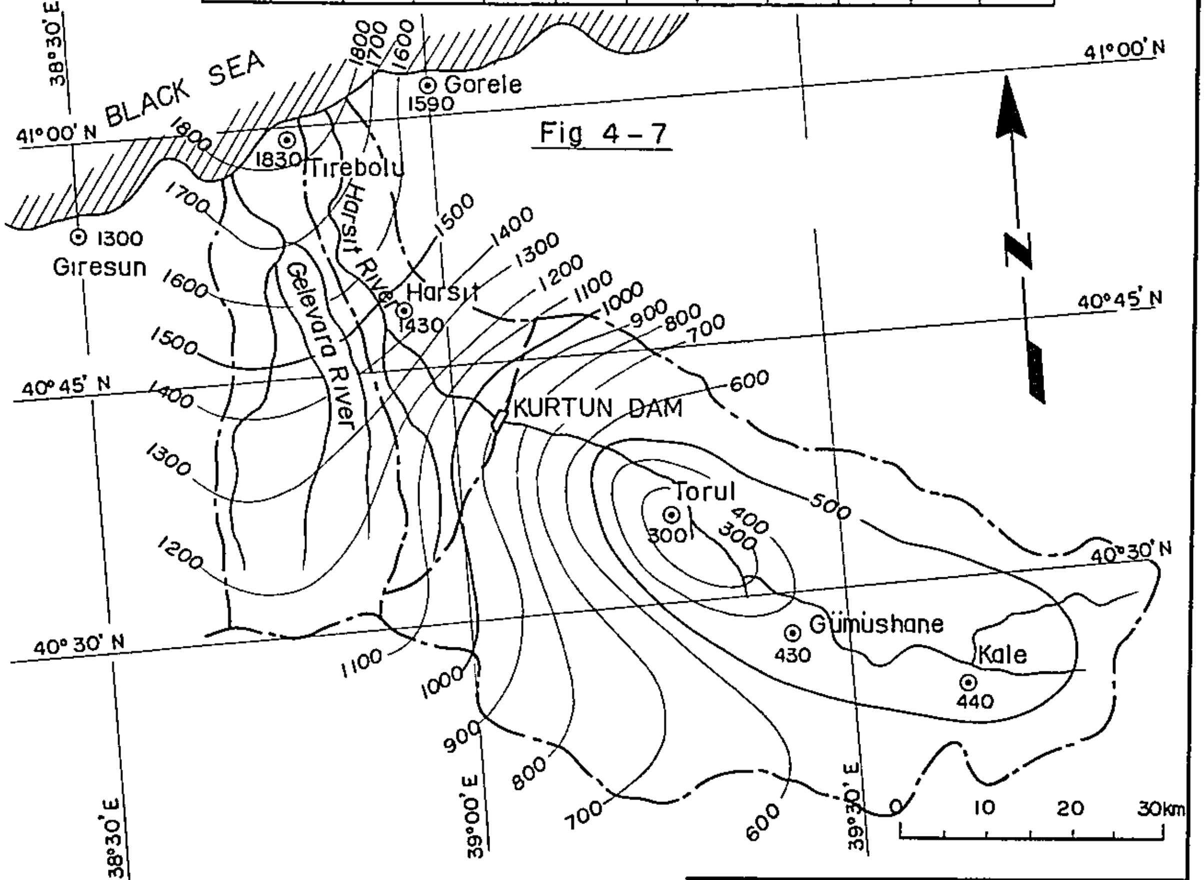


Fig 4-7



Station	(1) Basin Average	(2) Gumushane	(3) (1)/(2)
Torul	500mm	430mm	1.2
Kurtun	550	〃	1.3
Giris	600	〃	1.4
Total	700	〃	1.6

Fig. 4 – 6

Monthly Precipitation

Fig. 4 – 7

Isohyetal Map of Annual Precipitation

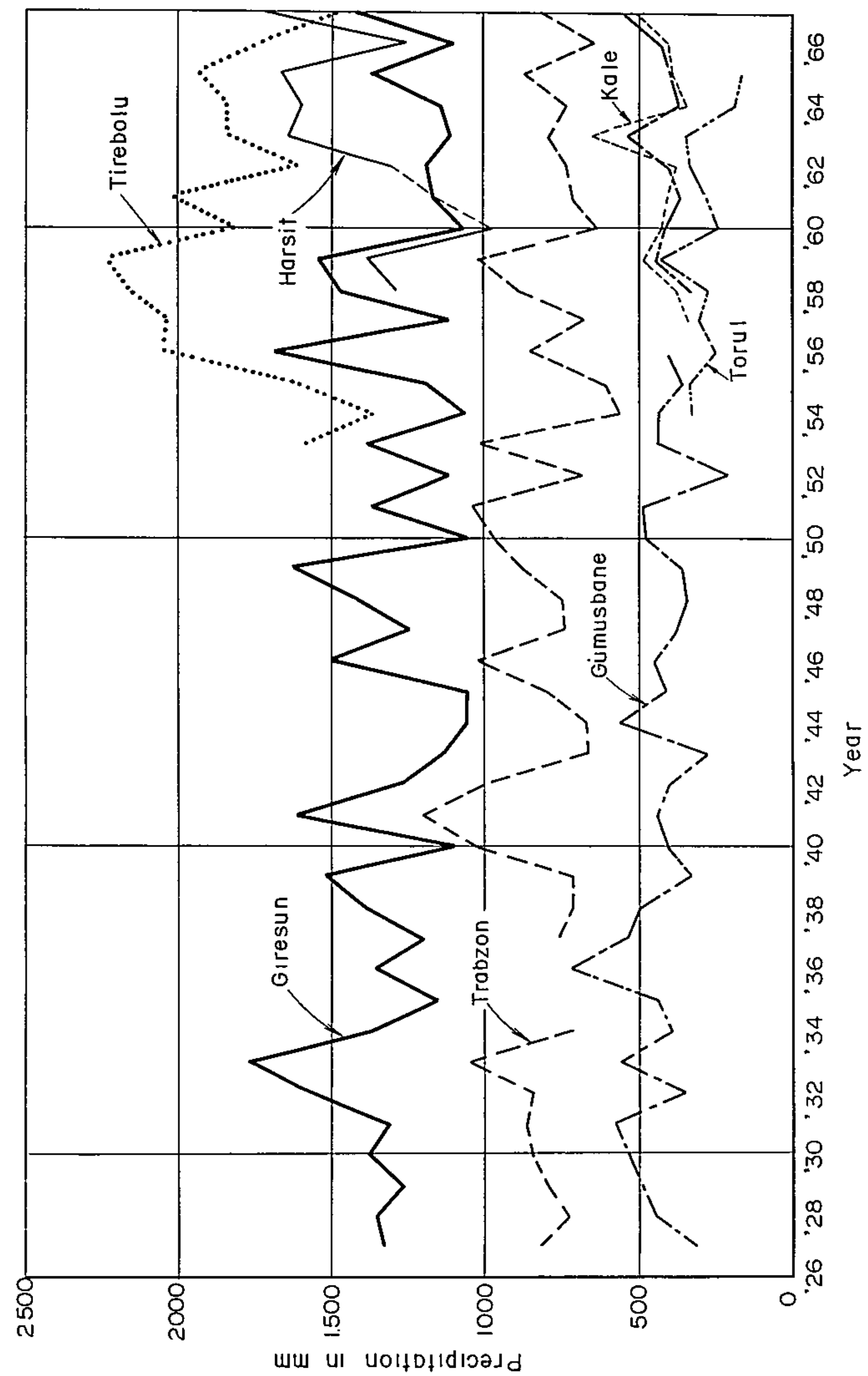
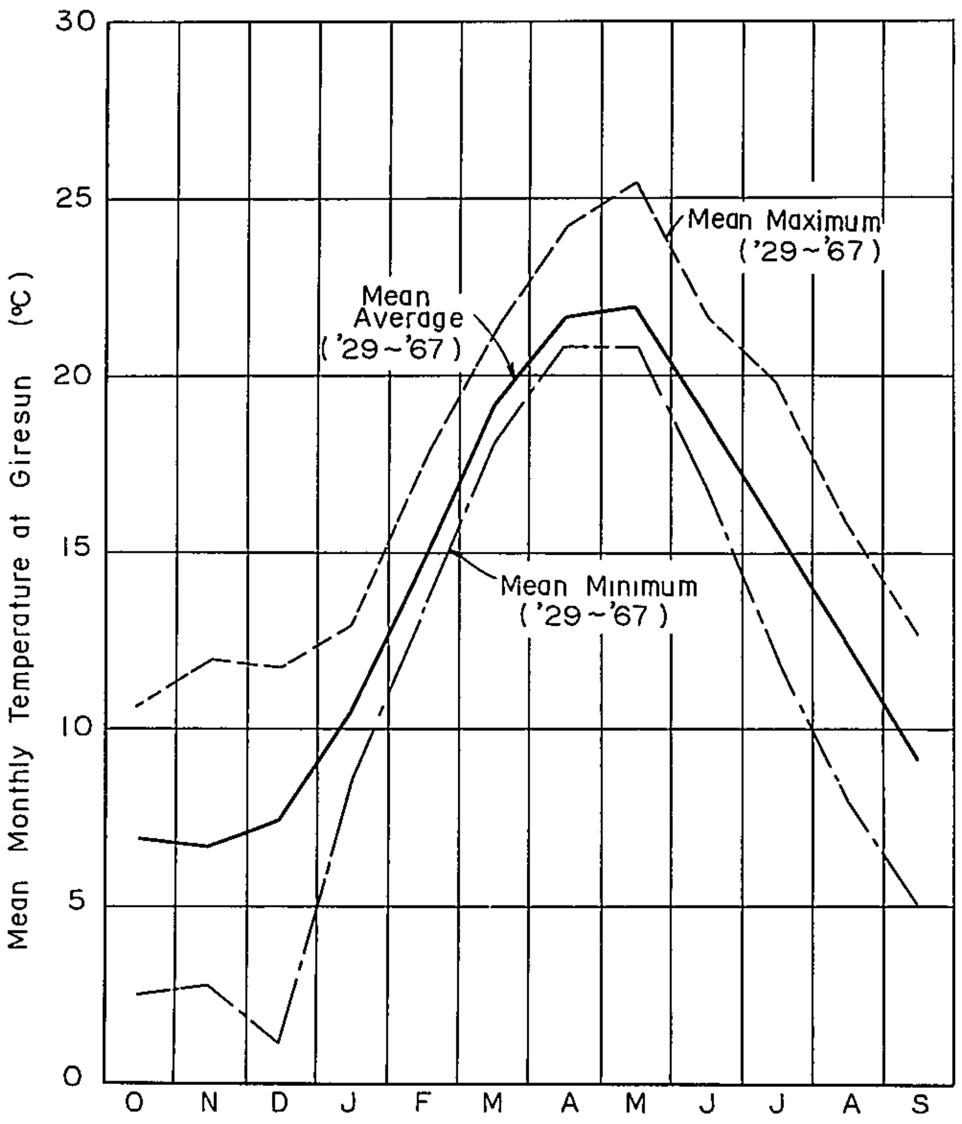


Fig 4 – 8

Annual Precipitation



Note . Difference of Temperature between Giresun and Kürtün Dam Site is about 35°C according to a pseudoadiabatic lapse rate or observed temperature at Gümushane

Fig 4-9

Monthly Temperature

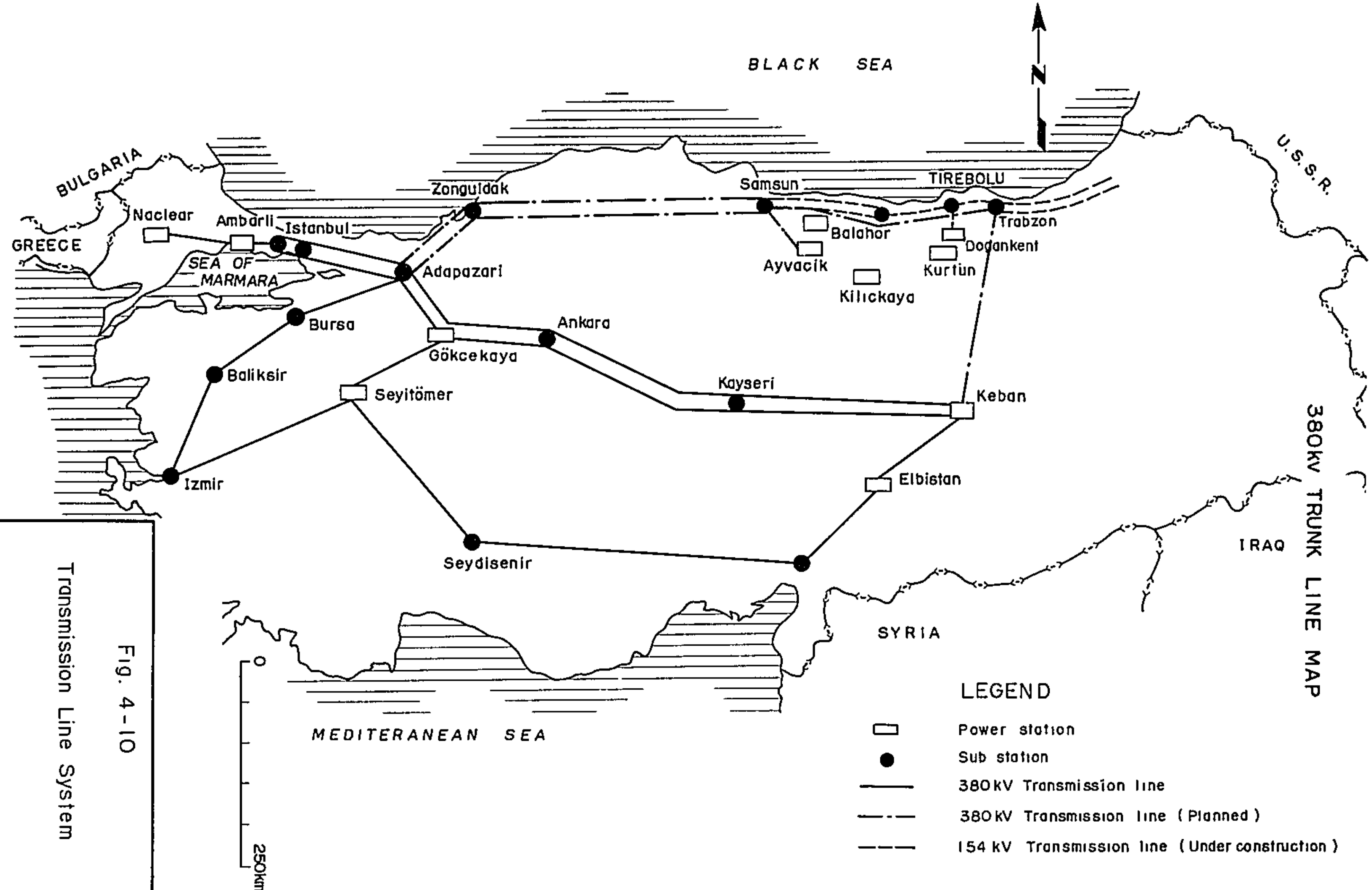


Fig. 4-10

Transmission Line System

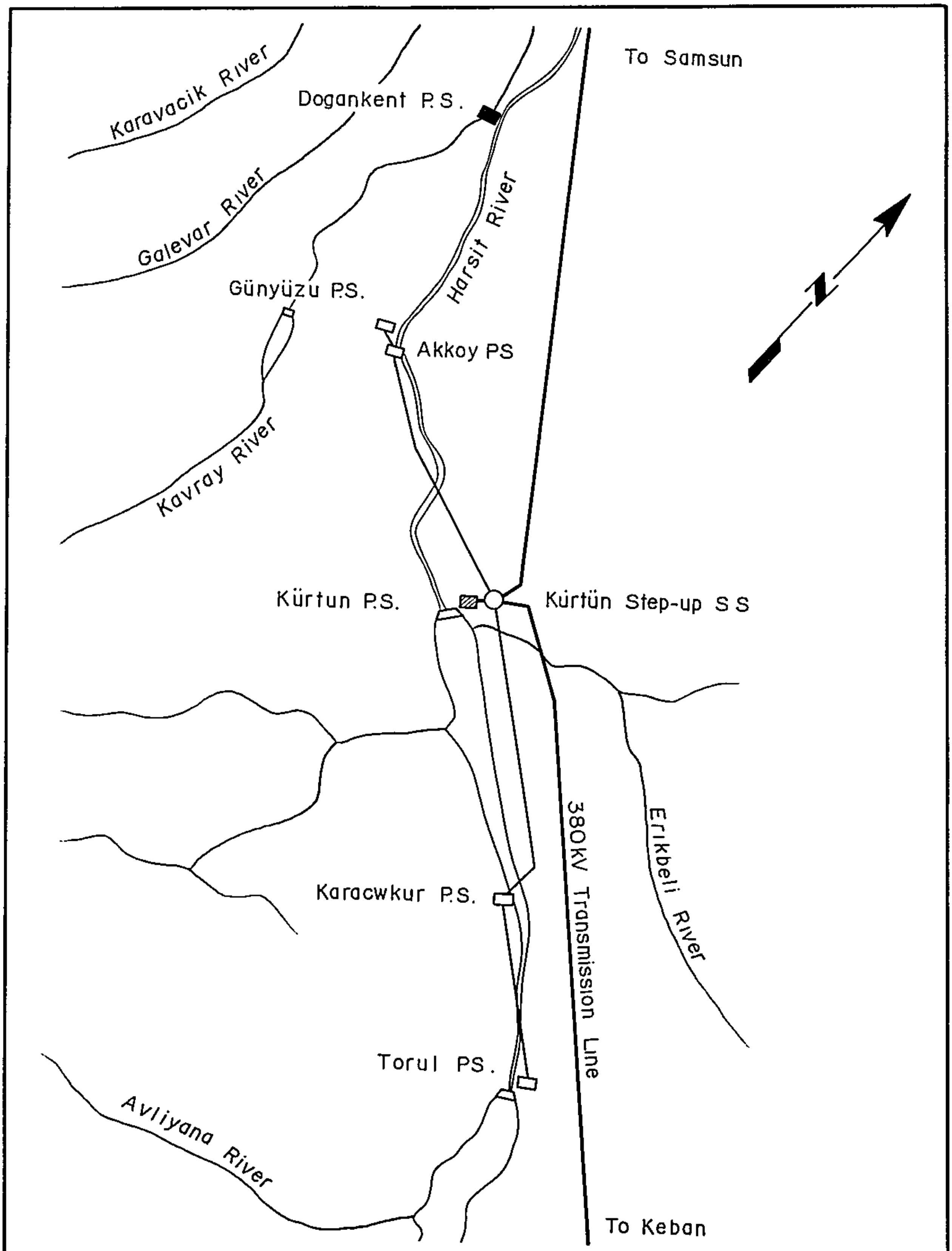


Fig 4-11

Transmisson Route

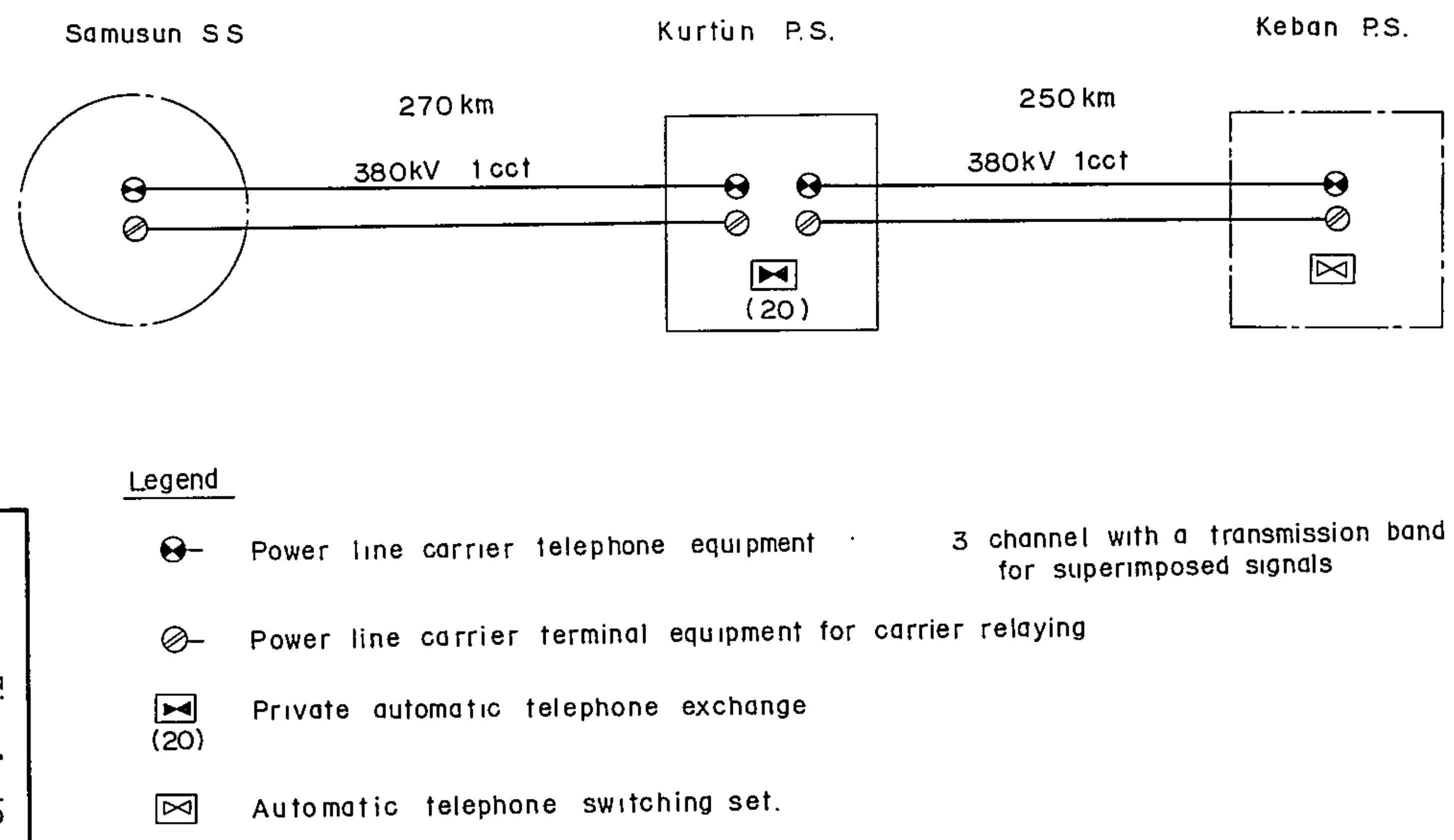


Fig. 4-12

Telecommunication System Diagram

CHAPTER 5

SCALE OF DEVELOPMENT

(Review of the Harsit River Comprehensive Development Plan by DSI)

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CHAPTER 5 SCALE OF DEVELOPMENT

(Review of the Harsit River Comprehensive Development Plan by DSI)

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DSI's comprehensive development program for the Harsit River consists of construction of 3 reservoir-type power plants and 4 waterway-type power plants on the mainstream of the Harsit River and a power plant using diverted water from the upstream part of Gelevela Creek for a total installed capacity of 654 MW to secure a potential annual energy production of 2,365 x 10^6 kWh.

The summarized data of the various projects are listed below.

Torul Project

Normal high water-surface of reservoir	EL. 1,015 m
Total storage capacity	492 x 10^6 cu.m
Effective Storage capacity	375 x 10^6 cu.m
Installed capacity	120 MW
Annual energy Production	192.4 x 10^6 kWh

Karacukur Project

Effective head	153 m
Waterway length	7,000 m
Installed capacity	42 MW
Annual energy production	180.1 x 10^6 kWh

Kurtun Project

Normal High Water	EL. 650 m
Total Storage capacity	303 x 10^6 cu.m
Effective storage capacity	243 x 10^6 cu.m
Installed capacity	120 MW
Annual energy production	237.6 x 10^6 kWh

Akkoy Project

Effective head	148 m
Waterway length	12,150 m
Installed capacity	40 MW
Annual energy production	264 x 10^6 kWh

Dogankent Project

Effective head	183 m
Waterway length	7,127 m
Installed capacity	61 MW
Annual energy production	462.1 x 10^6 kWh

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CHAPTER 5 SCALE OF DEVELOPMENT

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Dogankent Project

Effective head	183 m
Waterway length	7,127 m
Installed capacity	61 MW
Annual energy production	462.1 x 10^6 kWh

Aslancik Project	
Effective head	100 m
Waterway length	8,750 m
Installed capacity	40 MW
Annual energy production	241.7 x 10^6 kWh
Tirebolu Project	
Normal High Water Surface	EL. 70 m
Total storage capacity	328 x 10^6 cu.m
Effective storage capacity	220 x 10^6 cu.m
Installed capacity	120 MW
Annual energy production	200.2 x 10^6 kWh
Günyüzü Project	
Total storage capacity	87.4 x 10^6 cu.m
Effective storage capacity	81.4 x 10^6 cu.m
Effective head	1,215 m
Installed capacity	111 MW
Annual energy production	587.7 x 10^6 kWh

5.2 BASIC CONSIDERATIONS IN REVIEW

The Kurtun Project is located at the middle reaches of the Harsit River and the site scheduled for its reservoir has a close relationship with the downstream Dogankent Project presently under construction and with the various other upstream and downstream project sites being planned, especially with the Torul Project, a reservoir-type power plant of the upstream.

In other words, the Kurtun Project has been formulated as one of the links in the Harsit River Electric Power Development Program, and in this regard, DSI in advance of feasibility studies of the Kurtun Project, strongly called for a review of the Harsit River Comprehensive Development Program by DSI.

The review of the comprehensive program was carried out in accordance with the fundamental conditions given below based on various information obtained in field investigations.

5.2.1 Calculation of Inflow at Each Project Site

The periods of observation of the runoff gaging stations and meteorological observation stations within the Harsit River Basin are as shown in the separately attached Appendix 1.

The longest period of observation is the 14 years at Kurtun Gaging Station (EIE). However, upon seeking the correlation with the annual precipitation at Gumushane, it is found that the runoff data of Kurtun Gaging Station (EIE, 2201) are poorer in reliability than those of Harsit Gaging Station (EIE, 2220).

The observation records of Harsit Gaging Station (EIE) are for a period of about 6 years. Fatli Gaging Station on the Yesilirmak River, which is nearby the Harsit River, has observation records for a long period from 1938 to 1966. Upon seeking the logarithmic correlation between the records of Harsit and Fatli Gaging Stations, a good result of 0.95 was obtained.

The inflow at each project site on the Harsit River was estimated by the procedure described below based on the discharge data of the Fatli and Harsit Gaging Stations obtained by EIE and the results are shown in Table A1-1 - 14 of Appendix 1.

(1) Based on the logarithmic correlation between the Fatli runoff data and the Harsit runoff data, monthly runoff at Harsit Gaging Station (EIE, 2220) from April 1938 to September 1964 was estimated for the period for which the actual measurement data of the Harsit Gaging Station (EIE, 2220) from February 1957 to September 1958 and October 1960 to September 1964 cannot cover.

(2) The runoff of Giris (DSI) for the period from April 1938 to April 1964 was estimated in proportion to catchment area on the basis of the Harsit runoff estimated according to (1) above, and the actual records of Giris from May 1964 to December 1968 were also adopted to give the runoff data of Giris Gaging Station (DSI) from April 1938 to December 1968.

(3) As the correlation between Giris (DSI 22-3) runoff and runoff of Torul Gaging Station (DSI 22-9) is good (correlation factor 0.96), the Torul runoff from April 1938 to January 1966 was estimated on a logarithmic correlation established and the actual measurement data of Torul from February 1966 to December 1968 was adopted. Thus run-off in the period between April 1938 to December 1968 was obtained.

(4) Inflows at the Torul and Karacukur damsites were calculated from the estimated runoff data of the Torul Gaging Station by multiplying the ratios of the catchment area at both dam sites to the Torul Gaging Station.

(5) Since the runoff data of the Kurtun Gaging Station (DSI 22-10) exceed the runoff of the downstream Giris Gaging Station at times, the inflows at the Kurtun and Akkoy damsites were obtained from the estimated runoff of the Giris Gaging Station by multiplying the ratios of the catchment area at both dam sites to the Giris Gaging Station (DSI 22-3).

(6) The inflows at the damsites of Dogankent, Aslancık and Tirebolu were calculated by the same method as described in (4) or (5) from runoff of the Giris Gaging Station (DSI 22-3).

(7) The inflows for the three damsites of the Gunyuzu Project were obtained from the runoff of Harsit Gaging Station on Kavraz Creek calculated by logarithmic correlation (correlation factor. 0.88) based on the runoff of the beforementioned Giris Gaging Station.

5.2.2 Storage Capacities of Respective Reservoirs

Storage capacities of respective reservoirs were estimated on the basis of reservoir capacity curves which were prepared according to 1/5,000 topographical map provided by DSI. (Re: Fig. 5-1)

5.2.3 Evaporation from Reservoir Surface

Based on the separately shown data, the evaporations of Torul Reservoir, Kurtun Reservoir and Tirebolu Reservoir were calculated at 1,000 mm annually for Torul and 330 mm each annually for Kurtun and Tirebolu.

5.2.4 Sedimentation at Each Reservoir

The sedimentation quantities at the Torul Reservoir, the Kurtun Reservoir and the Tirebolu Reservoir (after completion of the Kurtun Dam) were estimated at 1.6 x 10^6 cu.m, 2.2 x 10^6 cu.m and 0.4 x 10^6 cu.m respectively based on the data separately shown.

5.2.5 Combination of Normal High Water Surface of Kurtun and Torul Reservoirs

In determining the optimum scale of each project in the river system, the upper and lower limits of normal high water surface of the Kurtun and the Torul Reservoirs, which are the main reservoirs of the river basin, were decided considering the topographies, geologies, sedimentations and minimum necessary storages for runoff regulation.

The high water surface of reservoir contemplated by DSI were 690 m for the Kurtun Reservoir and 1,015 m for the Torul Reservoir. However, as a result of rough economic studies of the levels it has been concluded that the upper and lower limits of the water surface of the Kurtun Reservoir should be at EL.690m and EL.650m respectively, with a median level of EL.670m in consideration of comparatively poor storage efficiency. In a similar manner, EL. 1,015m and EL. 970m have been adopted as the upper and lower limits of the water surface of the Torul Reservoir with the median level at EL. 990m. Available drawndown was determined in consideration of total heads, sedimentation levels and dependable outputs.

The summarized data of the Kurtun and the Torul Reservoirs based on the various normal high water surfaces are as indicated below.

Torul Reservoir

Normal high water surface	EL. 1,015 m	EL. 990 m	EL. 970 m
Low water surface	EL. 962 m	EL. 946 m	EL. 942 m
Available drawdown	53 m	44 m	28 m
Total storage	505x10^6 cu.m	300x10^6 cu.m	183.82x10^6cu.m
Effective storage	355x10^6 cu.m	207.8x10^6 cu.m.	103.82x10^6cu.m
Rated head	137m	115m	101m

Kurtun Reservoir

Normal high water surface	EL. 690 m	EL. 670 m	EL. 650 m
Low water surface	EL. 642 m	EL. 630 m	EL. 620 m
Available drawdown	48 m	40 m	30 m
Total storage	297.24x10^6 cu.m	207.68x10^6cu.m	137.20x10^6 cu.m
Effective storage	182.82x10^6 cu.m	123.36x10^6cu.m	73.34x10^6 cu.m
Rated head	127 m	110 m	92 m

Tirebolu Reservoir

Normal high water surface	EL. 70 m
Low water surface	EL. 48 m
Available drawdown	22 m
Total storage	312.8×10^6 cu.m
Effective storage	171.2×10^6 cu.m
Rated head	58 m

Various combinations of the normal high water levels assumed for the study of reservoir scale are as below. Details of the various cases are shown in Table A3-6 of the Appendix 3.

	Kurtun Reservoir	Torul Reservoir
Case 1	EL. 690 m	EL. 1,015 m
Case 2	"	990 m
Case 3	"	970 m
Case 4	EL. 670 m	1,015 m
Case 5	"	990 m
Case 6	"	970 m
Case 7	EL. 650 m	1,015 m
Case 8	"	990 m
Case 9	"	970 m

As described later, in consideration of the fact that reservoirs with small capacity such as Case 8 or Case 9 was found to be the optimum scale from economic point of view and that the mean river gradient of the Harsit River is 1/100, a study was also made of a proposal to create only one of either Torul or Kurtun as reservoir-type. The normal high water level assumed in the study are:

	Kurtun Reservoir	Torul Reservoir
Case 10	690 m	0 m
Case 11	0 m	1,015 m
Case 12	0 m	970 m

5.2.6 Firm Available Discharge, Maximum Available Discharge and Installed Capacity of Each Power Station

The firm available discharge, maximum available discharge and installed capacity of each power station were determined as follows:

(1) For each combination of the high water surface as given in the preceding paragraph, the firm available discharge of each power station in each case was calculated based on the residual mass curves of the Torul and the Kurtun Reservoirs for the period between 1938 and on 1968 and the effective storage capacities of each reservoir.

(2) Since the Kurtun and Torul Power Stations would be reservoir-type power stations requiring creation of dams of which construction cost counts for an extremely large portion of the entire project cost, the maximum available discharges and installed capacities were determined at a plant factor of 25% upon an assumption that the power stations would be operated for peak load.

(3) Since the Gunyuzu Power Station is proposed in dam-water-way type, it would be desirable that the maximum available discharge of the power station be made as large as possible. However, as the power station is proposed to operate under a high head of 1,215 m, applicable diameter of penstock would naturally be restricted due to technical limitations in manufacturing. Taking these factors into account, the maximum available discharge of the Gunyuzu Power Station was determined at 11 c.m.s. Therefore, the installed capacity would be 113,000 kw.

(4) Economic comparisons of maximum available discharges of the various run of the river type power stations were made at plant factors of 70%, 50% and 25%. The maximum available discharges of the Akkoy, Dogankent and Aslancik Power Stations were determined based on the fact that tunnel capacity of the Dogankent Power Station now under construction would ultimately be 45 c.m.s. (Re Fig. A3-1 in Appendix 3) and that Dogankent Diversion Dam would not posses a regulating capacity, and further that the maximum available discharge of the Günyüzü Power Station would be 11 c.m.s.

5.2.7 Calculation of Construction Cost

(1) Kürtün and Torul Dams have been proposed in dome-type and cylinder-type arch dams, respectively. The calculations of dam volumes at various heights were made in accordance with results of analogical analysis based on a dam volume obtained by preliminary design of an arch dam with a height of 173 m. The unit cost of dam concrete of the Ayvacik Project studied by EPDC was referred to for the unit construction cost.

(2) In calculating the construction cost of tunnels, cross sections were calculated assuming a waterway gradient of 1/1,000, while the unit construction cost per meter was set to conform to DSI's unit cost established in 1967.

The results of the estimated construction cost are shown in Table A3-7 of the Appendix 3.

5.2.8 Power Benefit, Energy Benefit and Annual Cost

Power benefit, energy benefit and annual cost of power adopted for economic comparisons are as given below:

Benefit

Installed capacity of alternative thermal power plant		Power benefit	Energy benefit
100 MW	5% interest	181.8 T.L/kW	5.69 kr /kWh
	8% interest	227.8 T.L/kW	5.69 kr /kWh
300 MW	5% interest	148.9 T.L/kW	5.59 kr /kWh
	8% interest	189.1 T.L/kW	5.59 kr /kWh

Equalized Annual Cost Factor

5% interest	6.734%
8% interest	9.430%

5.3 OPTIMUM SCALE OF KURTUN AND TORUL RESERVOIRS

In determination of optimum scale of reservoirs, inflow, available discharge of power plant, reservoir water surface and available energy at each combination of high water surface described in 5.2 were calculated using an IBM-360 electronic computer for a period of 30 years from 1939 through 1968 The results of calculations are indicated in Appendix 3, Table A3-1 through A3-5. As regards operation of each reservoir, it was assumed that the firm discharge would be used until the reservoir surface reaches high water level and maximum available discharge would be used after high water surface is reached. While study of operation rules were made on reservoirs of optimum scale and are described in 5.4, "Reservoir Operation".

Based on the available energy and dependable peak capacity of each power station obtained in this manner, and unit value of benefit which is equivalent to the cost of assumed standard alternative thermal power station, annual power and energy benefit of each power station was obtained. Then, the benefit of each station was added together for the annual benefit of the entire river basin.

On the other hand, annual cost of the entire river basin was obtained by adding together the annual cost of each power station calculated based on its construction cost.

Thus, the combination of high water surface which gives the greatest difference between annual benefit and annual cost, that is the greatest surplus benefit, was considered to be the optimum scale. The results are as given in Appendix 3, Table A3-8. Table A3-8(1) indicates the results of economic comparison based on plant factors of 25% for dam-type power stations, Torul, Kurtun and Tirebolu, and 70% for other run-of the river type power stations. Table A3-8 (2) gives the results of economic comparison based on plant factors of 25% for dam-type power stations and 50% for run-of the river type power stations.

An economic comparison was made, of run-of the river type power stations for the case without diversion of water from Gunyuzu Power Station. The results are as shown in Table A3-8 (3). Although the Gunyuzu Project will be included in the Comprehensive Harsit River Development Plan, a study was made excluding the Gunyuzu Project for reasons that the main objective of the Kurtun and Torul reservoirs is the regulation of the discharge of mainstream Harsit and accordingly that it was desired to make an economic comparison of the scales of the Kurtun and Torul Reservoirs based solely on the river discharge of the main Harsit River eliminating the influence of the runoff diverted from Gunyuzu Power Station.

Fig 5-15 through Fig. 5-18 are graphical presentation of Table A3-8 (1) and Table A3-8 (2). As seen in these figures, Case 8 will be optimum scale at 5% interest and Case 9 at 8% interest. In either case, the high water surface of the Kurtun Reservoir is EL. 650 m. Assuming that construction funds will be available at a relatively low interest rate for development of the Kurtun Project, Case 8, which is the combination of the high water surface at EL. 990 m for the Torul Reservoir and EL. 650 m for the Kurtun Reservoir was selected as the optimum scale. The effective storage capacity of the reservoirs will be 207.8 x 10^6 cu.m and 73.34 x 10^6 cu.m, respectively.

In the meantime, considering that it might be preferable for the Kurtun Dam to be made as low as possible and taking into account the river gradient of the Harsit as a whole, an alternative development plan may be proposed, which aims at the development of the Kurtun Project in run-of the river type power plant. At present, investigation work for the Kurtun Project is being carried out for the development of a dam and reservoir type power station, and accordingly, geological data are not adequately available for the study of development in run-of the river type. Therefore, the study for the development in run-of the river type was made using 1/25,000 to 1/5,000 scale topographical maps.

Case 11 and Case 12 are proposals for development of the Kurtun in run-of the river type power station with high water level of the upstream Torul Reservoir at EL. 1,015 m and EL. 970 m, respectively.

Tables A3-8 (4) to A3-8 (5) in the appendix give the economic comparison of Case 8, which is the optimum scale when the Kurtun Project is developed in dam and reservoir type power station, Case 10, Case 11 and Case 12. The studies were made for plant factors of 25% for dam and reservoir type power stations, and 70%, 50% and 25% for run-of the river type power stations.

As seen in these Tables at an interest rate of 5% and plant factors of 70% and 80% for run-of the river type power stations Case 8 is more economical than Case 11 and Case 12. While, at plant factor of 25% and an interest rate of 8%, Case 11 and Case 12 are superior to Case 8.

Surplus benefit tends to get the more improved if plant factor be made smaller for run-of the river type power plants on the Harsit River. However, since the maximum available discharge of the Dogankent Power Station is 45 c.m.s., it is technically impossible to lower the plant factors of the various power plants downstream of the Kurtun to 25%. They will stand at a plant factor of 50-60% which is the principal cause of the above results.

While, if the annual energy productions of Case 8, Case 11 and Case 12 be devided into firm and secondary energy and one half of the value of firm energy be assumed for the value of secondary energy the surplus benefits of Case 8, Case 11 and Case 12 would be almost equal.

As a general tendency, capability of power plant could not fully be utilized at low plant factors, especially at the initial stage operation. Therefore, feasibility studies were carried out on case 8 at the plant factor of approximately 50% for the entire river system. As previously described, Case 8 is the optimum scale in case the Kurtun be developed in dam and reservoir type.

5.4 RESERVOIR OPERATION AND POWER PRODUCTION

5.4.1 Reservoir Operation

Inflow into the Kurtun Reservoir fluctuates by months, but the fluctuation is not of considerable extent on yearly basis.

Therefore, the operation rule of the Kurtun Reservoir must be established so as to control such fluctuation of the monthly inflow to obtain a constant discharge and to minimize spillage.

Fig. 5-19 is a reservoir operation curve obtained through trial and error based on this idea. If this reservoir operation is applied to the period of 30 years for which runoff data are available, the available discharge for power, spilled water and reservoir water surface level will be as shown in Fig. 5-20 and Fig. 5-21.

Since this operation rule is of a tentative nature, a more elaborate rule must be prepared before actual operation of the reservoir.

5.4.2 Power Production

(1) Energy Production

Monthly energy production covering a 30-year period was calculated from the available discharge for power and reservoir water surface level obtained from the reservoir operation rule described in 5.4.1, the result of which are shown in Fig. 5-22 - 24.

It was defined that the annual-firm energy is an amount of energy 12 times the minimum monthly energy in each year and the secondary energy is the annual total energy less the firm energy. Monthly firm, secondary and total energy covering a 30-year period which calculated according to this definition were tabulated in Table 5-1, and Table 5-2.

(2) Dependable Capacity

As dependable capacities, the third output from the minimum output in December covering a 30-year period were adopted. The result is as below:

Dependable capacity of Kurtun Power Station		46,000 KW
Dependable capacity of Akkoy Power Station		40,000 KW
Dependable capacity of Dogankont Power Station	Existed	32,800 KW
	Increased	37,200 KW
	Total	70,000 KW
Dependable capacity of three power stations		156,000 KW

Table 5-1 Energy Production of Kürtün, Akkoy and Dogankent Power Stations (Before Completion of Torul Reservoir)

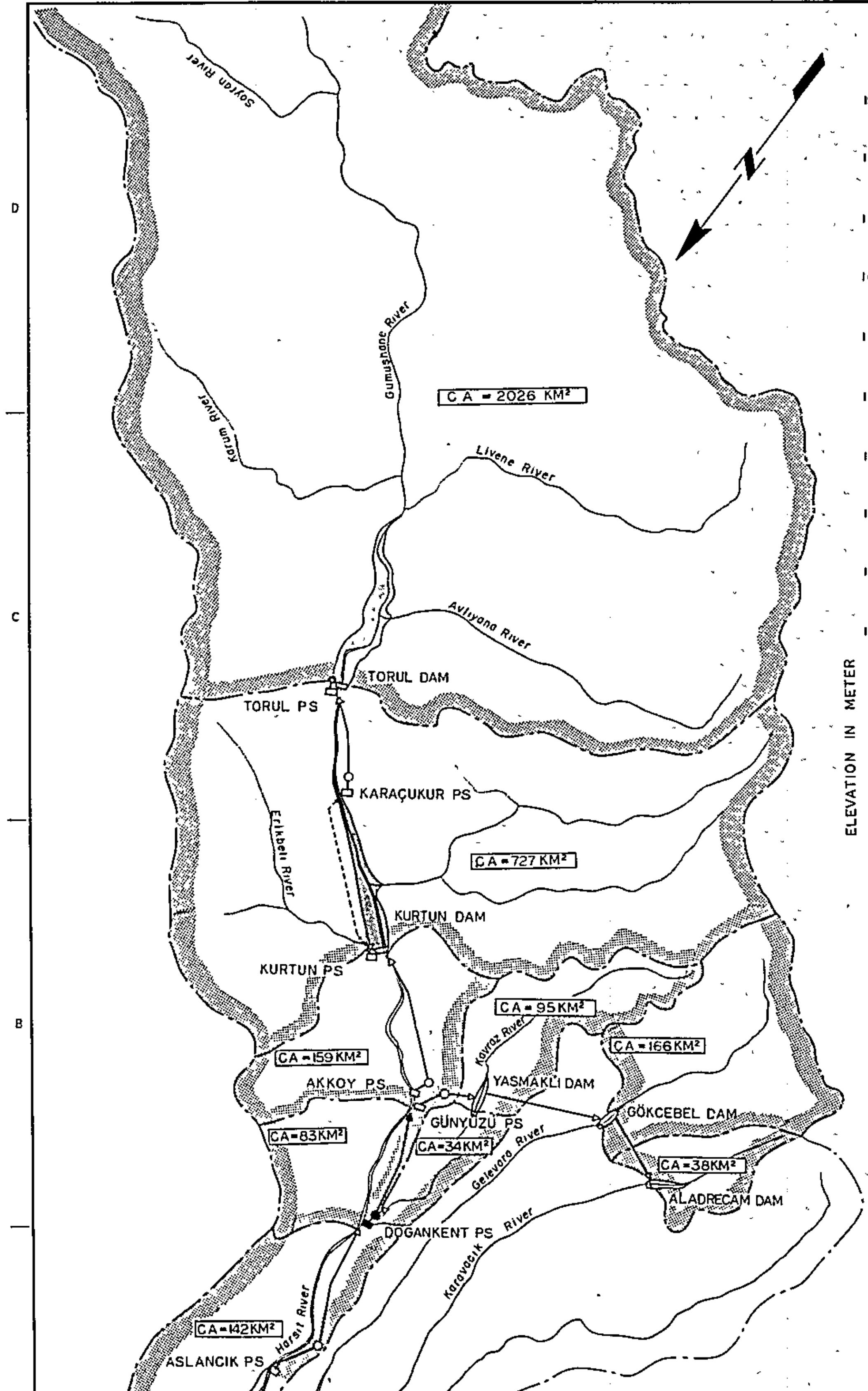
Unit: 10^6 kWh

Year	Kürtün (PKN)			Akköy (PYN)			Dogankent (PDN)		
	Firm	Secondary	Total	Firm	Secondary	Total	Firm	Secondary	Total
1939	92.7	98.3	191.0	129.1	94.8	223.9	198.2	160.7	358.9
1940	95.6	145.9	241.5	129.1	106.3	235.4	203.5	188.7	392.2
1941	95.1	156.7	251.8	129.1	114.3	243.4	199.5	202.4	401.9
1942	90.8	138.3	229.1	129.1	102.4	231.5	197.1	181.0	378.1
1943	82.7	158.6	214.3	121.5	110.4	231.9	196.7	174.1	370.8
1944	88.4	119.1	207.5	129.1	103.0	232.1	199.2	185.3	384.5
1945	78.9	110.9	189.8	121.5	106.7	228.2	188.9	173.8	362.7
1946	77.9	115.7	193.6	129.1	98.2	227.3	196.9	176.3	373.2
1947	75.3	78.2	153.5	121.5	93.6	215.1	184.2	154.3	338.5
1948	72.3	115.1	187.4	121.5	106.8	228.3	195.1	175.1	370.2
1949	52.5	103.9	156.4	96.4	116.8	213.2	151.8	184.6	336.4
1950	87.9	115.8	203.7	129.1	96.4	225.5	195.3	170.2	365.5
1951	88.9	86.4	175.3	129.1	96.3	225.4	197.5	172.3	369.8
1952	79.3	146.4	225.7	121.5	115.9	237.4	197.3	184.2	381.5
1953	81.2	101.2	182.4	129.1	97.5	226.6	199.9	167.5	367.4
1954	84.2	155.1	239.3	129.1	106.3	235.4	198.1	190.4	388.5
1955	57.1	78.1	135.2	104.7	97.2	201.9	167.8	144.6	312.4
1956	56.8	98.3	155.1	104.1	113.6	217.7	166.8	189.0	355.8
1957	81.0	121.9	202.9	121.5	111.2	232.7	190.4	190.8	381.2
1958	79.0	99.2	178.2	121.5	114.9	236.4	187.2	202.3	389.5
1959	77.3	92.3	169.6	129.1	94.5	223.6	197.3	167.4	364.7
1960	73.4	152.8	226.2	121.5	110.8	232.3	178.6	198.4	377.0
1961	43.6	89.5	133.1	79.9	120.7	200.6	127.1	193.6	320.7
1962	76.7	104.3	181.0	121.5	110.3	231.8	183.6	190.4	374.0
1963	89.8	151.2	241.0	129.1	113.1	242.2	200.0	196.2	396.2
1964	80.2	143.0	223.2	121.5	111.2	232.7	189.7	189.8	379.5
1965	84.5	144.0	228.5	129.1	103.0	232.1	193.0	191.5	384.5
1966	66.8	169.3	236.1	121.5	121.8	243.3	179.2	214.7	393.9
1967	56.6	161.5	218.1	103.8	150.4	254.2	165.2	254.9	420.1
1968	77.4	160.2	237.6	121.5	117.4	238.9	186.1	205.4	391.5
Mean	77.5	123.7	200.3	120.8	108.5	229.4	187.0	185.7	372.7

Table 5-2 Energy Production of Kürtun, Akköy and Dogankent Power Stations (after completion of Torul Reservoir)

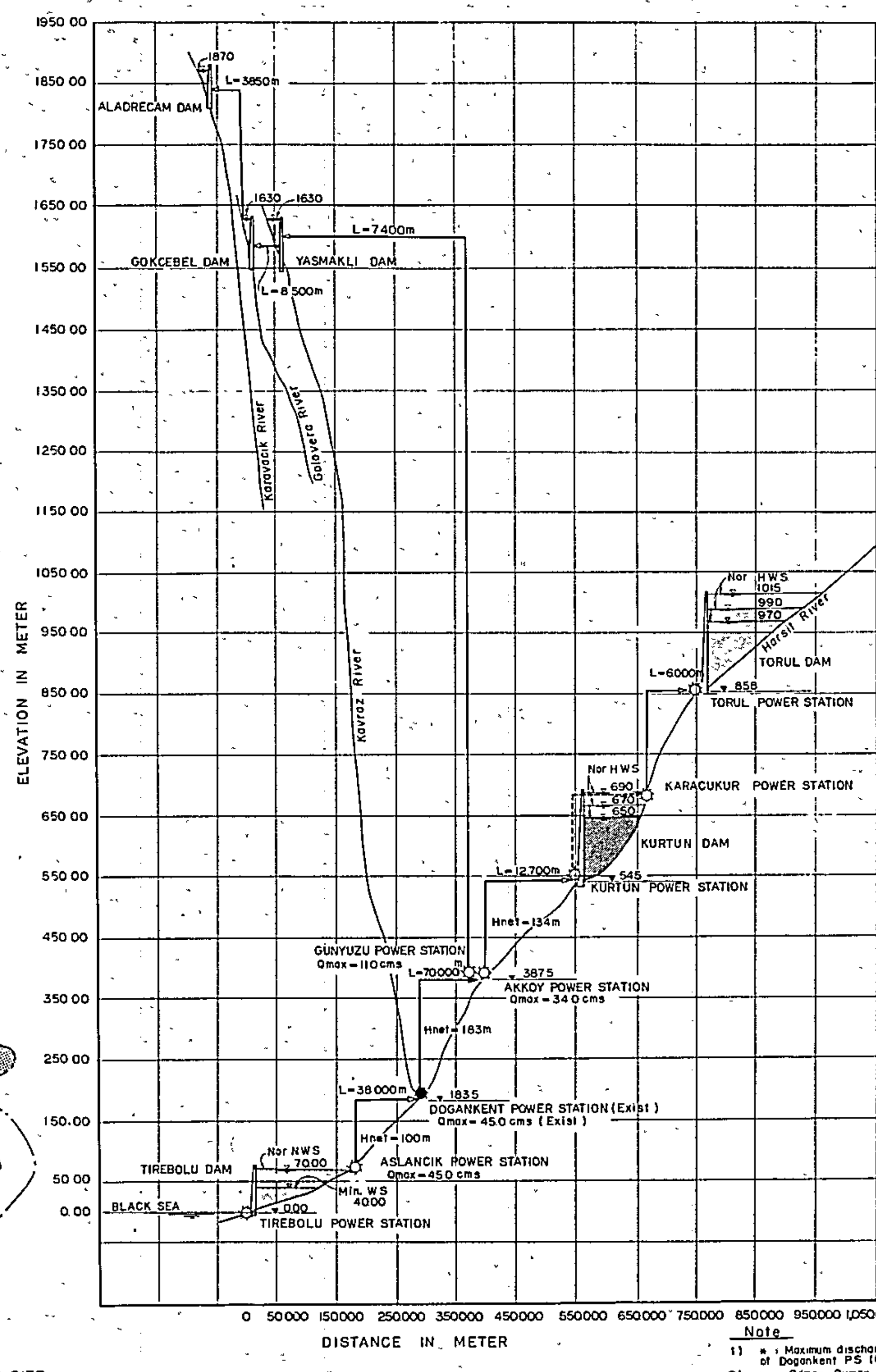
Unit: 10^6 kWh

Year	Kürtün (PKN)			Akköy (PYN)			Dogankent (PDN)		
	Firm	Secondary	Total	Firm	Secondary	Total	Firm	Secondary	Total
1939	139.0	36.2	175.2	196.3	-17.4	178.9	290.0	7.4	297.4
1940	138.4	105.7	244.1	196.3	37.8	234.1	292.0	98.5	390.5
1941	141.3	109.0	250.3	196.3	31.9	228.2	291.3	89.8	381.1
1942	136.0	89.8	225.8	196.3	23.4	219.7	288.9	77.3	366.2
1943	126.0	76.7	202.7	196.3	- 0.7	195.6	287.9	33.4	321.3
1944	123.0	94.2	217.2	196.3	5.8	202.1	291.0	56.1	347.1
1945	123.1	66.4	189.5	196.3	-16.0	180.3	286.4	10.4	296.8
1946	111.8	87.4	199.2	196.3	-12.4	183.9	288.6	24.1	312.7
1947	126.5	30.5	157.0	196.3	-16.6	179.7	283.3	13.3	296.6
1948	117.6	74.2	191.8	196.3	-16.5	179.8	286.8	15.1	301.9
1949	95.4	56.6	152.0	174.9	- 4.0	170.9	259.1	21.7	280.8
1950	121.8	76.0	197.8	196.3	- 6.4	189.9	287.1	29.9	317.0
1951	121.5	72.0	193.5	196.3	13.0	209.3	289.3	62.5	351.8
1952	123.8	88.6	212.4	196.3	14.1	210.4	288.3	62.0	350.3
1953	115.7	74.7	190.4	196.3	-12.6	183.7	291.7	15.8	307.5
1954	127.6	107.1	234.7	196.3	10.7	207.0	289.9	62.8	352.7
1955	108.4	14.3	122.7	196.3	-35.5	160.8	283.3	-17.4	265.9
1956	94.9	83.2	178.1	174.0	5.3	179.3	262.2	44.4	306.6
1957	124.9	90.0	214.9	196.3	9.7	206.0	282.2	67.2	349.4
1958	123.3	63.1	186.4	196.3	1.3	197.6	289.5	47.3	336.8
1959	115.1	60.8	175.9	196.3	-14.0	182.3	289.1	20.2	309.3
1960	122.4	93.1	215.5	196.3	7.7	204.0	280.7	63.0	343.7
1961	102.6	19.2	121.8	196.3	-41.4	154.9	275.0	-19.1	255.9
1962	118.3	84.9	203.2	196.3	0.3	196.6	276.5	52.7	329.2
1963	123.1	127.5	250.6	196.3	21.8	218.1	291.8	71.5	363.3
1964	126.9	96.3	223.2	196.3	4.0	200.3	281.4	57.7	339.1
1965	119.1	104.6	223.7	196.3	11.7	208.0	284.7	66.9	351.6
1966	119.2	114.9	234.1	196.3	17.3	213.6	281.3	72.1	353.4
1967	112.8	112.3	225.1	196.3	25.6	221.9	287.0	86.8	373.8
1968	121.4	109.0	230.4	196.3	12.9	209.2	287.5	67.1	354.6
Mean	120.7	80.6	201.3	194.8	2.0	196.9	284.8	45.4	330.1



TOTAL CATCHMENT AREA AT DAM SITE OR DIVERSION SITE OF POWER STATIONS

TORUL	T C A	= 2026 KM²
KARACUKUR	〃	= 〃 〃
KURTUN	〃	= 2026 + 727 = 2753 KM²
AKKOY	〃	= 〃 〃 〃
GUNYUZU	〃	= 38 + 166 + 95 = 299 KM²
DOGANKENT	〃	= 2753 + 159 = 2912 KM²
ASLANCIK	〃	= 2912 + 95 + 34 + 83 = 3124 KM²
TIREBOLU	〃	= 3124 + 142 = 3266 KM²



STORAGE CAPACITY AND POWER DISCHARGE OF ALTERNATIVE SCHEME

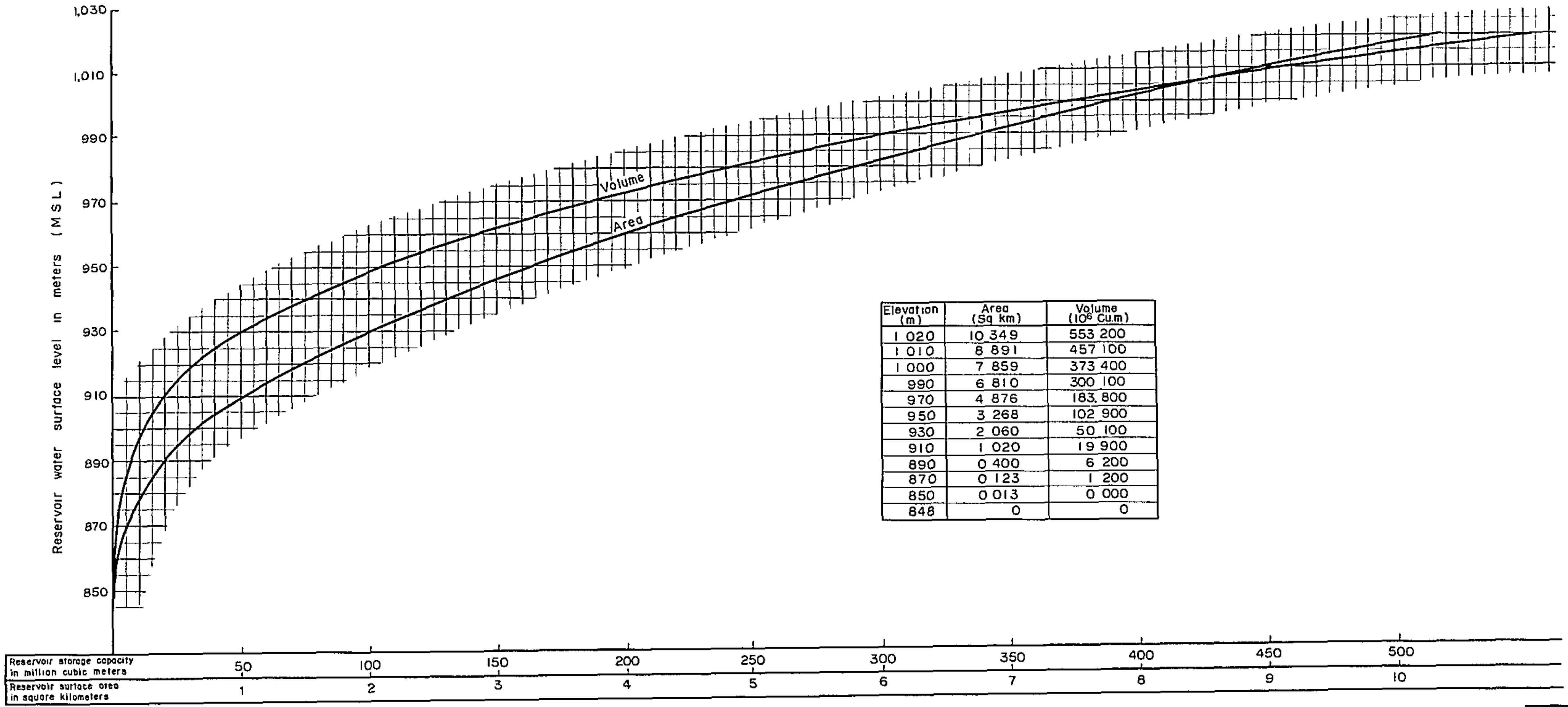
PLAN	ITEM	TORUL	KARCUKUR	KURTUN	AKKOY	DOGANKENT	ASLANCIK	TIREBOLU
1	Nor H W S m	1015	850	690	545	383	180	70
	Eff Storage Capacity mcm	3550	09	1829	13	—	—	1712
	Firm Discharge cms	144	144	236	236	286	287	323
	Max Discharge (70) 〃	57	20	94	** 34	* 45	* 45	129
	〃 (50) 〃	〃	29	〃	** 34	* 45	* 45	〃
	〃 (25) 〃	〃	57	〃	95	106	106	〃
2	Nor H W S m	990	850	690	545	383	180	70
	Eff Storage Capacity mcm	2078	09	1829	13			1712
	Firm Discharge cms	122	122	214	214	264	265	301
	Max Discharge (70) 〃	48	18	85	31	42	42	120
	〃 (50) 〃	〃	25	〃	** 34	* 45	* 45	〃
	〃 (25) 〃	〃	48	〃	85	96	96	〃
3	Nor H W S m	970	850	690	545	383	180	70
	Eff Storage Capacity mcm	1038	09	1829	13			1712
	Firm Discharge cms	99	99	192	192	242	243	279
	Max Discharge (70) 〃	40	15	76	28	39	39	112
	〃 (50) 〃	〃	20	〃	** 34	* 45	* 45	〃
	〃 (25) 〃	〃	40	〃	76	87	87	〃
4	Nor H W S m	1015	850	670	545	383	180	70
	Eff Storage Capacity mcm	3350	09	1234	13			1712
	Firm Discharge cms	144	144	226	226	276	277	313
	Max Discharge (70) 〃	57	21	90	34	45	45	125
	〃 (50) 〃	〃	29	〃	** 34	* 45	* 45	〃
	〃 (25) 〃	〃	57	〃	90	101	101	〃
5	Nor H W S m	990	850	670	545	383	180	70
	Eff Storage Capacity mcm	2078	09	1234	13			1712
	Firm Discharge cms	122	122	203	203	253	254	290
	Max Discharge (70) 〃	48	18	81	29	40	40	116
	〃 (50) 〃	〃	25	〃	** 34	* 45	* 45	〃
	〃 (25) 〃	〃	48	〃	81	92	92	〃
6	Nor H W S m	970	850	670	545	383	180	70
	Eff Storage Capacity mcm	1038	09	1234	13			[illegible]
	Firm Discharge cms	99	99	181	181	231	232	[illegible]
	Max Discharge (70) 〃	40	15	72	26	37	37	[illegible]
	〃 (50) 〃	〃	20	〃	** 34	* 45	* 45	
	〃 (25) 〃	〃	40	〃	72	83	83	
7	Nor H W S m	1015	850	650	545	383	180	70
	Eff Storage Capacity mcm	3550	09	733	13			[illegible]
	Firm Discharge cms	144	144	219	219	269	270	[illegible]
	Max Discharge (70) 〃	57	21	87	32	43	43	22
	〃 (50) 〃	〃	29	〃	** 34	* 45	* 45	
	〃 (25) 〃	〃	57	〃	87	98	98	〃
8	Nor H W S m	990	850	650	545	383	180	70
	Eff Storage Capacity mcm	2078	09	733	13			1712
	Firm Discharge cms	122	122	197	197	247	248	284
	Max Discharge (70) 〃	48	18	78	29	40	40	114
	〃 (50) 〃	〃	25	〃	** 34	* 45	* 45	〃
	〃 (25) 〃	〃	48	〃	78	89	89	〃
9	Nor H W S m	970	850	650	545	383	180	70
	Eff Storage Capacity mcm	1038	09	733	13			1712
	Firm Discharge cms	99	99	174	174	224	225	261
	Max Discharge (70) 〃	40	14	70	25	36	36	104
	〃 (50) 〃	〃	20	〃	34	45	45	〃
	〃 (25) 〃	〃	40	〃	70	81	81	〃
10	Nor H W S m	—	850	690	545	383	180	70
	Eff Storage Capacity mcm	—	09	1829	13			1712
	Firm Discharge cms	—	32	178	178	228	229	265
	Max Discharge (70) 〃	—	5	71	26	37	41	106
	〃 (50) 〃	—	7	〃	** 34	* 45	* 45	〃
	〃 (25) 〃	—	13	〃	71	82	82	〃
11	Nor H W S m	1015	850	(690)	545	383	180	70
	Eff Storage Capacity mcm	3550	09	—	13			1712
	Firm Discharge cms	144	144	144	154	204	205	276
	Max Discharge (70) 〃	57	21	21	22	33	33	111
	〃 (50) 〃	〃	29	29	30	41	41	〃
	〃 (25) 〃	〃	57	57	** 34	* 45	* 45	〃
12	Nor H W S m	970	850	(690)	545	383	180	70
	Eff Storage Capacity mcm	1038	09	—	13			1712
	Firm Discharge cms	99	99	99	101	151	152	231
	Max Discharge (70) 〃	40	14	14	14	25	25	92
	〃 (50) 〃	〃	20	20	20	31	31	〃
	〃 (25) 〃	〃	40	40	** 34	* 45	* 45	〃
13	Nor H W S m	—	850	(690)	545	383	180	70
	Eff Storage Capacity mcm	—	09	—	13			1712
	Firm Discharge cms	—	32	32	42	92	93	215
	Max Discharge (70) 〃	—	5	5	6	17	17	86
	〃 (50) 〃	—	7	7	8	19	19	〃
	〃 (25) 〃	—	13	13	17	28	28	〃
14	Nor H W S m	—	850	650	545	383	180	70
	Eff Storage Capacity mcm	—	09	733	13			1712
	Firm Discharge cms	—	32	122	122	172	172	220
	Max Discharge (70) 〃	—	5	78	19	27	27	88
	〃 (50) 〃	—	7	〃	26	36	36	〃
	〃 (25) 〃	—	13	〃	** 34	* 45	* 45	〃

Note

1) * : Maximum discharge of existing tunnel section of Dogankent PS (Qdmax)
2) ** Qdmax – Qumax = 45 – 11 = 34 cms
3) Qumax = Maximum discharge of Gunynuz PS
4) (70), (50), (25) = plant Factor of Run of River Type Power Station
5) (690) = Without Rereruoir Run of River Type of Kurtün
6) Max Discharge of Dogankent = Max Discharge of AKKOY + 11.0 (Max. Discharge of GUNYUZU)

Fig. 5-1

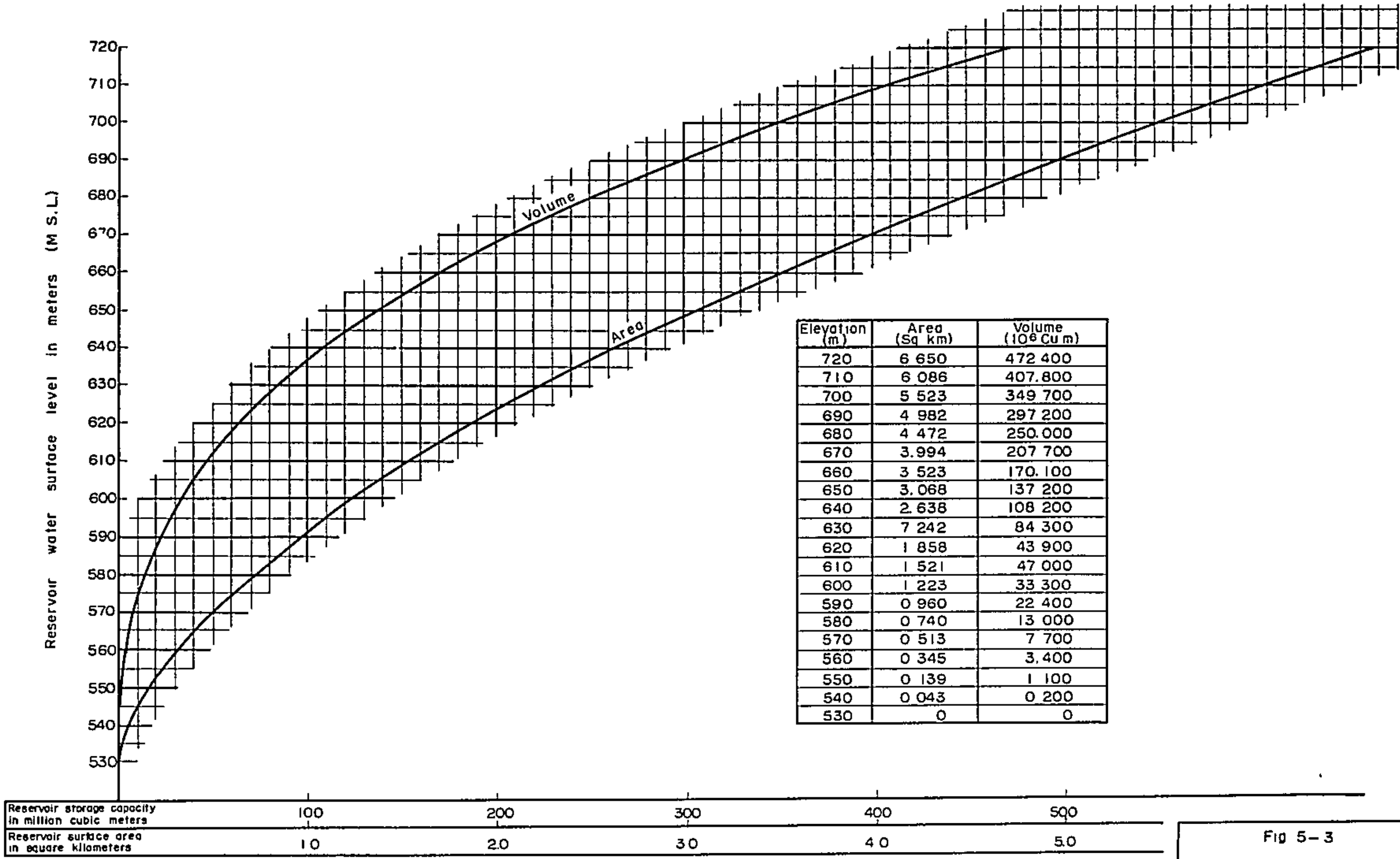
Plan and Profile of Alternative Scheme



Elevation (m)	Area (Sq km)	Volume (10^6 Cu.m)
1 020	10 349	553 200
1 010	8 891	457 100
1 000	7 859	373 400
990	6 810	300 100
970	4 876	183. 800
950	3 268	102 900
930	2 060	50 100
910	1 020	19 900
890	0 400	6 200
870	0 123	1 200
850	0 013	0 000
848	0	0

Fig 5-2

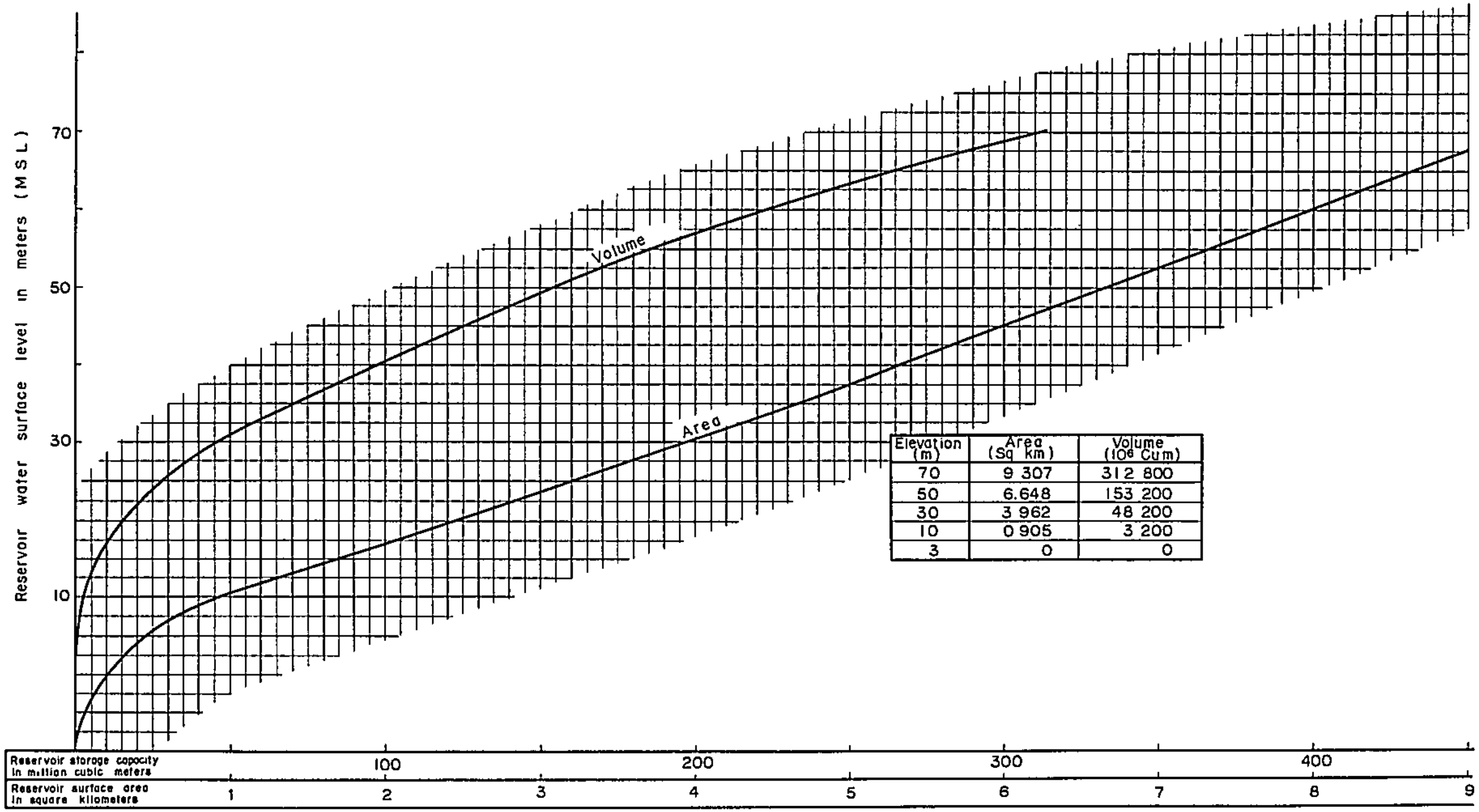
Area Capacity Curves for Torul Reservoir



Elevation (m)	Area (Sq km)	Volume (10^6 Cu m)
720	6 650	472 400
710	6 086	407.800
700	5 523	349 700
690	4 982	297 200
680	4 472	250.000
670	3.994	207 700
660	3 523	170.100
650	3.068	137 200
640	2.638	108 200
630	7 242	84 300
620	1 858	43 900
610	1 521	47 000
600	1 223	33 300
590	0 960	22 400
580	0 740	13 000
570	0 513	7 700
560	0 345	3,400
550	0 139	1 100
540	0 043	0 200
530	0	0

Fig 5-3

Area Capacity Curves For Kurtun Reservoir

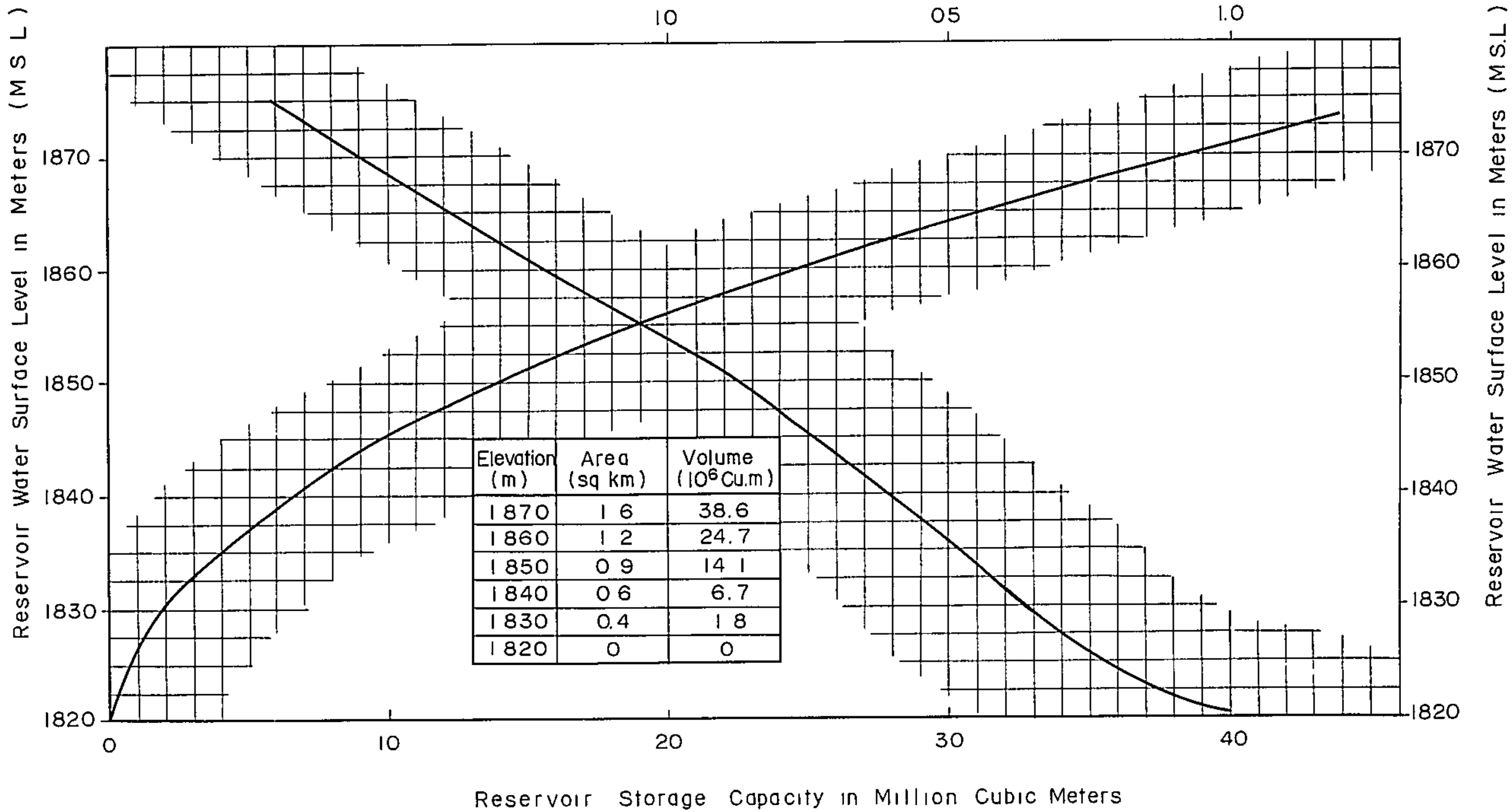


Elevation (m)	Area (Sq km)	Volume (10^6 Cu m)
70	9 307	312 800
50	6.648	153 200
30	3 962	48 200
10	0 905	3 200
3	0	0

Fig. 5-4

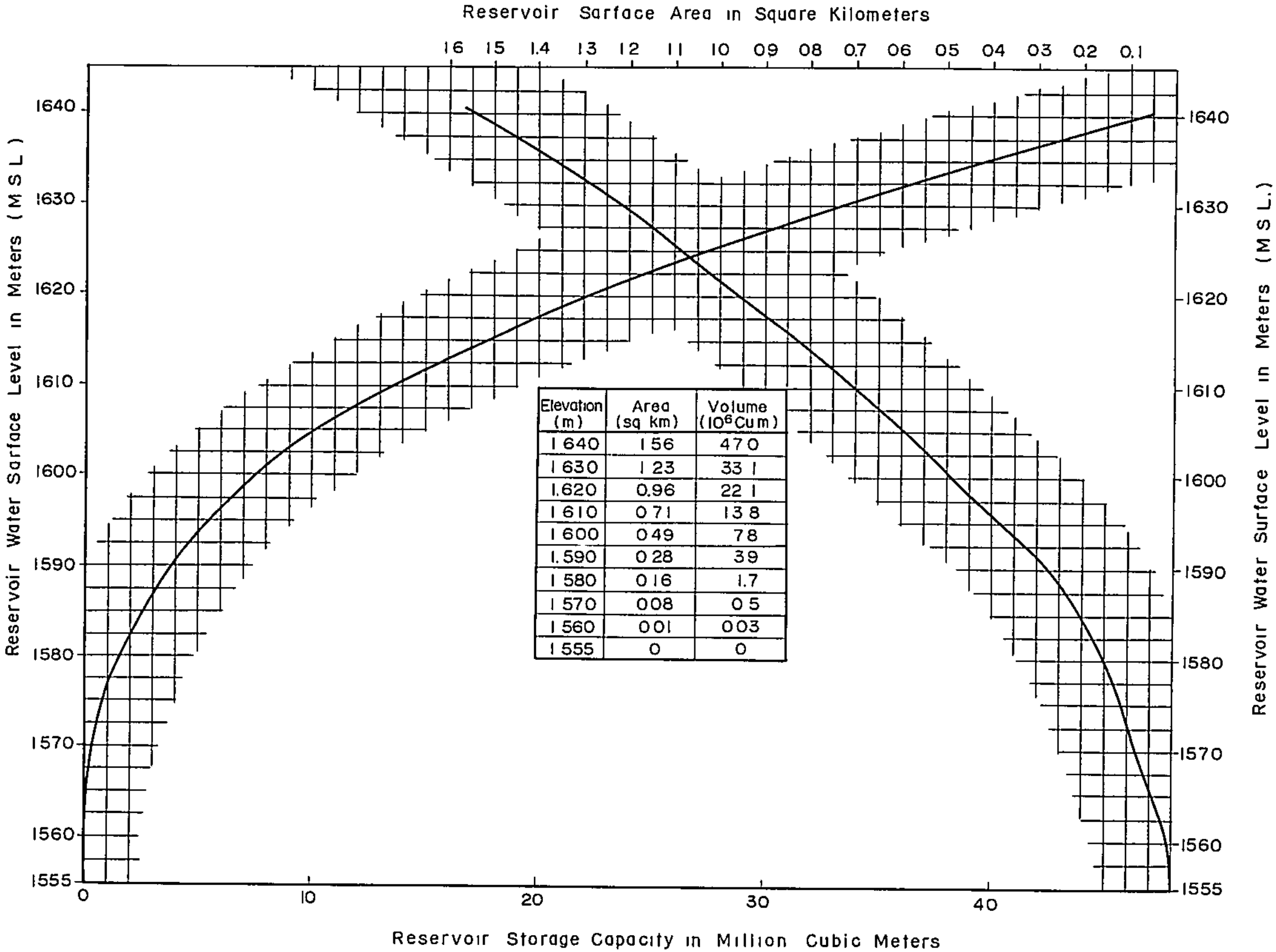
Area Capacity Curves for Tiribolu Reservoir

Fig 5-5 Fig 5-5 Area Capacity Curve of Aladeracan Reservoir



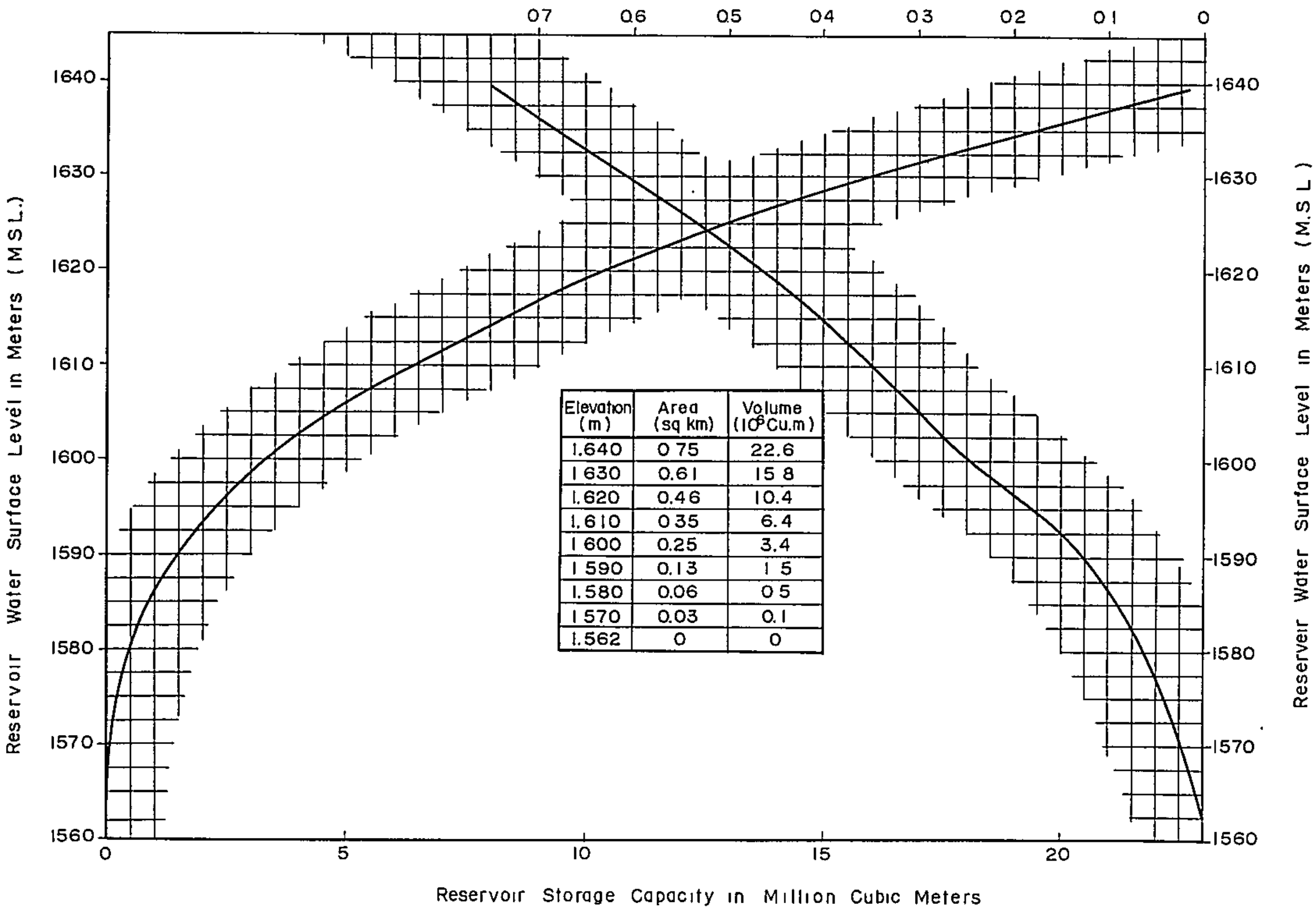
Elevation (m)	Area (sq km)	Volume (10^6 Cu.m)
1870	1 6	38.6
1860	1 2	24.7
1850	0 9	14 1
1840	0 6	6.7
1830	0.4	1 8
1820	0	0

Fig 5-6 Area Capacity Curve of Gokcebel Reservoir

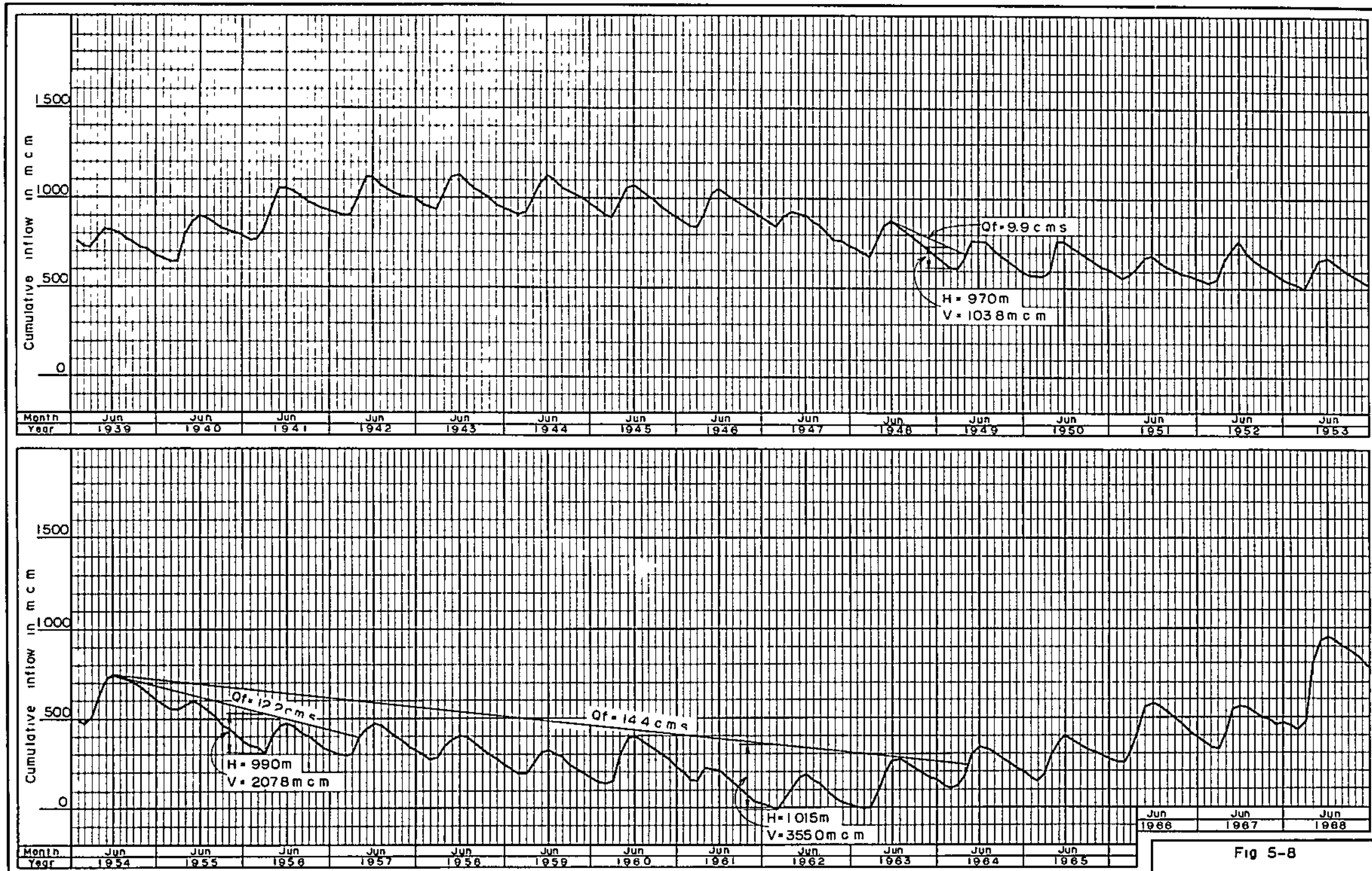


Elevation (m)	Area (sq km)	Volume (10^6 Cu m)
1 640	1 56	47 0
1 630	1 23	33 1
1,620	0.96	22 1
1 610	0 71	13 8
1 600	0 49	7 8
1,590	0 28	3 9
1 580	0 16	1.7
1 570	0 08	0 5
1 560	0 01	0 03
1 555	0	0

Fig. 5-7 Area Capacity Curve of Yasmakli Reservoir



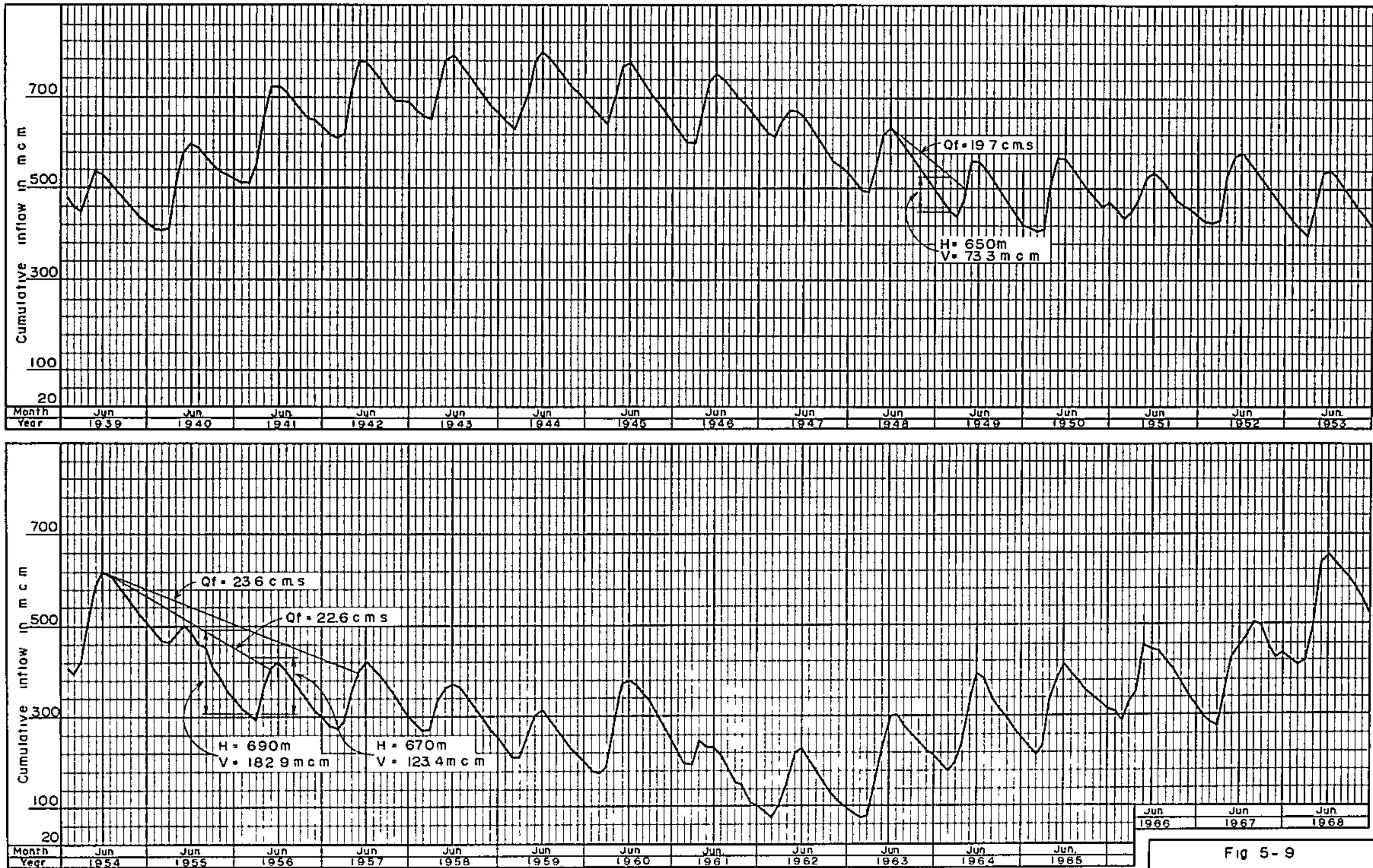
Elevation (m)	Area (sq km)	Volume (10^6 Cu.m)
1,640	0 75	22.6
1 630	0.61	15 8
1,620	0.46	10.4
1,610	0 35	6.4
1 600	0.25	3.4
1 590	0.13	1 5
1,580	0.06	0 5
1 570	0.03	0.1
1,562	0	0



c m s = Cubic meter per second
m c m = Million cubic meter
H = Normal high water surface
V = Available storage capacity
Qf = Firm discharge

Fig 5-8

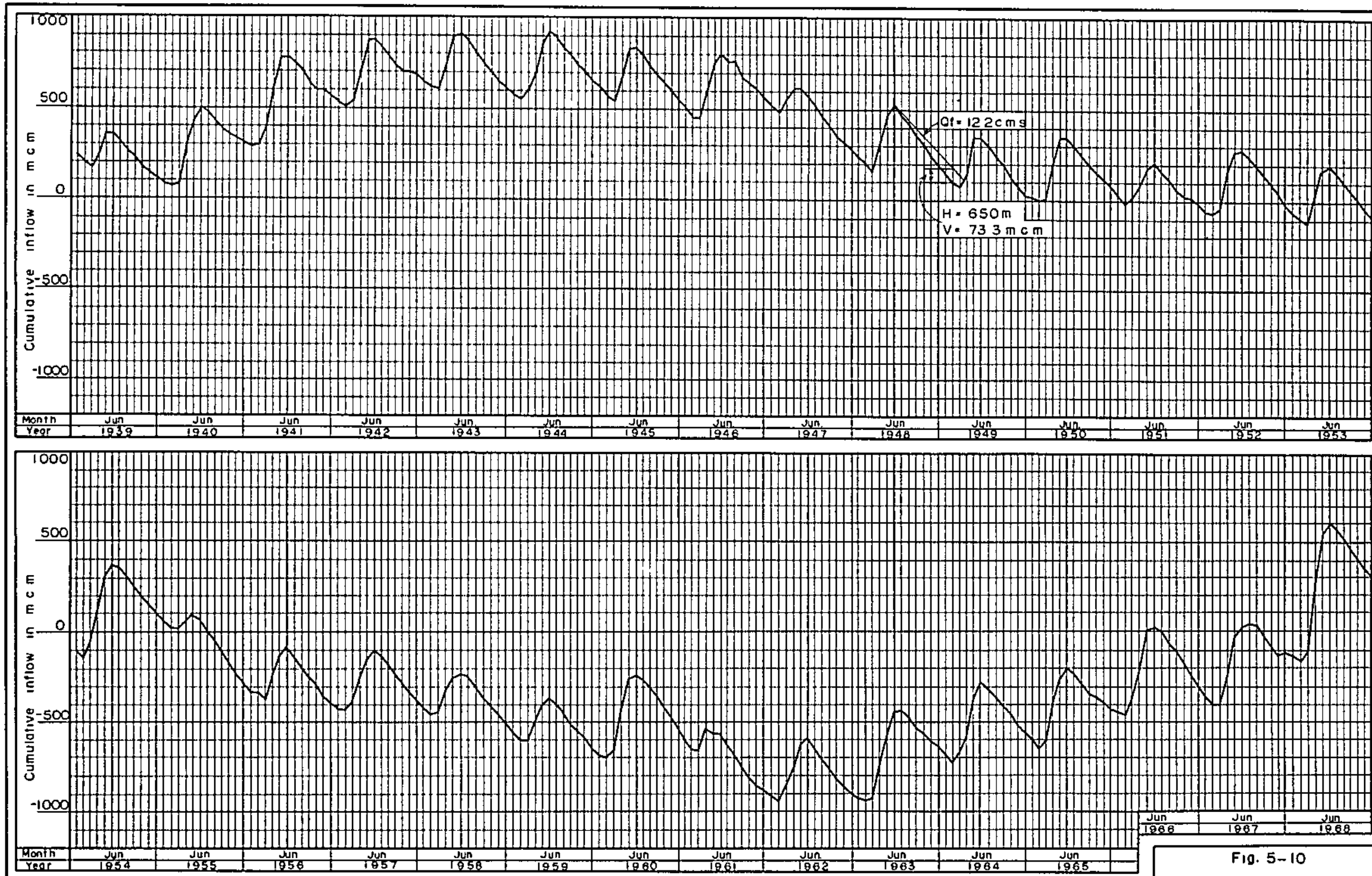
Residual Mass Curve at Torul Dam Site



c m s = Cubic meter per second
m c m = Million cubic meter
H = Normal high water surface
V = Available storage capacity
Qf = Firm discharge

Fig 5-9

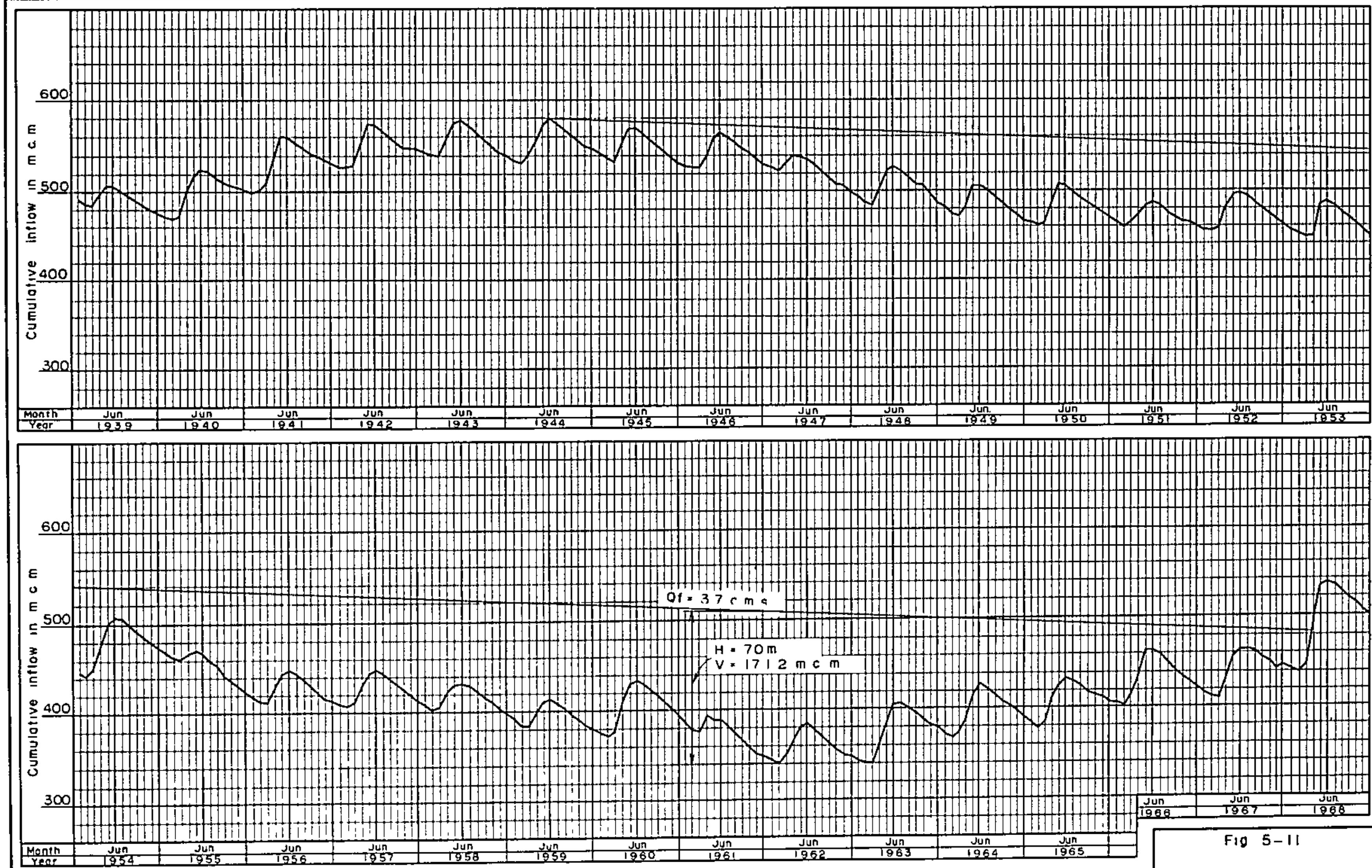
Residual Mass Curve at Kurtun Dam Site (With Torul)



c m s = Cubic meter per second
m c m = Million cubic meter
H = Normal high water surface
V = Available storage capacity
Qf = Firm discharge

Fig. 5-10

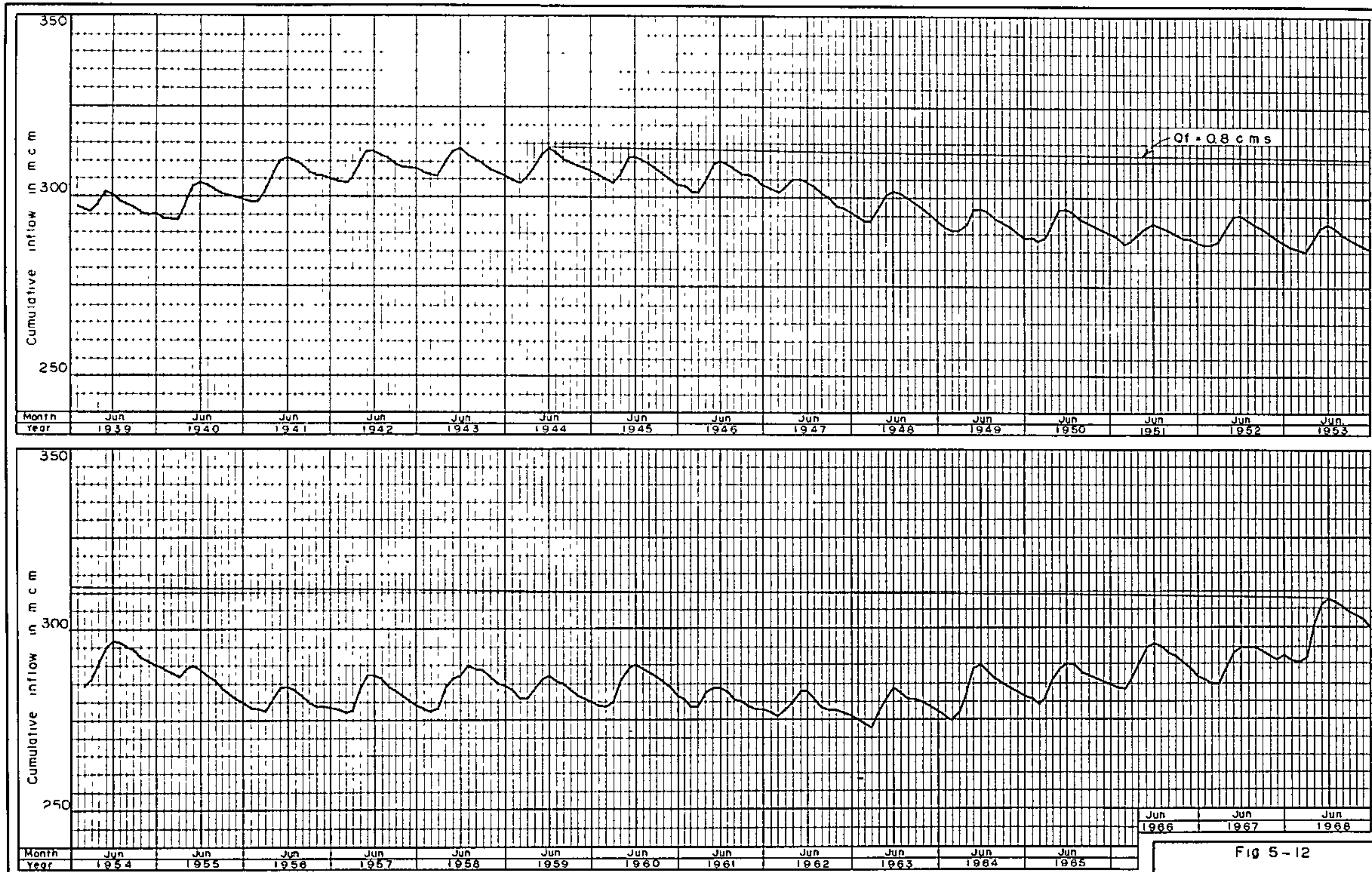
Residual Mass Curve
at Kurtun Dam Site
(Without Torul)



c m s = Cubic meter per second
m c m = Million cubic meter
H = Normal high water surface
V = Available storage capacity
Qf = Firm discharge

Fig 5-11

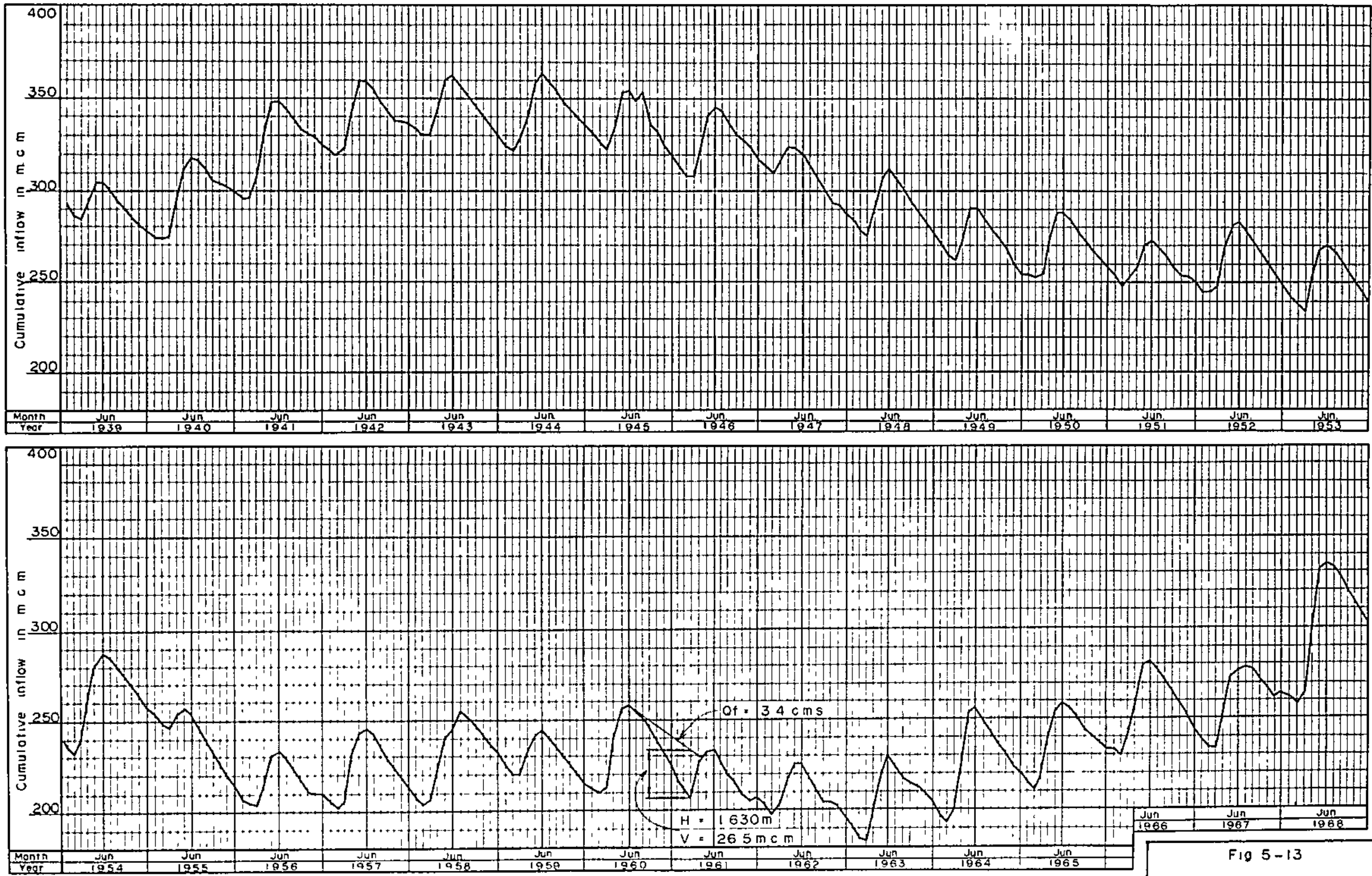
Residual Mass Curve at Tirebol Dam Site



c m s = Cubic meter per second
m c m = Million cubic meter
H = Normal high water surface
V = Available storage capacity
Qf = Firm discharge

Fig 5 - 12

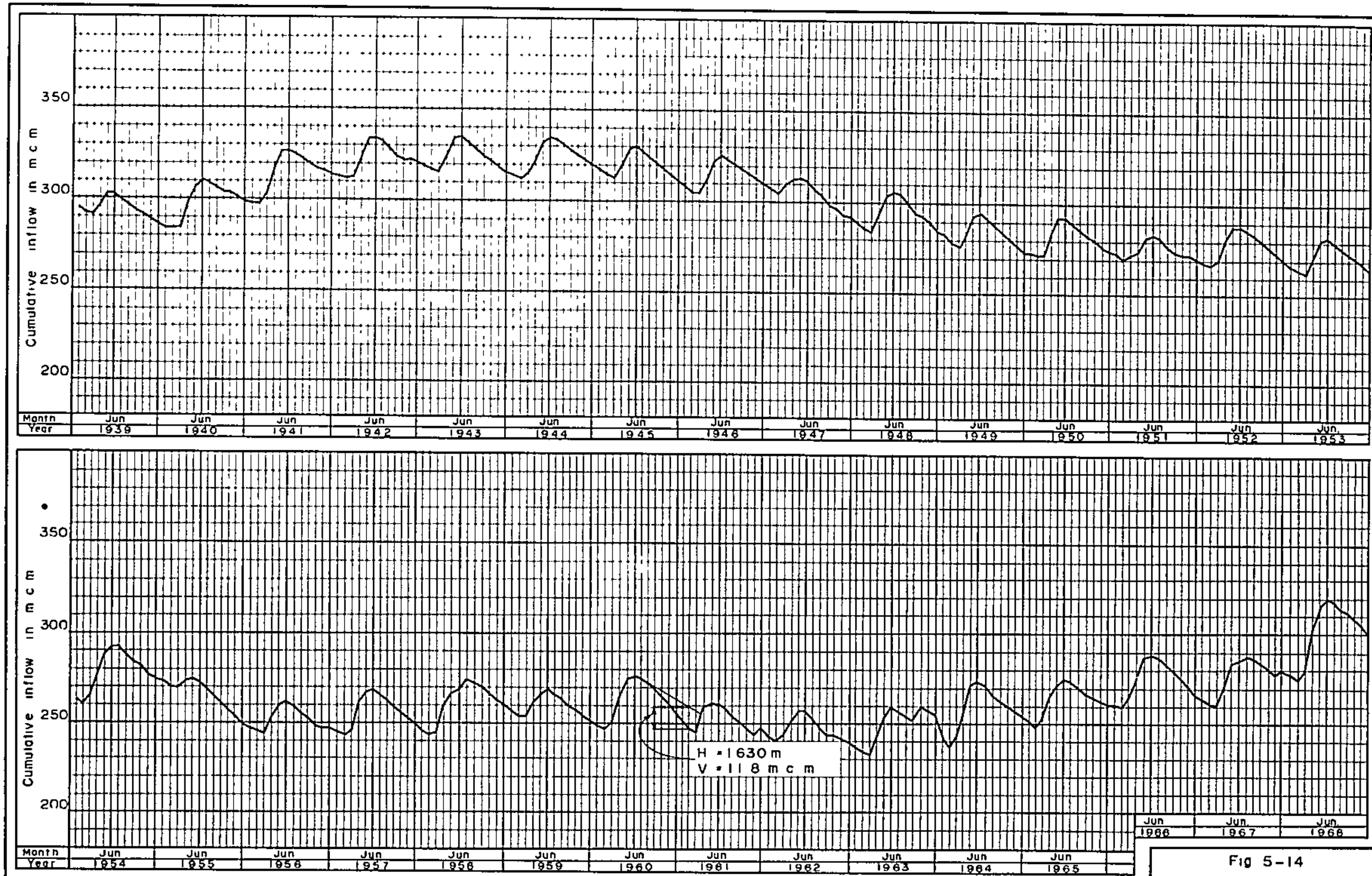
Residual Mass Curve at Aladerecan Dam Site



c m s = Cubic meter second
m c m = Million cubic meter
H = Normal high water surface
V = Available storage capacity
Qf = Firm discharge

Fig 5-13

Residual Mass Curve at Gokçebel Dam Site



cms = Cubic meter per second
mcm = Million cubic meter
H = Normal high water surface
V = Available storage capacity
Qf = Firm discharge

Fig 5-14

Residual Mass Curve at Yosmakli Dam Site

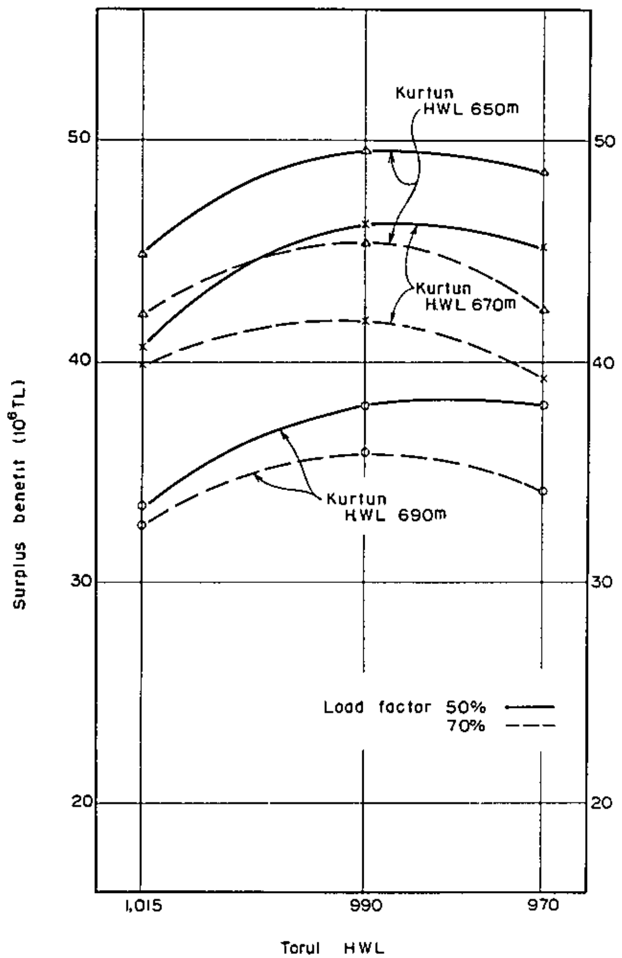


Fig 5-15

Diagram of Surplus Benefit

(Alternative Thermal Power Plant 100MW, Interest 5%)

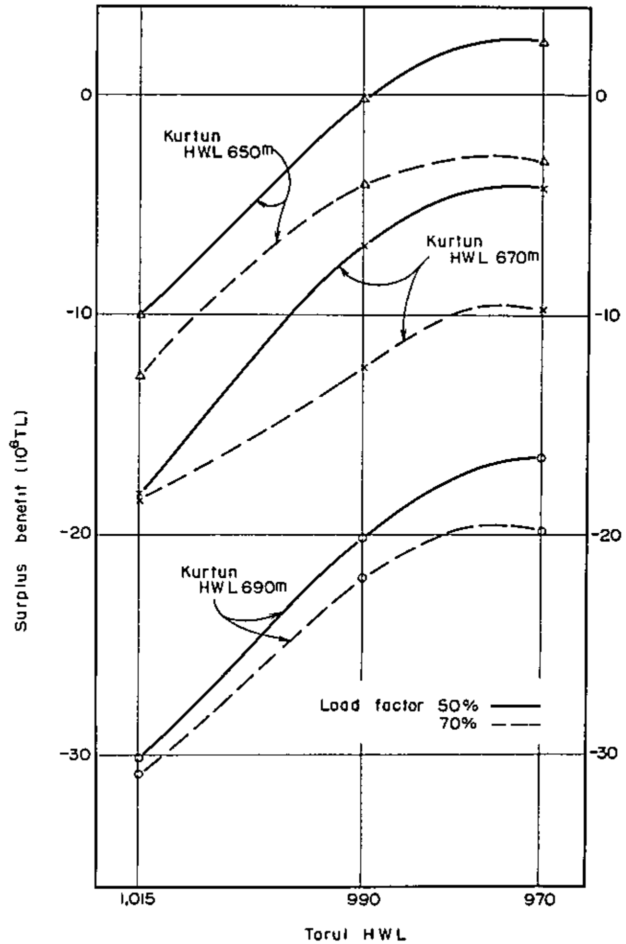


Fig 5-16

Diagram of Surplus Benefit

(Alternative Thermal Power Plant 300MW, Interest 8%)

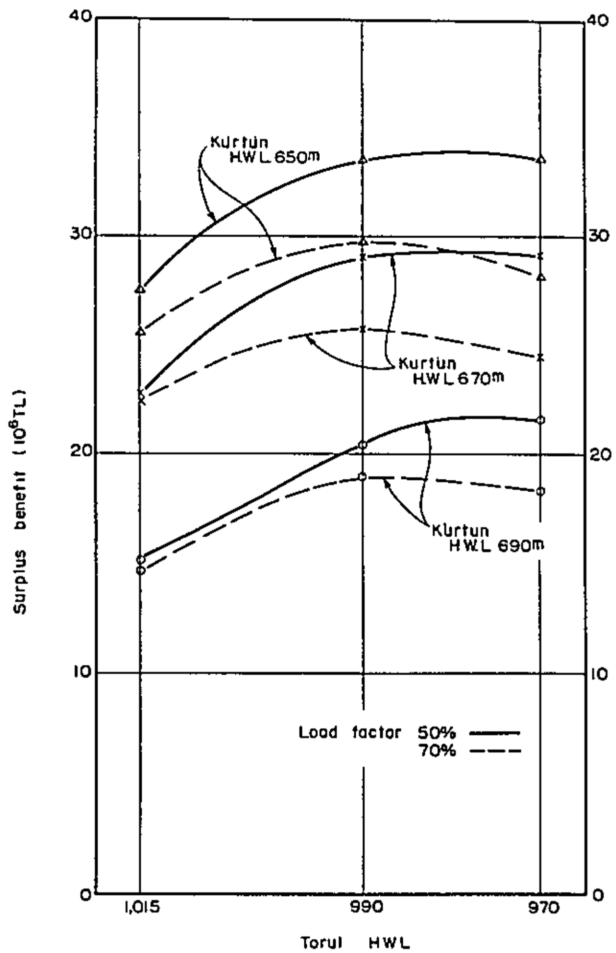


Fig 5-17

Diagram of Surplus Benefit

(Alternative Thermal Power Plant 300MW, Interest 5%)

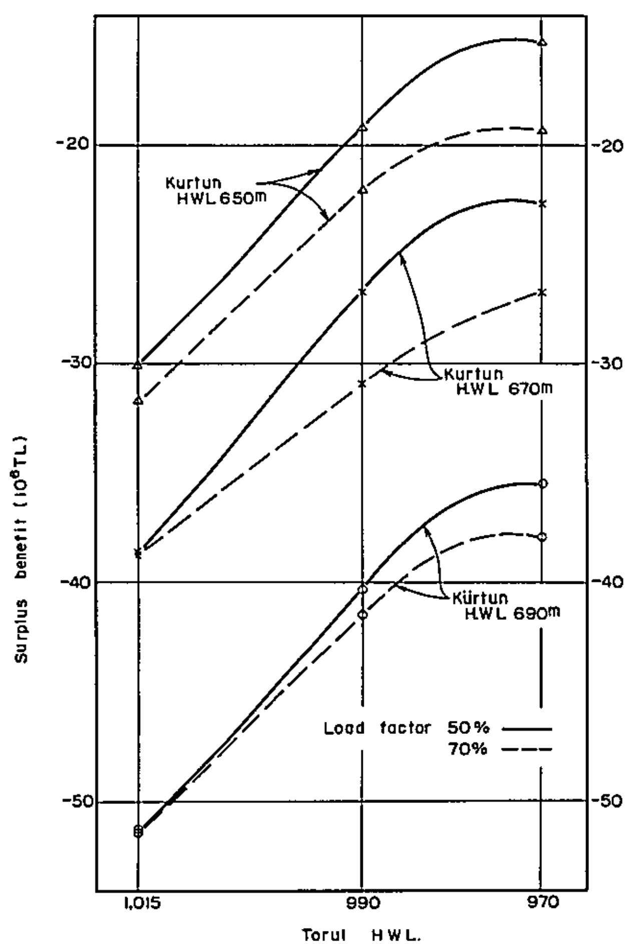
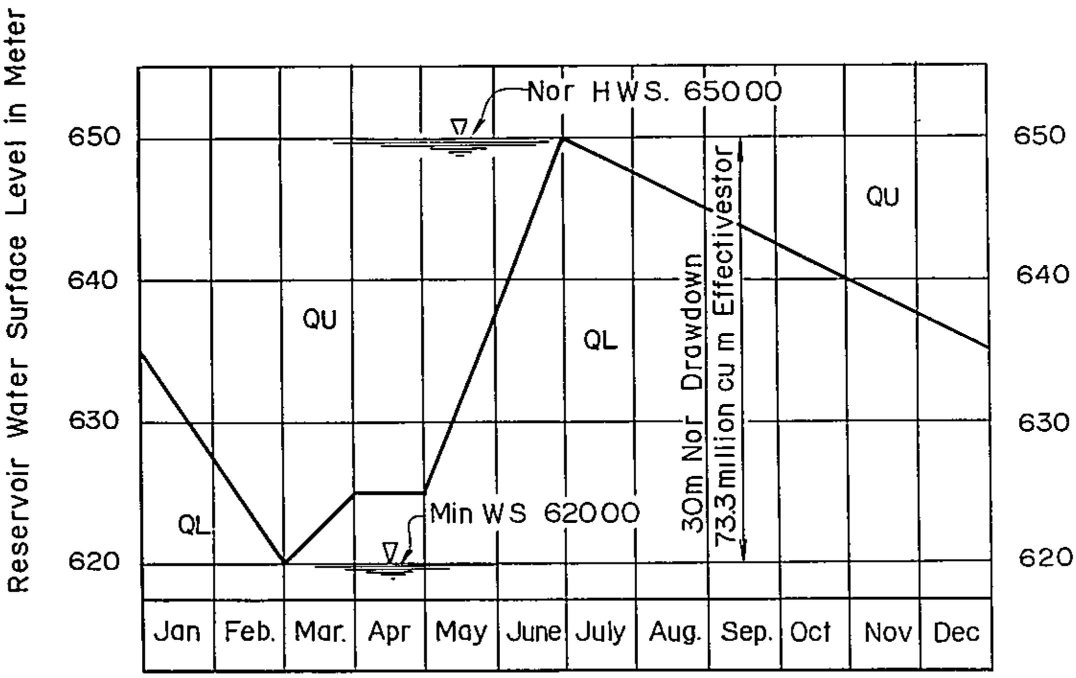


Fig 5-18

Diagram of Surplus Benefit

(Alternative Thermal Power Plant 300MW, Interest 8%)



Month	HN	VU	QU	QL	Month
	m	mill cu m	mill cu.m	mill cu m	
Jan	627	78.0	51.7	51.7	Jan
Feb	620	63.9	65.8	51.7	Feb
Mar	625	74.0	65.8	51.7	Mar
Apr	625	74.0	65.8	51.7	Apr
May	638	102.0	92.1	51.7	May
June	650	137.2	78.9	51.7	June
July	647	128.0	51.7	51.7	July
Aug	645	122.0	51.7	51.7	Aug
Sep	643	119.0	51.7	51.7	Sep
Oct	640	108.7	51.7	51.7	Oct
Nov	637	100.0	51.7	51.7	Nov
Dec	635	96.0	51.7	51.7	Dec

QMAX = 205.1 mill cu.m

Fig. 5-19

Tentative Operation Rule of Kurtun Reservior

m c m = Million cubic meter

Fig. 5-20

Reservoir Operation of Kürtün with Torul

m c m = Million cubic meter

Fig 5-21

Reservoir Operation of Kurtün without Torul

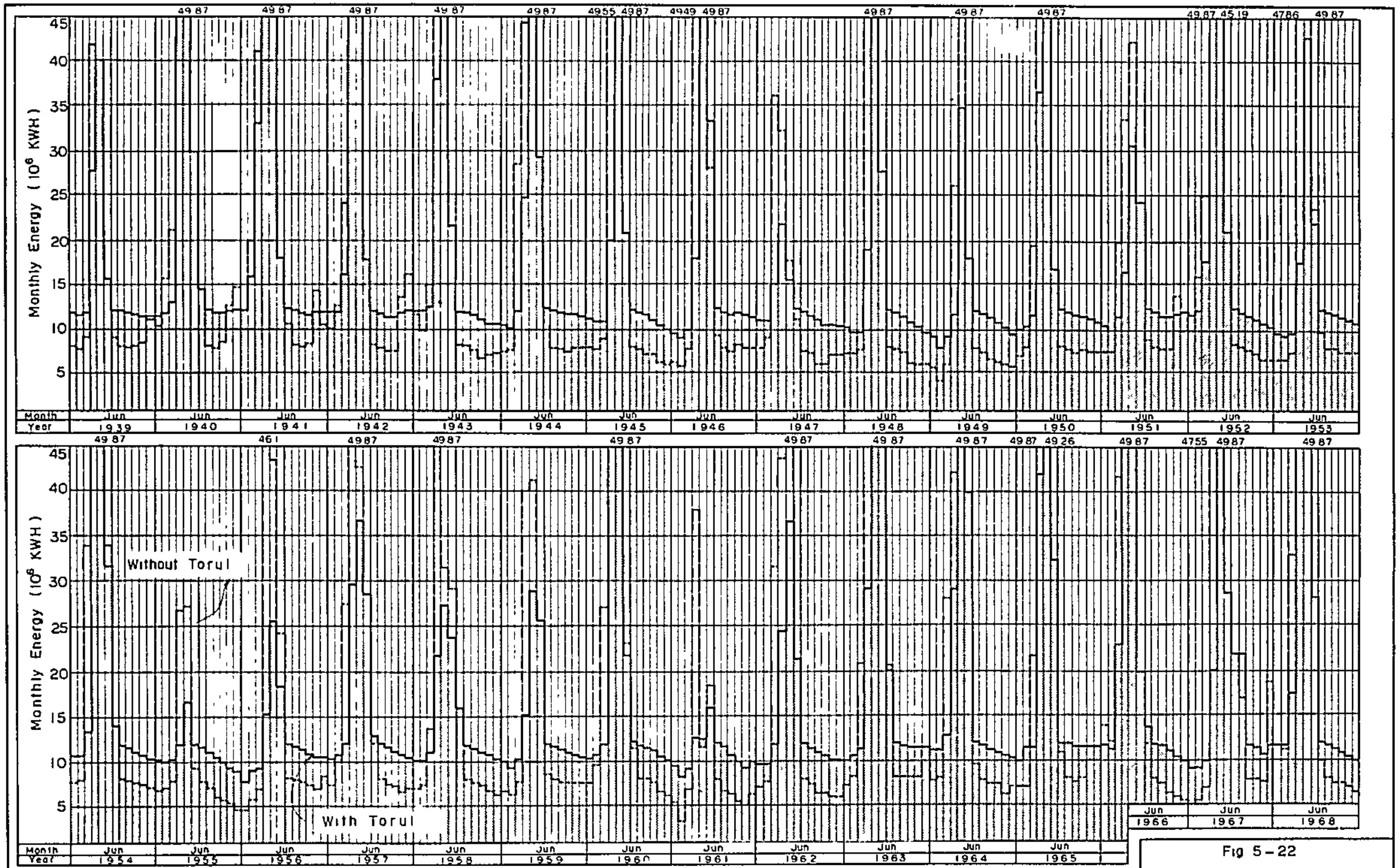


Fig 5-22

Monthly Energy of Kurtun Power Station

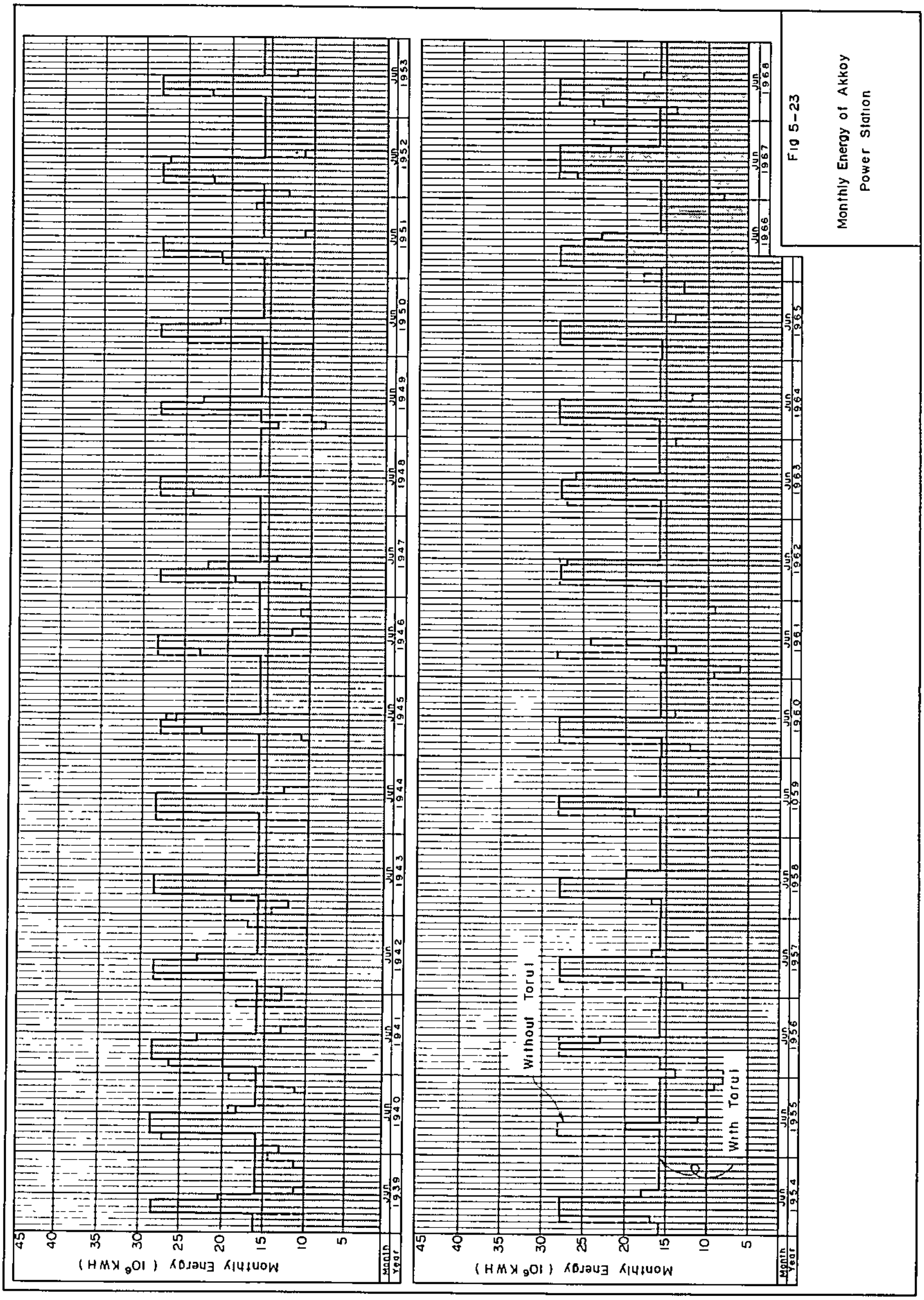


Fig 5-23 Monthly Energy of Akkoy Power Station

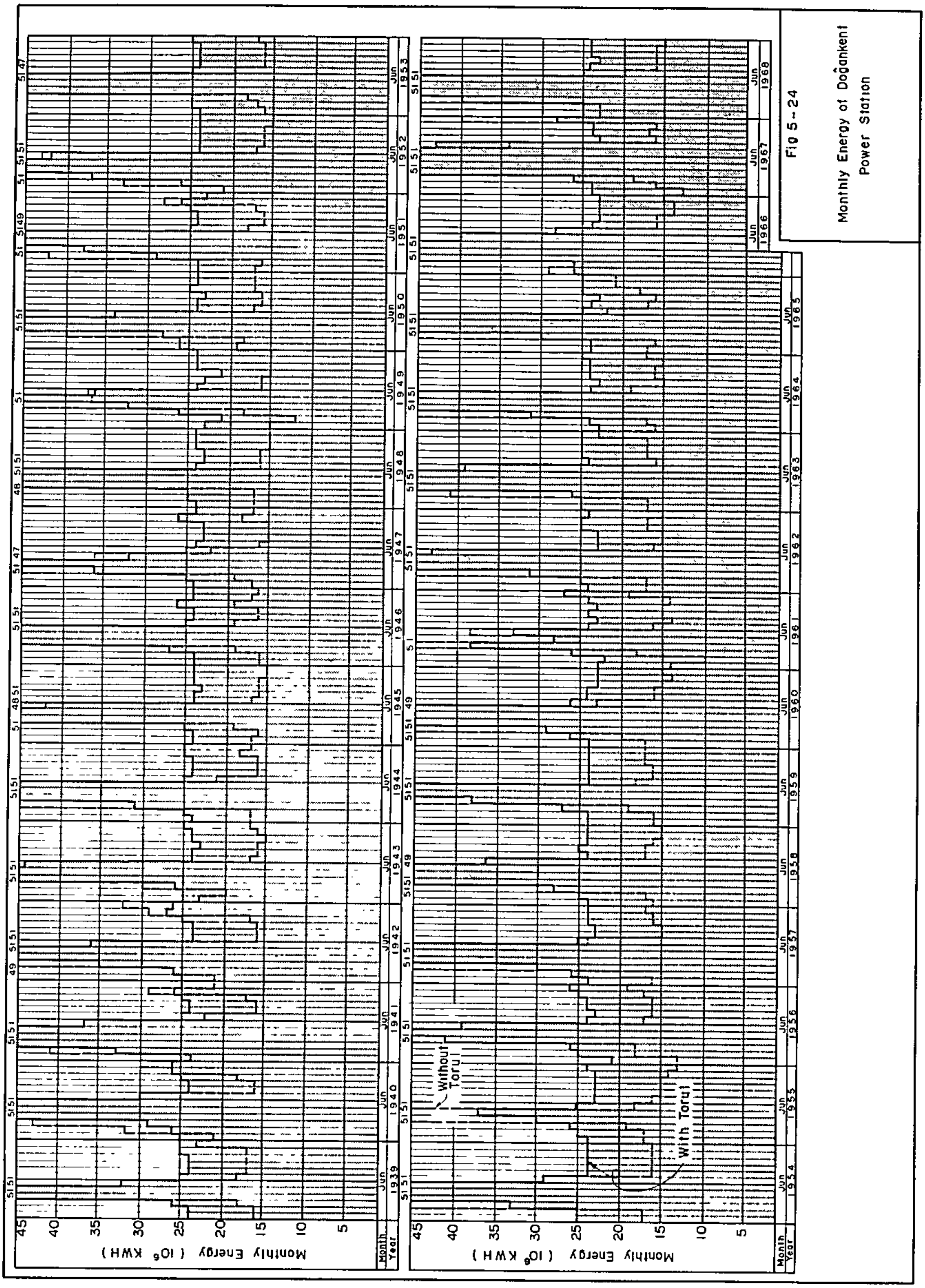


Fig 5 - 24

Monthly Energy of Doğankent Power Station

CHAPTER 6

PRELIMINARY DESIGN, CONSTRUCTION SCHEDULE AND CONSTRUCTION METHOD

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CHAPTER 6 PRELIMINARY DESIGN, CONSTRUCTION SCHEDULE AND CONSTRUCTION METHODS

6.1 DESCRIPTION OF STRUCTURES

6.1.1 Hydraulic Structures

The summarized data of the major structures of the Kurtun Power Station are as given in the Brief Description of Project.

In view of the shape of the valley at the Kurtun damsite, the construction of dam will be in a proportional dimension of 3:1 at dam crest length and dam height.

Of 35 existing arch dams in Japan higher than 60 m, 14 dams have a ratios of 2.5 to 3.5:1 in the proportional dimension of crest length to dam height, and the shape of the valleys where they are located are mostly similar to that at the Kurtun damsite. Besides, the results of geologic investigations by exploratory adits and borings show no geological problems in particular such as large-scale faults which might obstruct construction of an arch dam. The modulus of elasticity of the bedrock is estimated to be between 500,000 and 150,000 kg/sq.cm, and in consideration of the design flood discharge of 2,000 c.m.s, arch type was selected for the Kurtun Dam. Naturally, in consideration of such topography, it is conceivable to build a rockfill dam as an alternative. However, in the light of past experience, it will be difficult to determine economical superiority or inferiority by simple comparisons and a final decision would have to await detailed investigations of geology and materials. According to present indications, approximately 500,000 cu m of impervious core material would be required if a rockfill dam is to be built at the Kurtun site. However, no detailed information or data has been made available as yet with respect to availability of impervious core material in such volume, for this reason and in consideration of the hydrologic, topographic and geologic conditions of the project which are described before the preliminary design for the Kurtun Dam was studied for creation of an arch-type concrete dam. In the study, two varieties of the type were taken up for comparison; one being thinly-shelled dome-type and the other being cylinder-type shelled more thickly, the comparative study has resulted in favour of dome-type. The conditions taken into consideration in the design of dam and spillway are given below:

(1) Reservoir

High water surface	EL. 650 m
Estimated minimum elevation of foundation rock	EL. 520 m
Design elevation of sedimentation	620 m
Specific gravity of water	1.0
Apparent specific gravity of sediment in air	1.8 ton/cu.m
Void ratio of sediment	0.3
Coefficient of soil pressure	0.4
Design flood discharge	2,000 c.m.s.

Drawings

Figures

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Void ratio of sediment	0 3
Coefficient of soil pressure	0.4
Design flood discharge	2,000 c.m.s.

(2) Dam Concrete

Allowable compressive stress	70 - 90 kg/sq.cm (at normal condition)
Modulus of elasticity	2,000,000 ton/sq.m
Unit weight	2.35 ton/cu.m
Poisson's ratio	0.2

(3) Foundation Rock

Ratio of modulus of elasticity between concrete and foundation rock	$E_C/E_R = 2$
Poisson's ratio	0.2

(4) Earthquake Action

Horizontal seismicity	K = 0.10

Stress calculations for the arch proper were carried out by the trial load method based on adjustment of the radial direction, while the stability of the natural ground for the foundation of the dam was studied by seeking the locus resulting in a shearing friction safety factor of 4 for the foundation rock as a whole. The results of stress calculation is shown in DWG. No.3.

For the type and arrangement of the spillway, considerations were given to the fact that the design flood discharge is 2,000 c.m.s. and to the location of the powerhouse, and two alternative proposals were studied on comparison basis; the one to provide a crest overflow chute-type spillway on the right bank with the powerhouse immediately below the dam and the other to provide a crest overflow spillway along the center line of the dam with the powerhouse 150 to 200 m downstream of the dam were compared and studied. According to result of the study, the latter would require a smaller construction cost than the former. However, since the latter may involve problems with respect to maintenance and operation of the power plant at the time of flood overflow, the former was adopted. Therefore, the intake would be provided appurtenant to the dam at the right bank and the discharge will be conducted to the powerhouse by a penstock of 4.5 m diameter and 130 m length.

The powerhouse would be outdoor type.

6.1.2 Power Generation, Transmission and Telecommunication Facilities

The type of the turbine would be a vertical-shaft, single-wheel, single-stream Francis turbine.

The rated head at this power station would be 92 m with the turbine output 31,500 kW x 2 units, and the Francis turbine most suited to these conditions was selected. The revolving speed of the turbine was selected to be as high as possible without exceeding the limits of specific speed for Francis turbines, and taking into account the standard number of poles of the generator, it was set at 300 rpm.

The generator would be a vertical-shaft, revolving field, fully enclosed, internally cooled, ordinary type in consideration of output and rotating speed.

Since a 380-kV transmission line will be constructed passing the vicinity of the Kurtun Power

Station by 1980, the power obtainable at the power station will be put into the transmission line in π connection and, for this purpose, a step up substation will be provided on the mountain side of the powerhouse. Overhead cable will be provided to the main transformer to be installed at the powerhouse approximately 350 m distant from the step-up substation.

Since the output of the generators is relatively small at 34,000 kVA x 2 units, one main transformer of 68,000 kVA will be installed for the 2 generators. An outdoor, 3 phase, pumped-oil, air-cooled type would be suitable as the main transformer.

Further, in the future, 154-kV transmission line interconnecting the Gunyuzu Power Station, Akkoy Power Station, Karacukur Power Station, Torul Power Station, etc. will be led in, and a 380/154-kV, single-coil transformer will be installed for connection with the 380-kV step-upssubstation. Since the charging current of the 380-kV transmission line will be substantial, it will be necessary to install a 120,000 kVA shunt reactor. This shunt reactor will not be connected through the transformer, but will be coupled directly to the 380-kV bus line.

The load dispatching of the Kurtun Power Station will be effectuated among the Adapazari Load Dispatching Center, the Sumsun Substation and the Keban Power Station. However, telemeters and supervision between the Adapazari Load Dispatching Center and the Kurtun Power Station were not included in this project, because they should be extended in accordance with the expansion of future power systems.

Power line carrier systems will be composed of a 380 kV transmission line with double connectors of 954 MCM.

For this purpose, coupling capacitors of respective power station will be attached to each phase (3 phase).

6.2 CONSTRUCTION SCHEDULE AND CONSTRUCTION METHODS

6.2.1 Construction Schedule

The principal structures to be built in the development of the Kurtun Project comprise, as described in the preceding paragraph, an arch dam rising 133 m from the foundation rock, a spillway and intake appurtenant to the dam, waterway consisting mainly of a penstock, and an outdoor type powerhouse.

The quantity of excavation for the entire works including the dam, spillway, intake, penstock and powerhouse foundation would be 615,000 cu.m. Required amount of concrete placement will be 510,000 cu.m. The excavation quantity, concrete volume and total length of foundation grout of the dam which is the main part of the work and which has a gross influence on the construction period of this Project are 460,000 cu.m, 458,000 cu.m and 24,000 m respectively.

As described later, the roads in the project area are comparatively well developed and the period of construction will not be greatly influenced by works on access roads.

It is thought approximately 45 months will be required as the period of construction for completion of the Project taking into consideration the relation between the overall construction schedule and the sizes of construction equipment, hydrology, meteorology and traffic conditions, and construction plans. Impounding of water at Kurtun Reservoir is scheduled to be commenced at the end of March 1982 in consideration of balance of demand and supply and the rainy season of the Harsit River. The schedule of major construction works are as shown in Fig. 6-1.

6.2.2 Related Items Influencing Construction Schedule

(1) Meteorology

Although there are no observation data of the temperature at the Kurtun damsite, the temperature of the damsite estimated based on data observed for 35 years at Giresun would be annual mean temperature of 14.6°C, February mean temperature of 2.5°C, and August mean temperature of 17°C. The estimation was made in consideration of a lapse rate to be 0.6°C per 100 m of elevation.

The annual precipitation in the project area is roughly 1,000 mm with 70 to 80 days of rainfall of 5 mm or more. The above meteorological conditions are relatively favorable for placement of concrete and execution of other work, but in consideration of the fact that the temperature data consist of monthly averages, the construction schedule was prepared with concrete placement to be discontinued in the two winter months of January and February.

(2) Traffic

As a road leading to the Kurtun damsite from the highway connecting the Black Sea coastal areas from east to west, there is presently the Harsit River Road from Tirebolu at the mouth of the Harsit River to Torul which runs through Dogankent and Kurtun. This road connects at Torul with a paved road leading from Trabzon through Torul to Erzurum.

The grades and alignment of the road are not very good since it is constructed along the Harsit River and the surface is unpaved, but transportation of construction equipment and materials would be feasible if partial improvements are made.

Besides the above, as compensation works of the Kurtun Project, relocation of a sector of 21 km upstream of the damsite is planned, while also, a separate road project from Tirebolu to Kurtun with minimum curve radius of 60 to 100 m is being contemplated. The nearest ports are those of Trabzon and Samsun. The cargo landing capacities of these two ports annually are 1,000,000 tons and 6,000,000 tons respectively. The distance from Trabzon to the damsite is 112 km via Torul and 161 km via Tirebolu.

(3) Construction Materials

Of the construction materials, cement, fly-ash, steel rods, lumber, fuel, oils and explosives can be purchased domestically, but large-sized construction machinery, air-entraining agents, etc. must be imported. The places of manufacture and production amounts of the major construction materials procurable domestically are given below:

There is a cement plant at Trabzon with production capacity of 400,000 tons annually. Also, a cement plant is under construction at Unye which it is said will have a capacity of 600,000 tons annually. These cements are normal portland cement and there is no information regarding moderate heat cement. Fly ash is produced at the Kutahya Thermal Power Station. Steel rods are being manufactured at Karabuk in sizes up to ϕ 36 mm, but larger diameters must be specially orderd.

(4) Aggregate

Sand and gravel deposits are widely distributed both upstream and downstream of the vicinity of the dam. However, required amount of 750,000 cu.m for the main structures such as the dam, spillway and powerhouse could not be economically collected. Therefore, it was decided to use the rocks obtained from the quarry and from the part of excavation of the dam foundation as concrete aggregate for the main structures. The sand and gravel deposited at the river will be used as concrete aggregate for the diversion channel and the temporary equipments.

The rock widely distributed at the damsite is mainly composed of granodiorite besides there are andesite, porphyrite and crystalline limestone. These rocks are suitable as concrete aggregate. It was decided to provide the quarry on the right bank 1 km downstream from the dam-site in consideration of the arrangement of the construction facilities such as aggregate crushing plant, screening plant, batching plant and access roads.

(5) Power for Construction

From 10 to 15 MW of power will be required for construction purposes and this will be received from the downstream Dogankent Power Station. For this purpose, the 154-kV transmission line needed between the Akkoy and Kurtun Stepup Substations proposed to put the power of the Akkoy Power Station into the system should be constructed in advance of the works on the Kurtun and Akkoy Power Stations and be used as the power transmission line for construction work.

6 3 CONSTRUCTION METHODS OF MAJOR STRUCTURES

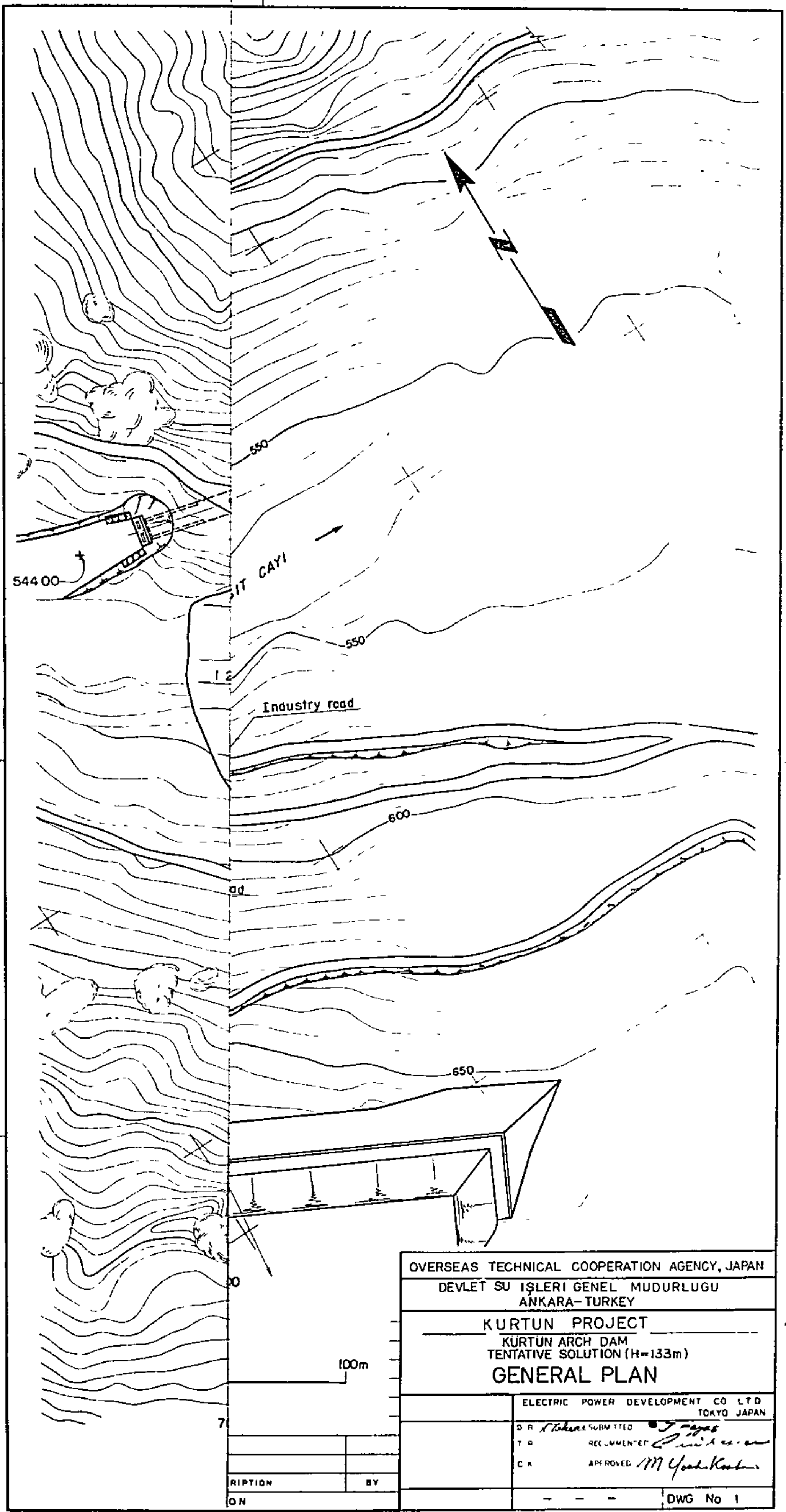
This Project consist of a dam and reservoir type power station characterized by such major structures other than the dam as the spillway, intake, penstock and powerhouse which are mostly attached or very close to the dam. Therefore, the construction method of these major structures should be carried out in accordance with the progress of the dam construction on which construction period depends largely.

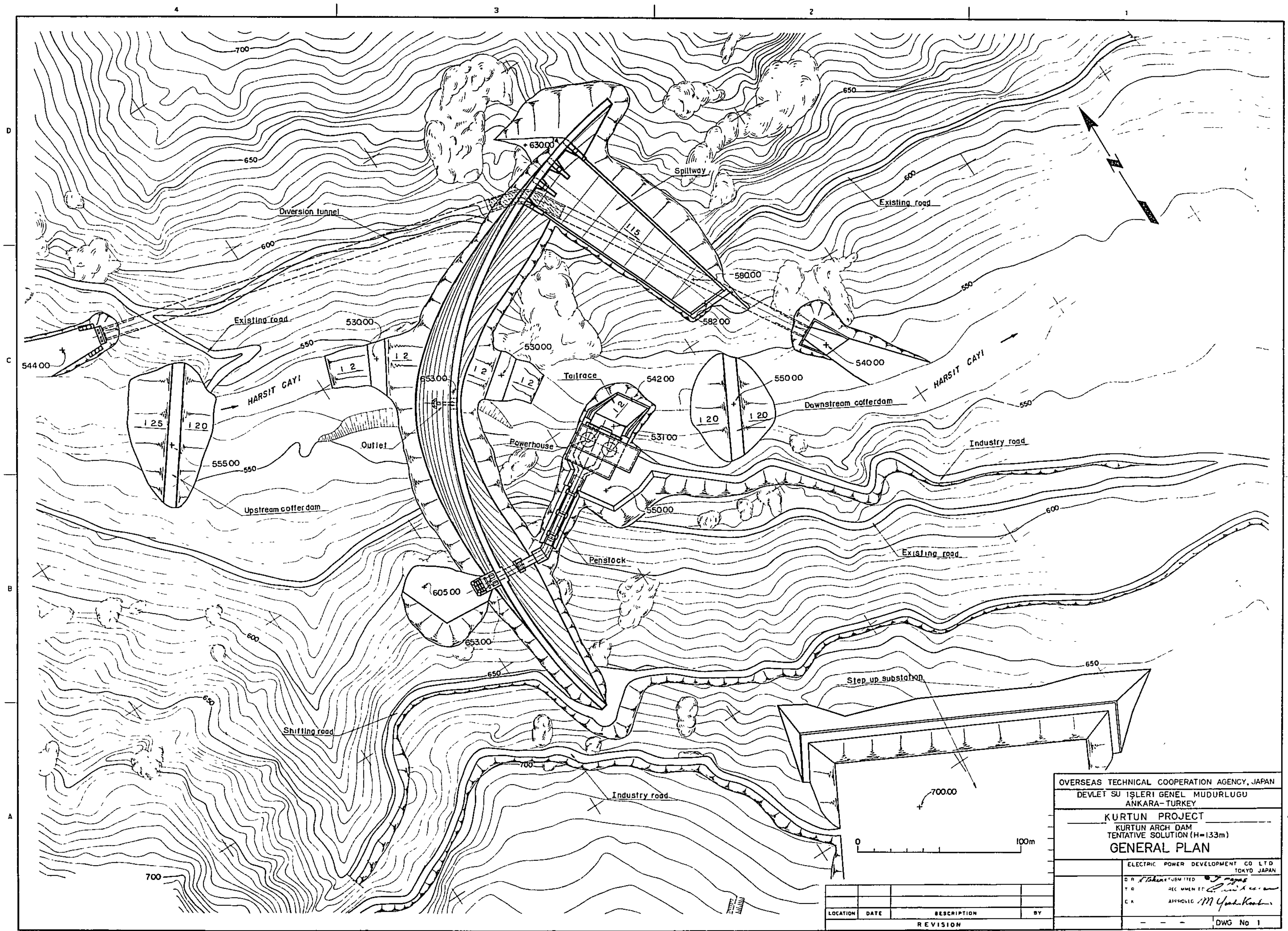
In July 1978, immediately upon start of construction, works should be commenced on relocation of roads in the vicinity of the damsite, delivery of construction machinery and on temporary equipments including construction camp, aggregate plant, batching plant, cable crane and transmission lines for construction, then works on the 460 m long diversion tunnel on the left bank and on upstream and downstream coffer dams would be initiated. The diversion tunnel will have a discharge capacity of maximum 380 c m s. during the construction period and will be lined with concrete at the inlet and outlet portals and portions beneath the dam. The fill-type coffer dams will be built in a manner to provide adequate line of creep in order not to hinder the excavation of the dam foundation.

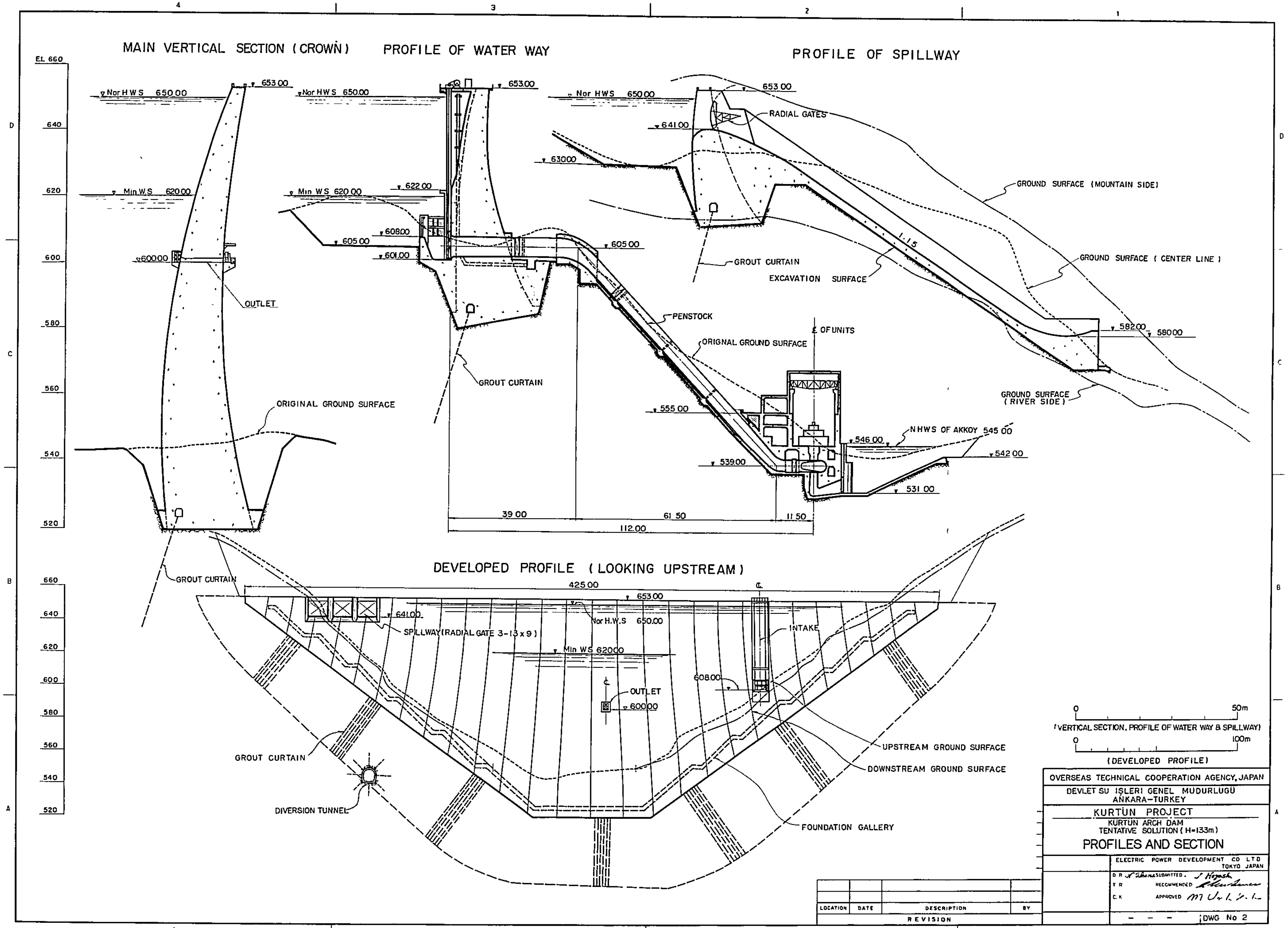
The foundation excavation for the river bed portion of the dam will be carried out after the diversion works is completed, but foundation excavation for the spillway and the upper portions of the dam on the left and right banks will be performed while the work on diversion tunnel and coffer dam progresses. Foundation grouting consisting of consolidation grouting and curtain grouting will be carried out in parallel with excavation and a part of curtain grouting will be executed from the inspection gallery. Concrete placing of the dam and the spillway will be started in July 1979 upon completion of the concrete mixing plant and other related facilities, foundation excavation and foundation treatment. Considering the lift schedule and the capacity of the cable crane, a period of approximately 24 months will be required for concrete placing.

Joint grouting of the dam will be performed in step with the rise of the dam concrete and will be completed in February 1982.

Installation of spillway gates, construction of intake, penstock and powerhouse will be carried out simultaneously with the work on the dam and there will be no special problems requiring consideration in execution of the work.

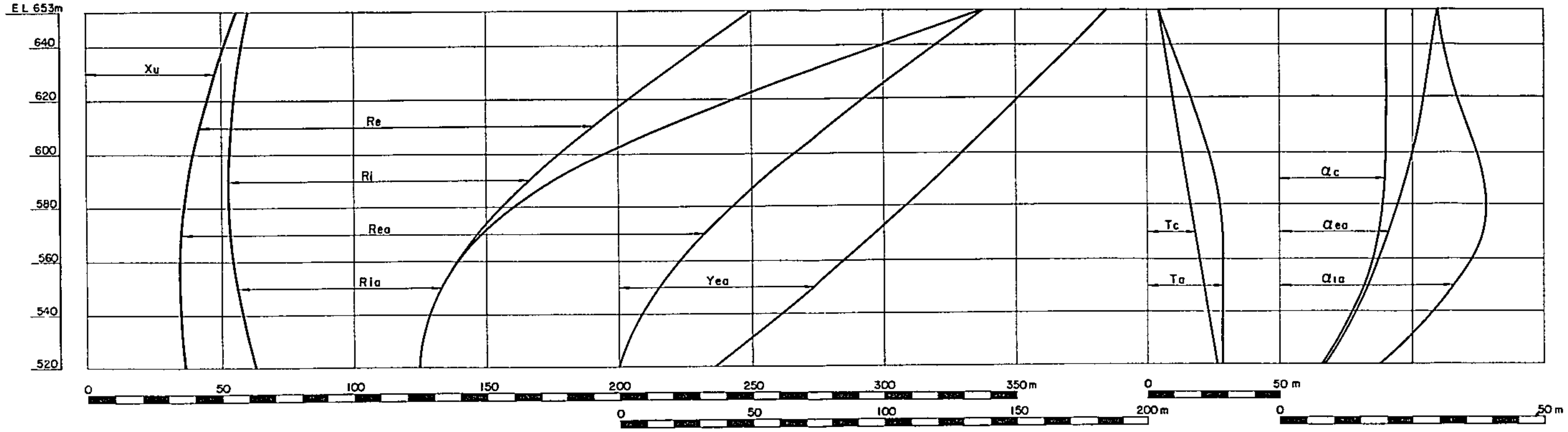

550
IT CAYI
550
Industry road
600
650
544.00
100m
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
DEVLET SU IŞLERI GENEL MUDURLUGU
ANKARA-TURKEY
KURTUN PROJECT
KURTUN ARCH DAM
TENTATIVE SOLUTION (H=133m)
GENERAL PLAN
ELECTRIC POWER DEVELOPMENT CO LTD
TOKYO JAPAN
SUBMITTED
RECOMMENDED
APPROVED
DWG No 1
SHEET NO
OF


Diversion tunnel
Spillway
Existing road
+630.00
115
580.00
582.00
540.00
550.00
Downstream cofferdam
HARSIT CAYI
Tailrace
542.00
530.00
653.00
Outlet
Powerhouse
531.00
Industry road
544.00
555.00
Upstream cofferdam
550.00
Penstock
605.00
Step up substation
Shifting road
700.00
0
100m
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
DEVLET SU IŞLERI GENEL MUDURLUGU
ANKARA-TURKEY
KURTUN PROJECT
KURTUN ARCH DAM
TENTATIVE SOLUTION (H=133m)
GENERAL PLAN
ELECTRIC POWER DEVELOPMENT CO LTD
TOKYO JAPAN
SUBMITTED
RECOMMENDED
APPROVED
LOCATION
DATE
DESCRIPTION
BY
REVISION
DWG No 1
SHEET NO
OF

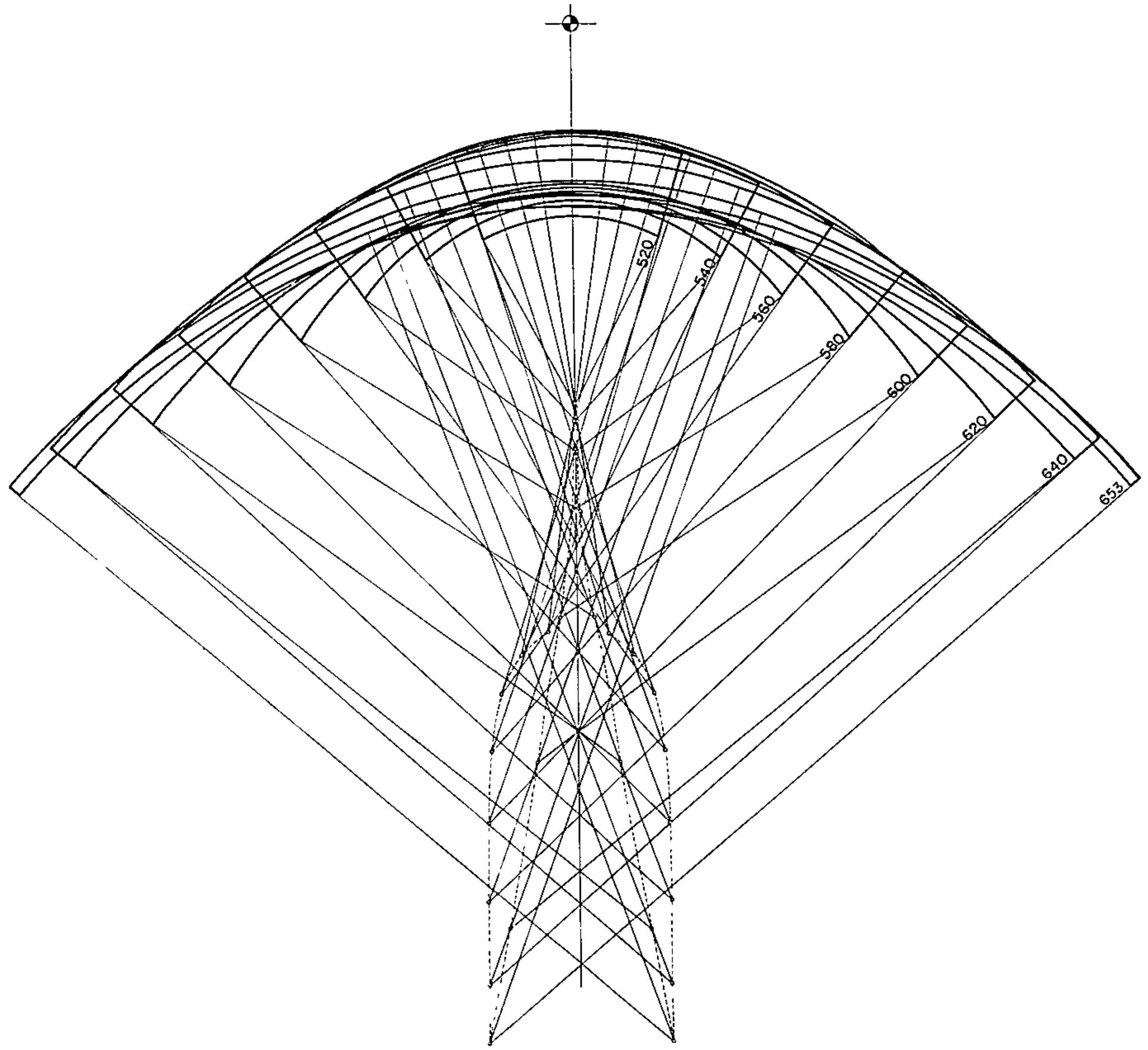


MAIN VERTICAL SECTION (CROWN)
PROFILE OF WATER WAY
PROFILE OF SPILLWAY
EL 660
640
620
600
580
560
540
520
Nor HWS 650.00
653.00
Min W.S 620.00
600.00
OUTLET
ORIGINAL GROUND SURFACE
GROUT CURTAIN
622.00
605.00
608.00
601.00
PENSTOCK
ORIGNAL GROUND SURFACE
℄ OF UNITS
555.00
539.00
546.00
NHWS OF AKKOY 545.00
542.00
531.00
39.00
61.50
11.50
112.00
641.00
630.00
RADIAL GATES
GROUND SURFACE (MOUNTAIN SIDE)
GROUND SURFACE (CENTER LINE)
GROUND SURFACE (RIVER SIDE)
EXCAVATION SURFACE
1:1.5
582.00
580.00
DEVELOPED PROFILE (LOOKING UPSTREAM)
425.00
SPILLWAY (RADIAL GATE 3-13 x 9)
Nor H.W.S 650.00
Min WS 620.00
INTAKE
608.00
OUTLET
600.00
UPSTREAM GROUND SURFACE
DOWNSTREAM GROUND SURFACE
DIVERSION TUNNEL
FOUNDATION GALLERY
0
50m
(VERTICAL SECTION, PROFILE OF WATER WAY & SPILLWAY)
100m
(DEVELOPED PROFILE)
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
DEVLET SU IŞLERI GENEL MUDURLUGU
ANKARA–TURKEY
KURTÜN PROJECT
KURTÜN ARCH DAM
TENTATIVE SOLUTION (H=133m)
PROFILES AND SECTION
ELECTRIC POWER DEVELOPMENT CO LTD
TOKYO JAPAN
SUBMITTED
RECOMMENDED
APPROVED
LOCATION
DATE
DESCRIPTION
BY
REVISION
DWG No 2
SHEET NO
OF

GEOMETRICAL DATA DIAGRAM

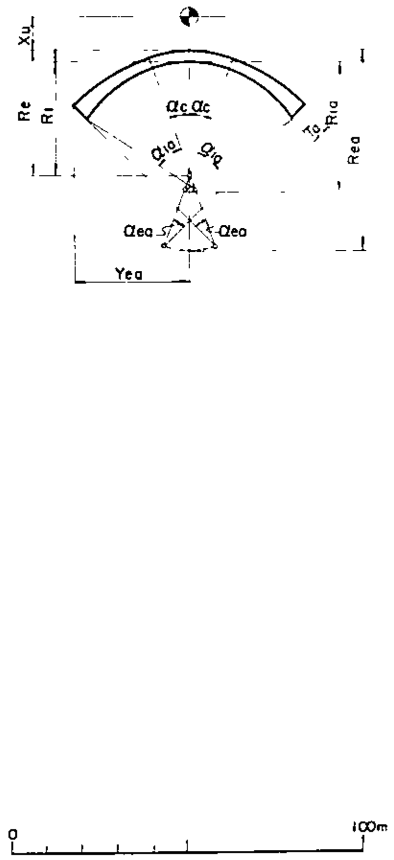


SUPERPOSED ARCHES



GEOMETRICAL DATA

EL	Xu	Re	Rea	Ri	Ria	Yea	Tc	Ta	αc	αea	αia
653	555	1945	2830	1900	2785	1850	45	45	200	295	295
650	544	1913	2798	1863	2702	1820	50	56	200	293	298
640	509	1806	2693	1740	2428	1717	66	92	200	286	308
630	476	1700	2587	1617	2160	1614	83	128	200	278	321
620	446	1594	2480	1495	1900	1510	99	164	200	270	336
610	419	1490	2374	1374	1654	1405	115	198	199	260	353
600	395	1389	2268	1256	1429	1299	132	229	198	249	370
590	375	1291	2165	1143	1234	1191	148	255	196	237	384
580	360	1200	2065	1035	1075	1080	165	272	192	222	390
570	349	1119	1970	937	952	967	182	280	185	204	383
560	343	1048	1884	850	858	851	198	281	174	184	361
550	342	990	1807	776	774	732	214	279	157	162	328
540	345	945	1740	715	715	610	230	277	134	138	287
530	353	911	1683	666	666	486	245	277	108	112	240
520	365	885	1635	625	625	360	260	278	80	85	188



LOCATION	DATE	DESCRIPTION	BY

REVISION

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

DEVLET SU İŞLERİ GENEL MUDURLUGU
ANKARA-TURKEY

KURTUN PROJECT
KURTUN ARCH DAM
TENTATIVE SOLUTION (H=133m)

GEOMETRICAL DATA

ELECTRIC POWER DEVELOPMENT CO LTD
TOKYO JAPAN

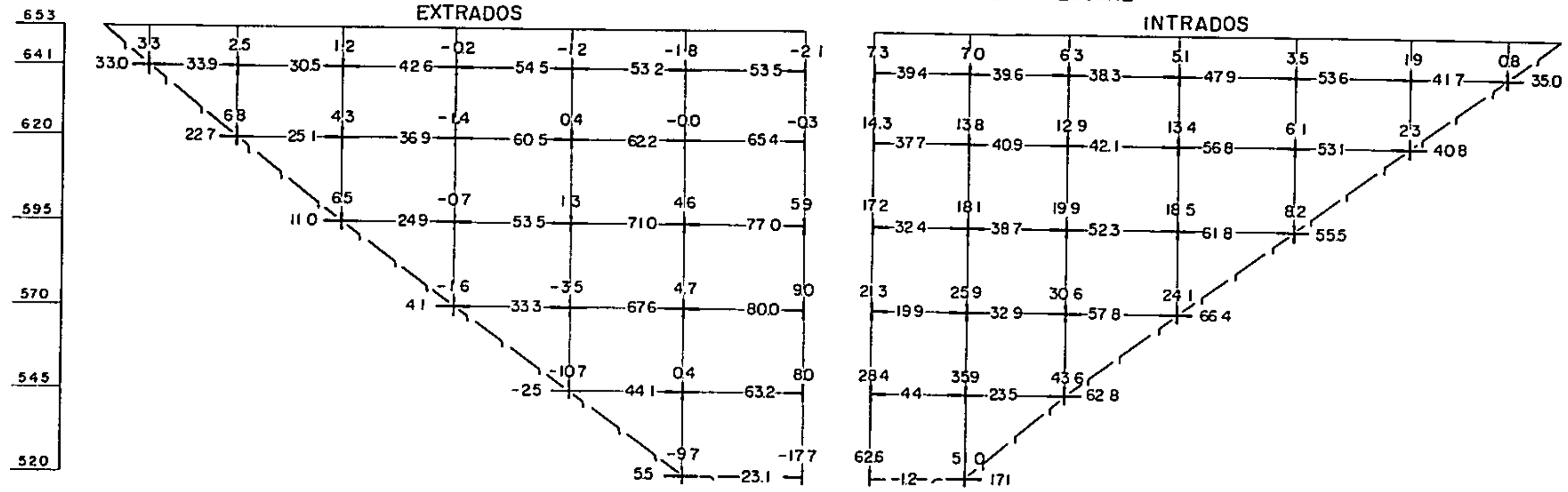
DR — SUBMITTED
TR — RECOMMENDED
CR — APPROVED

DWG No 3

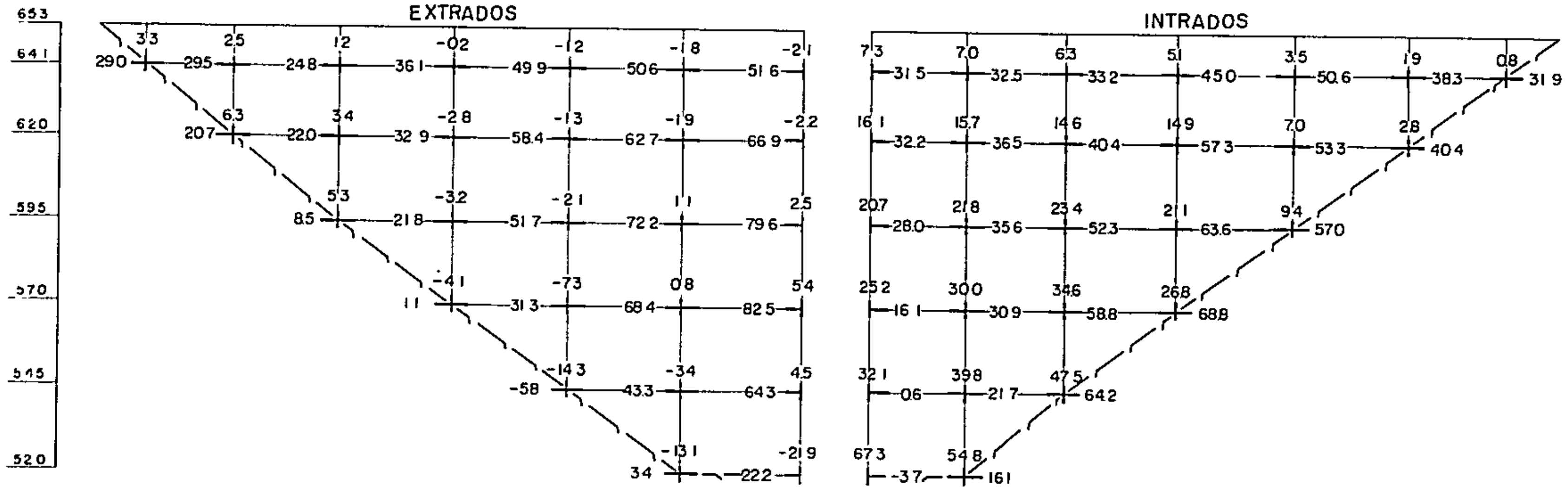
SHEET NO OF

HORIZONTAL AND VERTICAL STRESSES

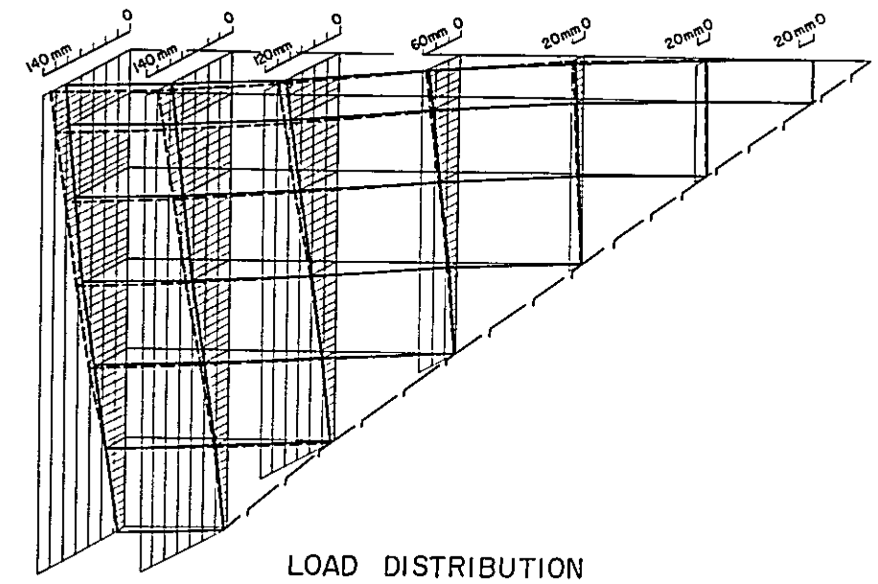
– OWN WEIGHT + HYDROSTATIC PRESSURE + SILT PRESSURE –



– OWN WEIGHT + HYDROSTATIC PRESSURE + SILT PRESSURE + TEMPERATURE CHANGE –

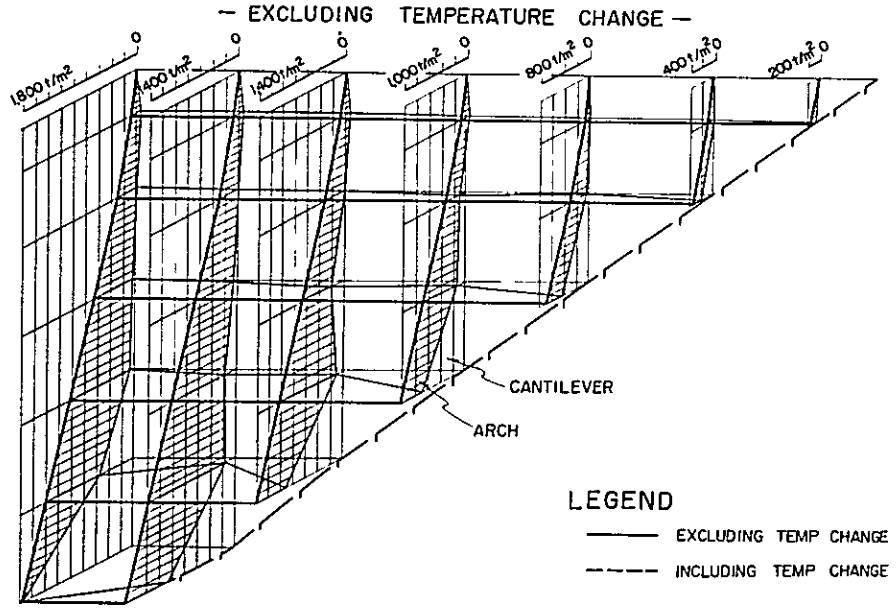


RADIAL DISPLACEMENT



LOAD DISTRIBUTION

– EXCLUDING TEMPERATURE CHANGE –

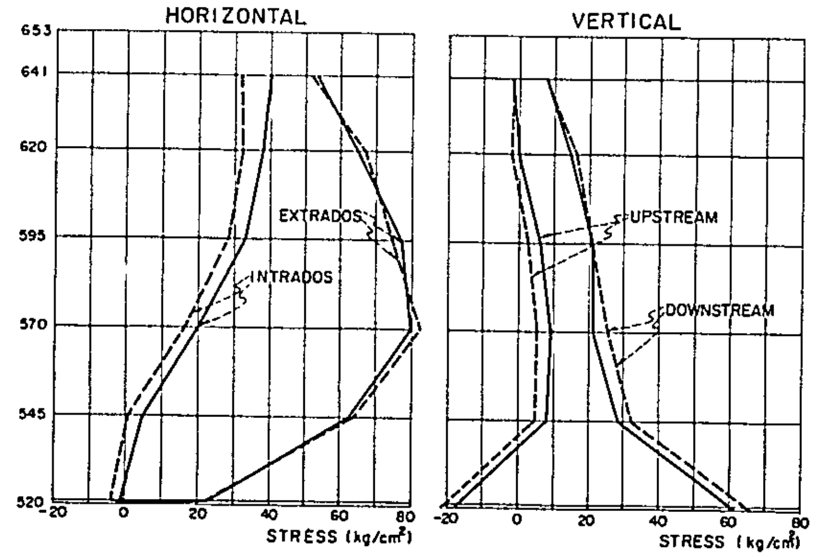


LEGEND

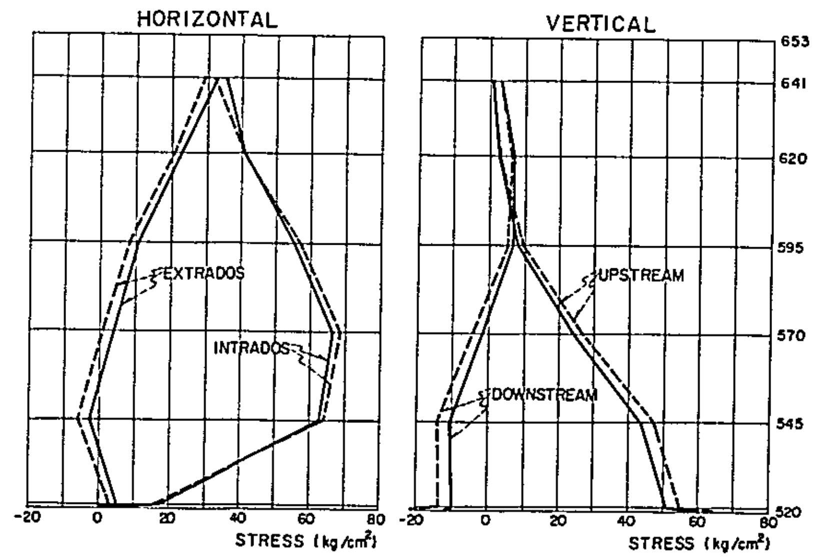
—— EXCLUDING TEMP CHANGE

– – – INCLUDING TEMP CHANGE

STRESS DISTRIBUTION AT CROWN



STRESS DISTRIBUTION AT ABUTMENT



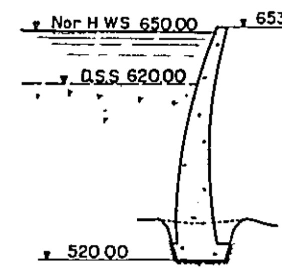
CALCULATION ASSUMPTION

METHOD RADIAL ADJUSTMENT

LOADING CONDITION

OWN WEIGHT FOR STRUCTURE BEFORE JOINT GROUTING

HYDROSTATIC AND SILT PRESSURE AS FOLLOWS



TEMPERATURE CHANGE : UNIFORM EFFECT ONLY

$t = \frac{60}{T+2.5}$ °C T THICKNESS OF DAM

CONSTANT Ec 200,000 kg/cm²

Er 100,000 kg/cm²

LOCATION	DATE	DESCRIPTION	BY
REVISION			

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

DEVLET SU IŞLERI GENEL MUDURLUGU
ANKARA–TURKEY

KURTUN PROJECT

KURTUN ARCH DAM
TENTATIVE SOLUTION (H=133m)

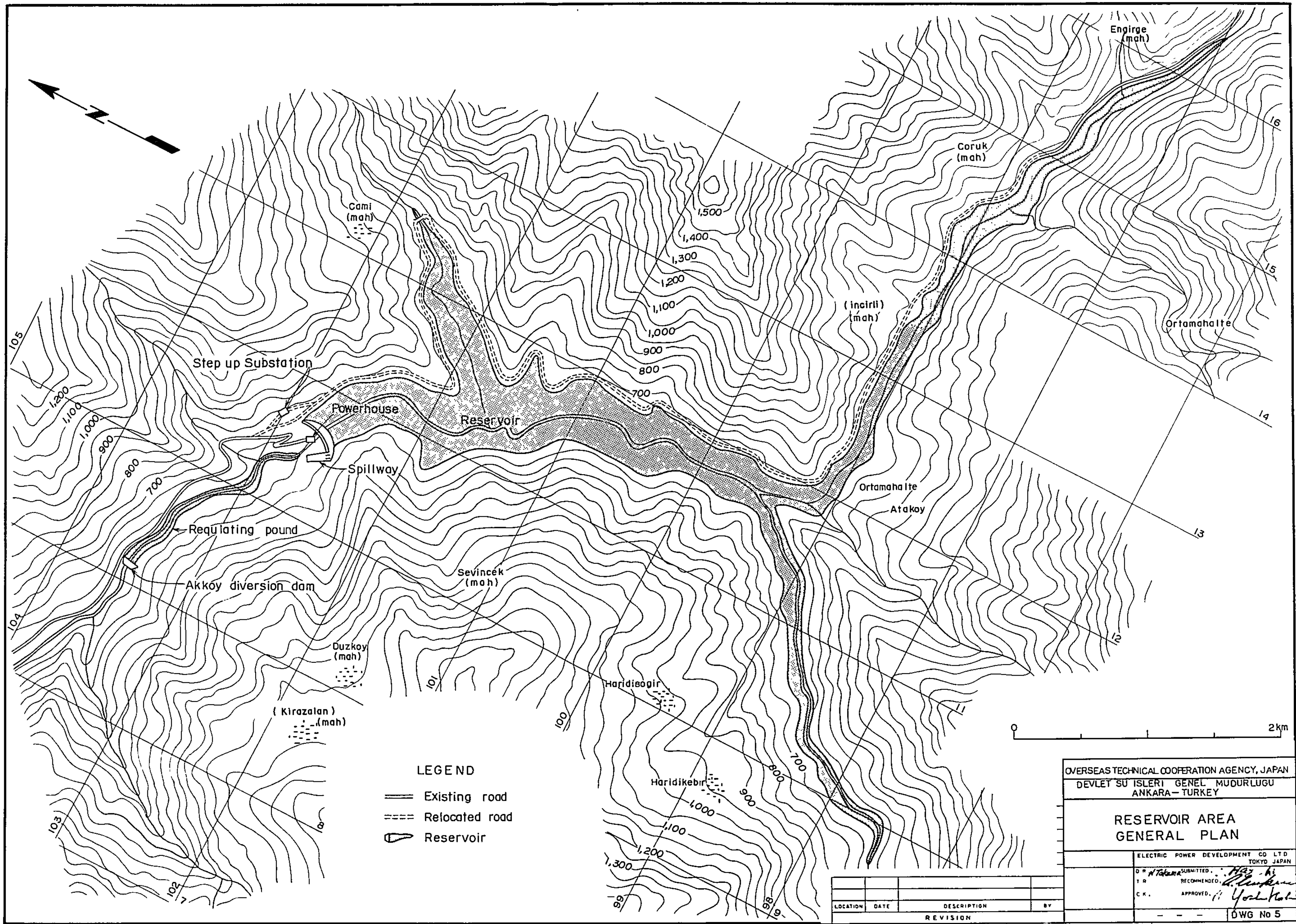
STRESS ANALYSIS

ELECTRIC POWER DEVELOPMENT CO., LTD
TOKYO JAPAN

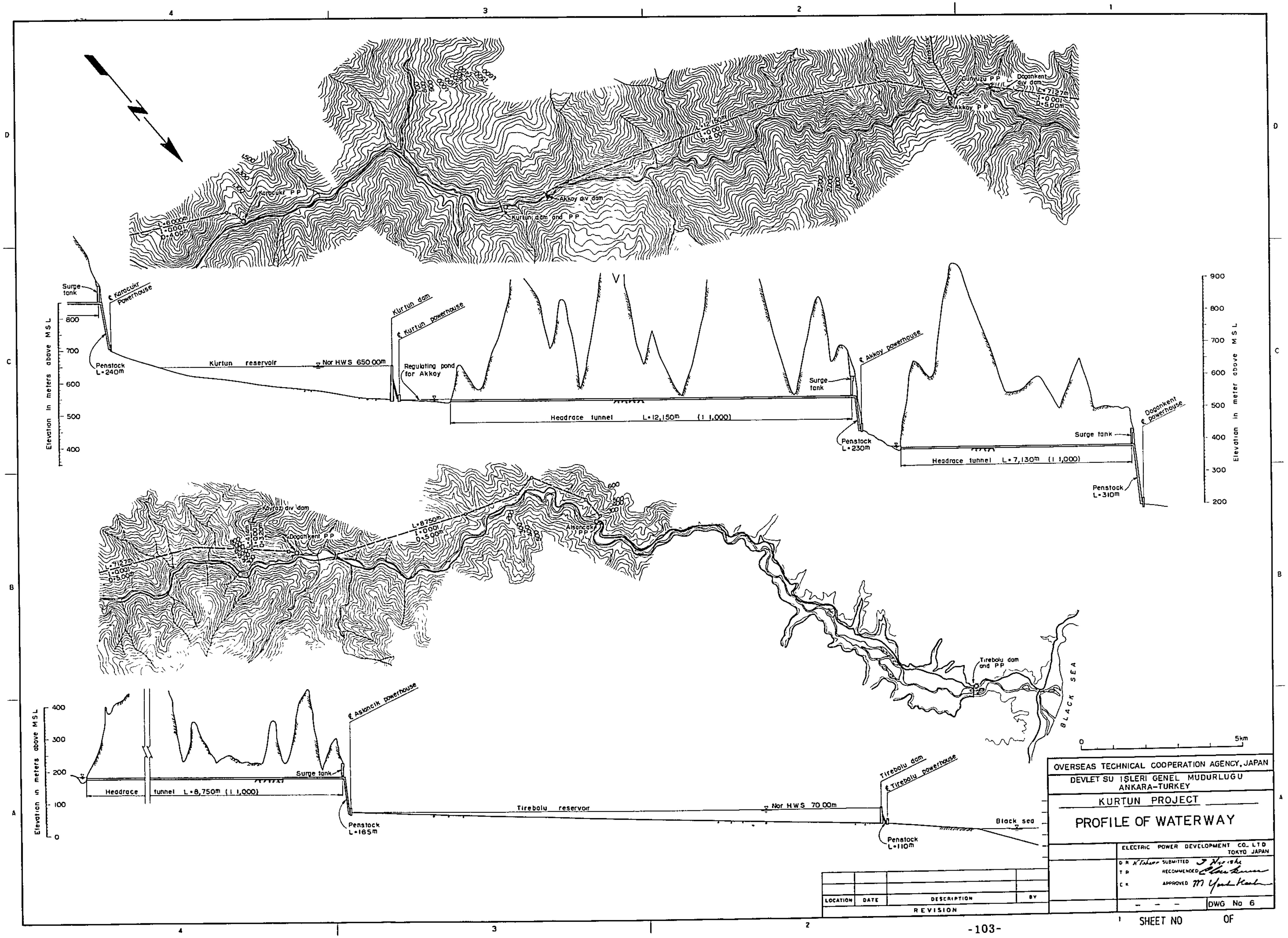
DR. SUBMITTED.
TR. RECOMMENDED.
CK. APPROVED.

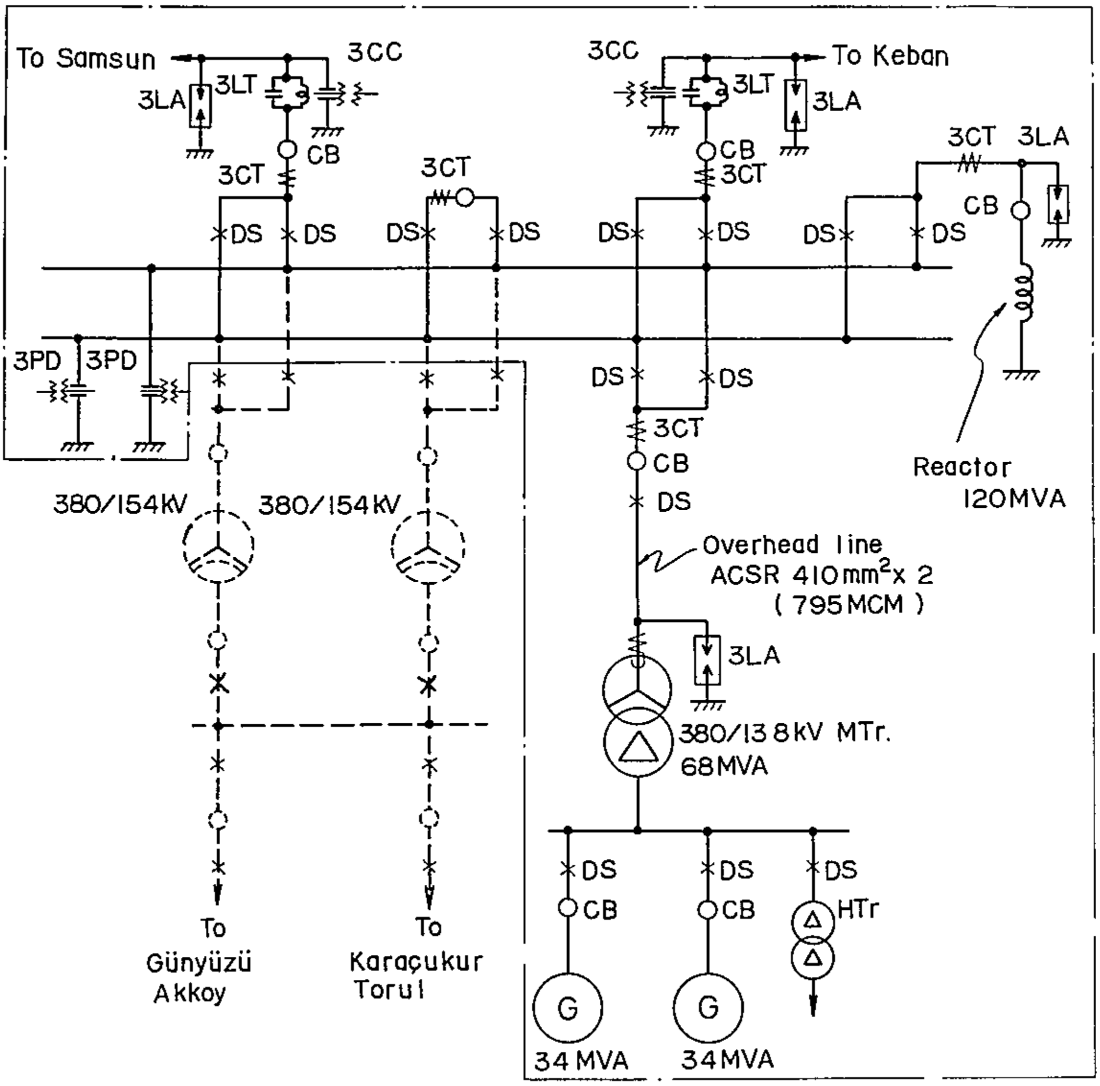
DWG No 4

SHEET NO OF


N
Engirge (mah)
Coruk (mah)
Cami (mah)
(incirli) (mah)
Ortamahalte
Step up Substation
Powerhouse
Reservoir
Spillway
Ortamahalte
Atakoy
Regulating pound
Akkoy diversion dam
Sevincek (mah)
Duzkoy (mah)
Haridisogir
(Kirazalan) (mah)
Haridikebir
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
0
1
2km
LEGEND
Existing road
Relocated road
Reservoir
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
DEVLET SU ISLERI GENEL MUDURLUGU
ANKARA - TURKEY
RESERVOIR AREA
GENERAL PLAN
ELECTRIC POWER DEVELOPMENT CO LTD
TOKYO JAPAN
SUBMITTED
RECOMMENDED
APPROVED
LOCATION
DATE
DESCRIPTION
BY
REVISION
DWG No 5

SHEET NO. OF


Karacukr P P
L = 6000m
I = 0.001
D = 4.00m
Kurtun dam and P P
Akkoy div dam
L = 12,150m
I = 0.001
D = 4.00m
Gunyuzu P P
Dogankent div dam
L = 7,127m
I = 0.001
D = 5.00m
Akkoy P P
Surge tank
℄ Karacukr Powerhouse
Elevation in meters above M S L
Penstock L = 240m
Kurtun reservoir
Nor HWS 650.00m
Kurtun dam
℄ Kurtun powerhouse
Regulating pond for Akkoy
Headrace tunnel L = 12,150m (1:1,000)
Surge tank
Penstock L = 230m
℄ Akkoy powerhouse
Surge tank
℄ Dogankent powerhouse
Headrace tunnel L = 7,130m (1:1,000)
Penstock L = 310m
Elevation in meter above M S L
Kayrazi div dam
Dogankent P P
L = 7,127m
I = 0.001
D = 5.00m
L = 8,750m
I = 0.001
D = 5.00m
Aslancik P P
Tirebolu dam and P P
BLACK SEA
0
5km
Elevation in meters above M S L
Headrace tunnel L = 8,750m (1:1,000)
Surge tank
℄ Aslancik powerhouse
Penstock L = 165m
Tirebolu reservoir
Nor HWS 70.00m
Tirebolu dam
℄ Tirebolu powerhouse
Penstock L = 110m
Black sea
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
DEVLET SU IŞLERI GENEL MUDURLUGU
ANKARA-TURKEY
KURTUN PROJECT
PROFILE OF WATERWAY
ELECTRIC POWER DEVELOPMENT CO., LTD
TOKYO JAPAN
SUBMITTED
RECOMMENDED
APPROVED
LOCATION
DATE
DESCRIPTION
BY
REVISION
DWG No 6
SHEET NO
OF



KÜRTÜN PROJECT

LEGEND

CB	Circuit Breaker
CC	Coupling Capacitor
CT	Current Transformer
DS	Disconnecting Switch
LA	Lightning Arrester
LT	Line Trap
PD	Potential Device
G	Generator
MTr	Main Transformer
HTr	House Transformer

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

DEVLET SU ISLERI GENEL MÜDÜRLÜGÜ
ANKARA – TURKEY

KÜRTÜN PROJECT
SINGLE LINE DIAGRAM

ELECTRIC POWER DEVELOPMENT CO., LTD
TOKYO JAPAN

D R. SUBMITTED. K. Ozaki
T R RECOMMENDED.
C.K. T.T APPROVED. M. [illegible]

LOCATION	DATE	DESCRIPTION	BY
REVISION			

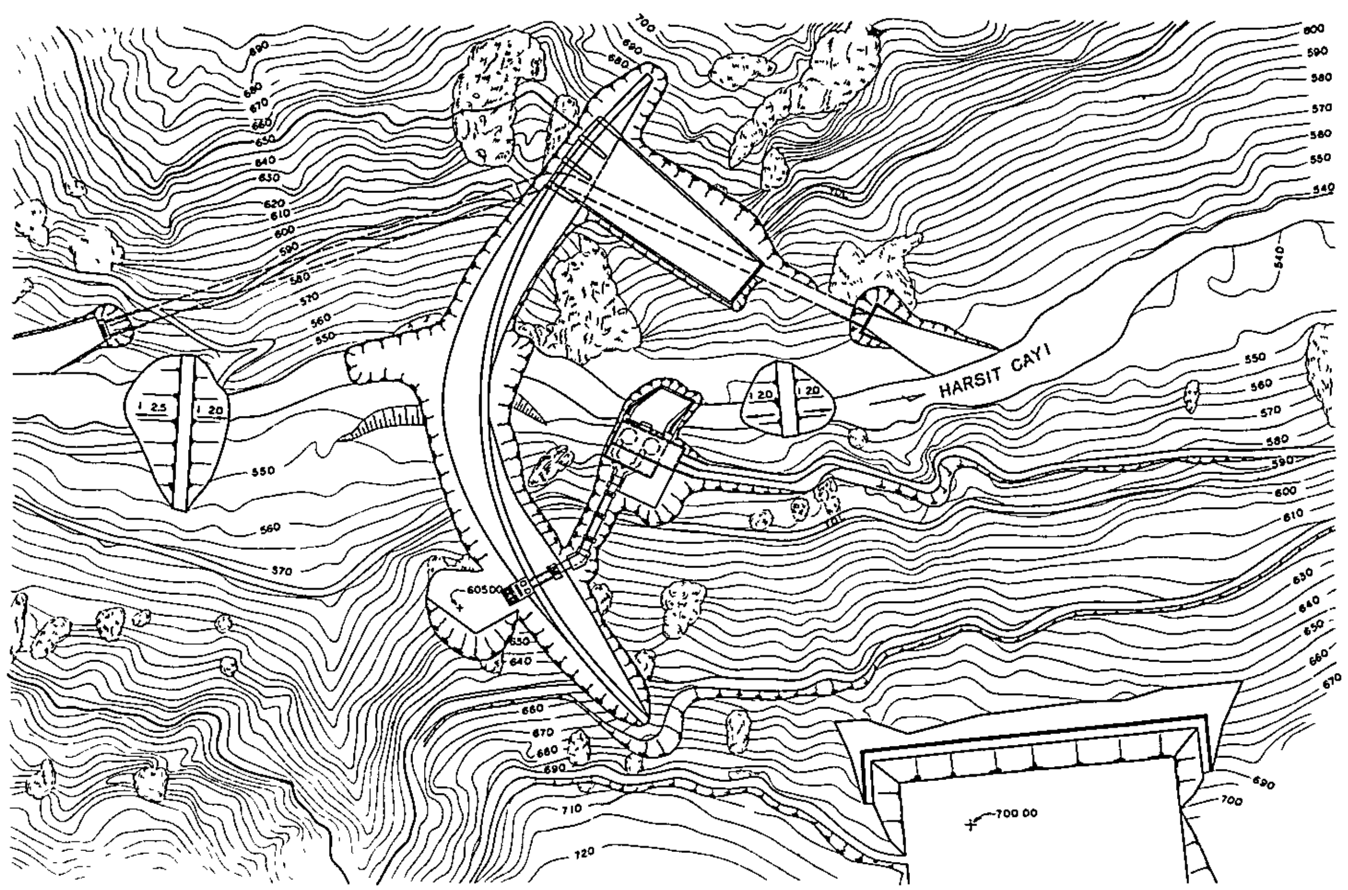
A

2 1

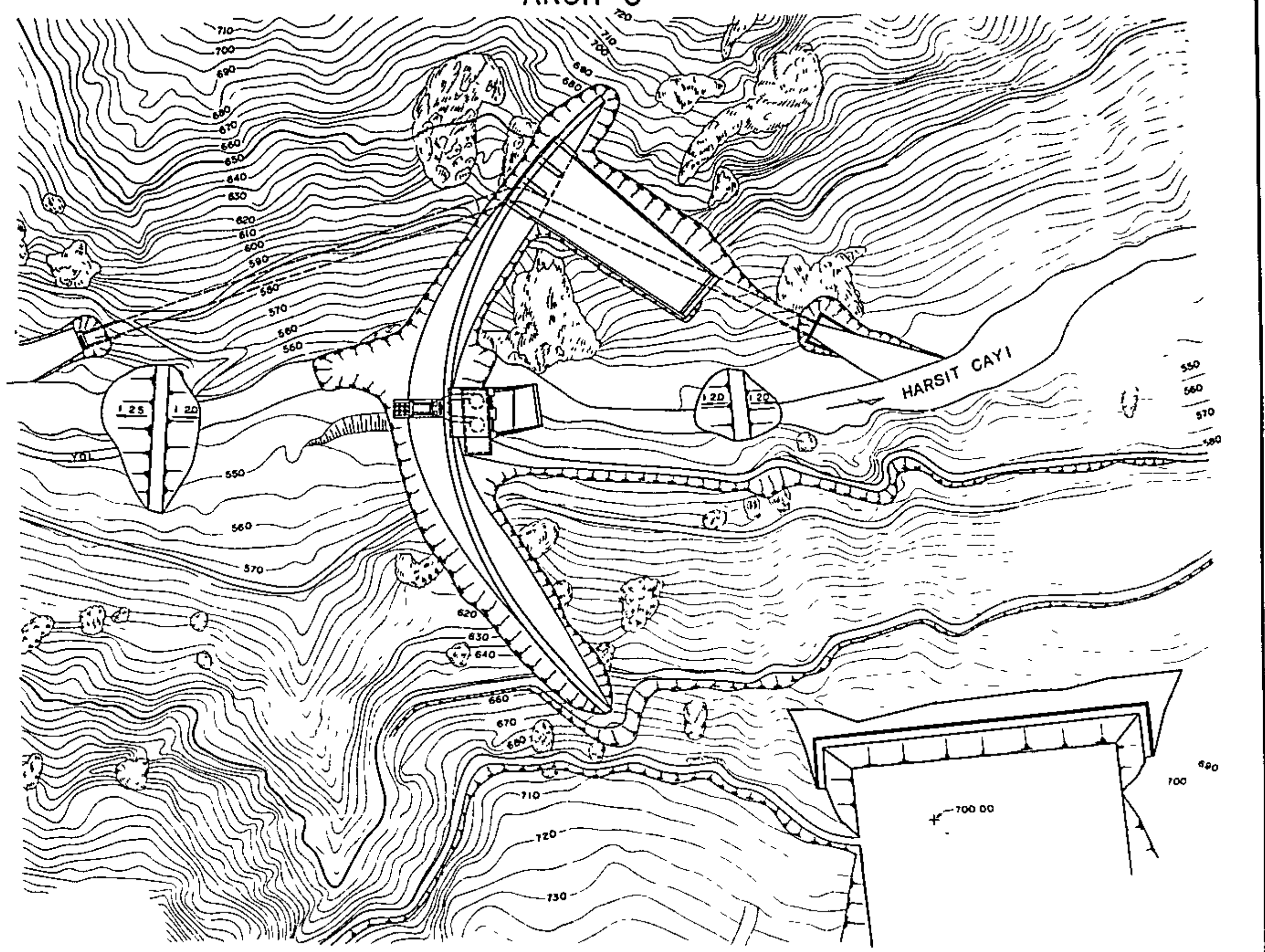
– – – DWG. No 7

SHEET NO OF

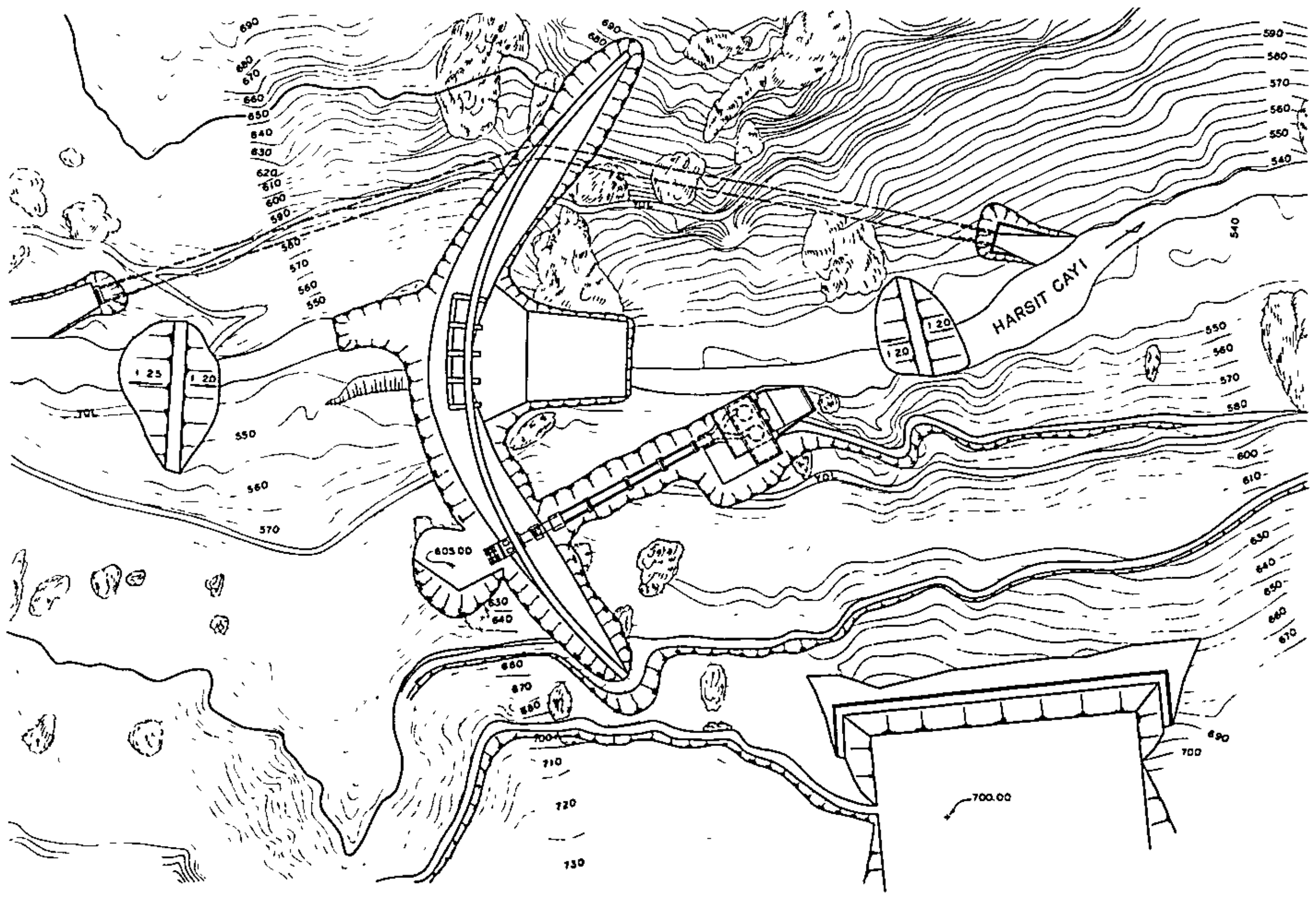
ARCH– A



ARCH–C



ARCH– B



0 100 200m

Fig 6–1

Kürtün Arch Dam & Power Plant General Plan

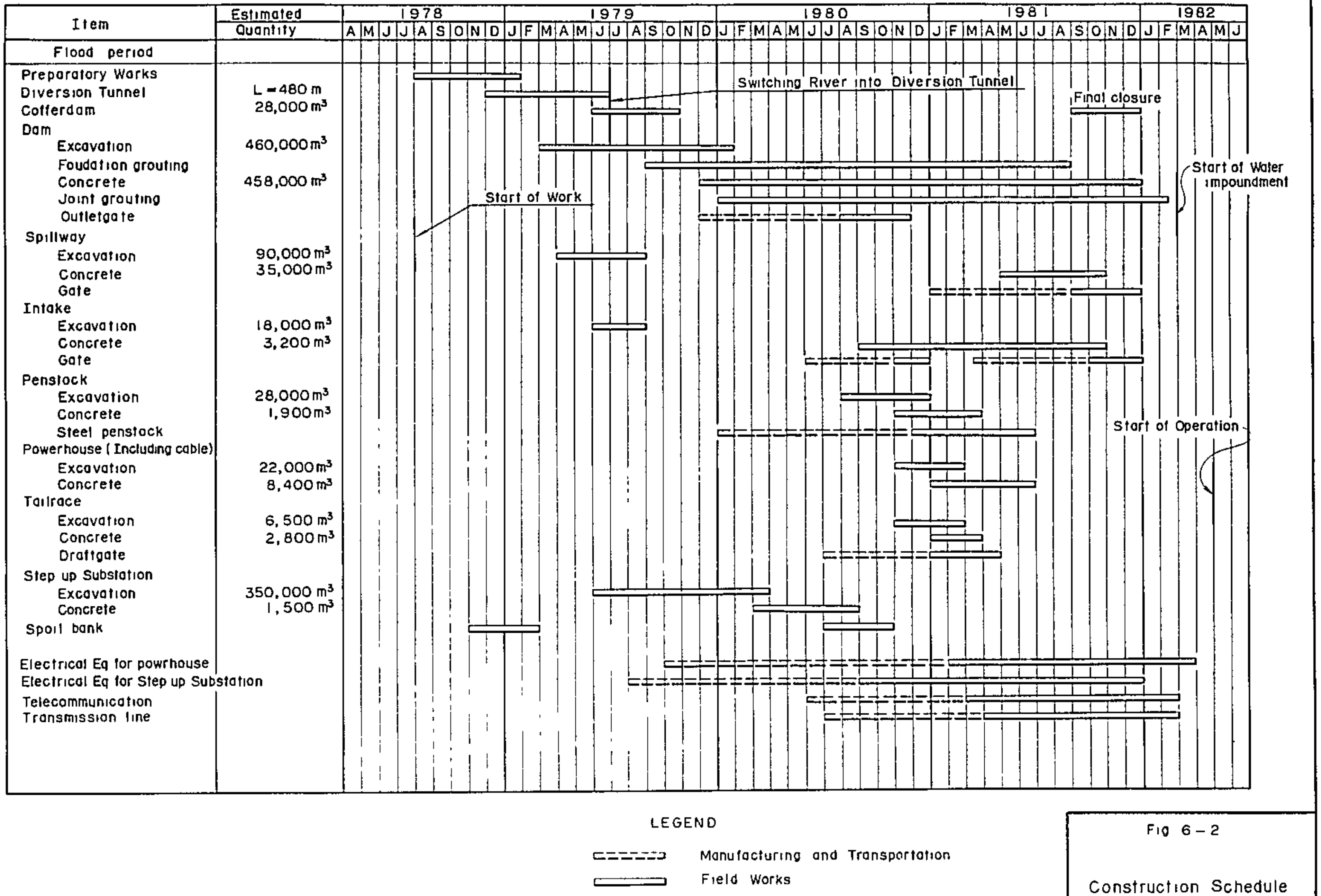


Fig 6 – 2

Construction Schedule

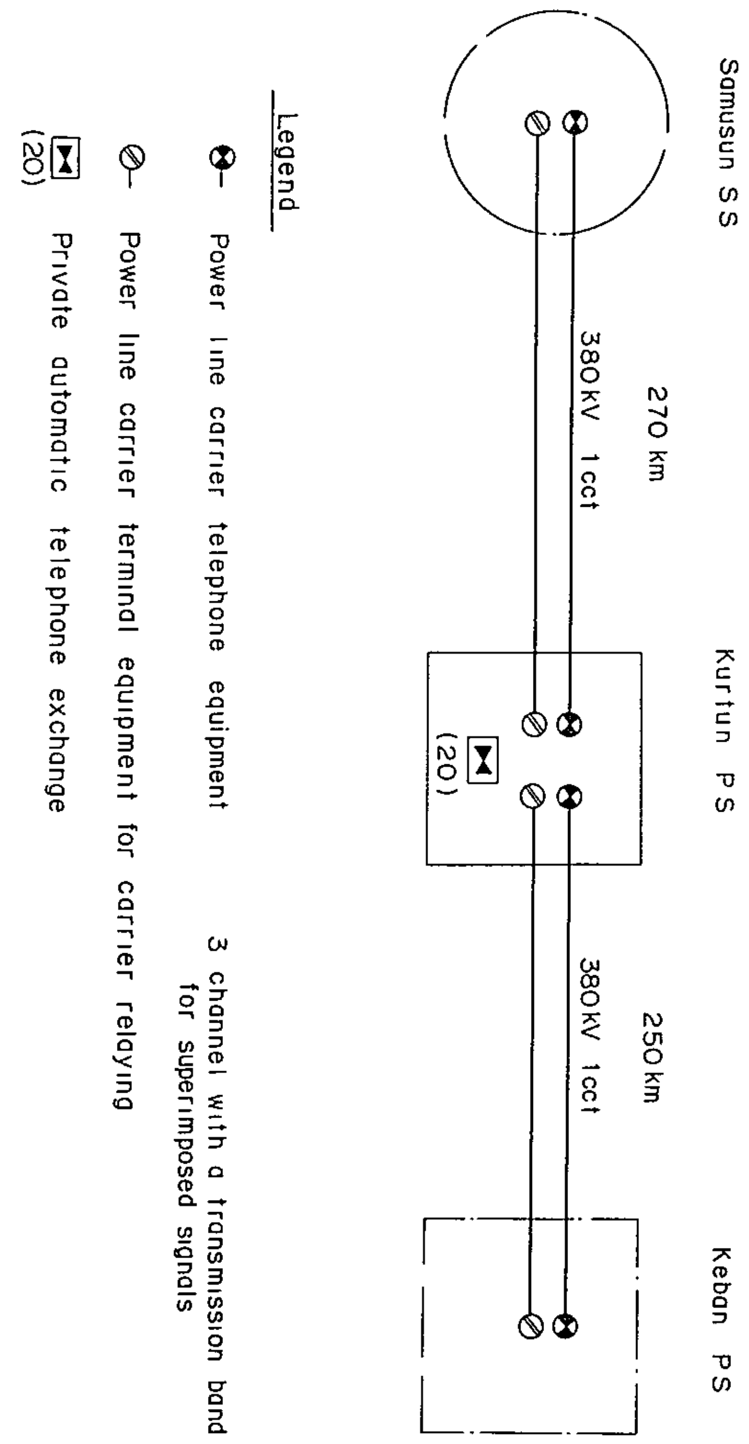


Fig. 6 – 3

Telecommunication System Diagram

CHAPTER 7

COST ESTIMATE

CONTENTS

Table

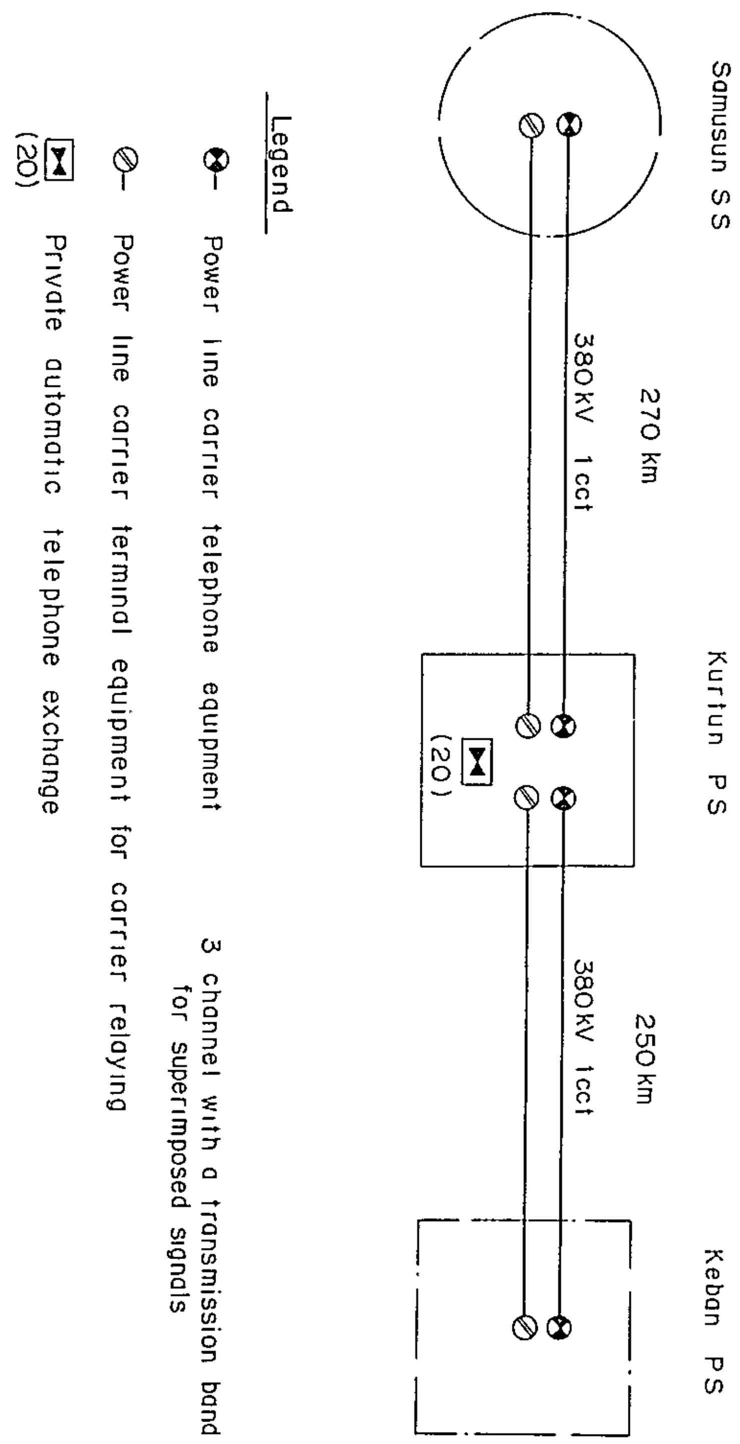


Fig. 6 – 3

Telecommunication System Diagram

CHAPTER 7

COST ESTIMATE

CONTENTS

Table

CHAPTER 7 COST ESTIMATE

7.1 SCOPE OF COST ESTIMATE

The estimation of the project cost is largely based on the same standardized methods as adopted for the study of Ayvacik Project which was made by EPDC in July of 1969. In addition to present levels of technology, geological and natural conditions are taken into consideration as well as regional conditions of project area.

In estimation of the project cost, the result of the field investigations were applied to the estimation of wages for labor and prices of materials.

(1) Scope of project facilities

The present estimation of the project cost include construction of the Kürtün dam, spillway, penstock, powerhouse building, step-up substation and communication facilities.

(2) Civil works

(a) Estimation was based on the preliminary design attached to this report.
(b) Unit costs applied for the Ayvacik Project were generally adopted taking into consideration of the prices of construction equipment investigated. As regards the equipment to be imported, market prices as of March 1969 were adopted. Bid results of the Gokcekaya Project and Keban Project were also referred to.
(c) Contingencies for civil works were assumed at 15% of net amount.

(3) Cost of Equipment

(a) Costs of machinery and equipment such as turbines, generators, transformers, excluding gates and penstock pipes were all estimated based on an assumption that they will be imported from foreign manufactures, and include costs of transportation to the site, works at site and installation.
(b) Contingencies for equipment were assumed at 5% of net cost.

(4) Expenses for investigation, project controlling services and management.

Upon discussion and agreement with DSI, expenses were assumed at 15% of the construction costs including the contingencies.

(5) Costs of land acquisition and relocation of existing facilities are as follows referring to data prepared by DSI.

Relocation of Road	·	27×10^6 TL
Compensation	:	18.7×10^6 TL

(6) Interest during construction

In accordance with requirement of DSI, two rates of 5% and 8% per annum were adopted for the calculation of interest during construction.

(7) Classification of domestic and foreign currencies

The project cost was divided into domestic and foreign currency requirements respectively on the same basis as that applied for the Ayvacik Project.

(8) Exchange rate applied is one US dollar to nine Turkish Lira.

7.2 PROJECT COST

The project cost for the Kurtun Project is as shown below.

Summary of Estimated Project Cost

Unit: 1000 TL

Item	Total Cost	Foreign Currency	Domestic Currency
(I) Generating Facilities			
1. Civil Works			
Diversion Works	12,000	4,680	7,320
Dam	138,095	55,238	82,857
Spillway	12,287	4,915	7,372
Intake & Penstock Line	3,520	1,126	2,394
Powerhouse & Tailrace	7,657	2,450	5,207
Contingencies (15%)	26,034	10,261	15,773
Sub total	199,593	78,670	120,923
2. Hydraulic Equipment			
Penstock	3,625	363	3,262
Gates	6,398	960	5,438
Others & Installation	250	-	250
Contingencies (5%)	514	66	448
Sub total	10,787	1,389	9,398
3. Electric Equipments			
Turbine	6,950	6,255	695
Generators	8,600	7,740	860
Transformers	2,750	2,200	550
Accessories etc.	6,340	5,706	634
Transportation & Installation	6,813	3,066	3,747
Consingencies (15%)	1,573	1,248	325
Sub total	33,026	26,215	6,811
4. Investigation, Project Controlling Services and Management Expenses	36,511	15,941	20,570
5 Land Acquisition	18,700	-	18,700
6. Relocation of Road	27,000	-	27,000
7. Camp facility	2,500	-	2,500
Total	328,117	122,215	205,902
8. Interest during Construction			
at 5% interest rate	26,249	9,777	16,472
at 8% interest rate	39,374	14,666	24,708
Total Construction Cost			
at 5% interest rate	354,366	131,992	222,371
at 8% interest rate	367,491	136,881	230,610
(II) Step-up Substation and Telecommunication			
1. Step-up Substation			
Outdoor switchgears	17,600	15,840	1,760
Civil Works	12,128	3,638	8,490
Contingencies	2,699	1,948	751
Sub total	32,427	21,426	11,001
2. Telecommunication	1,416	1,274	142
3. Investigation, Project & Controlling Services and Management Expenses	5,076	2,030	3,016
4. Interest during Construction			
at 5% interest rate	3,114	1,978	1,136
at 8% interest rate	4,982	3,165	1,817
Total			
at 5% interest rate	42,033	26,708	15,325
at 8% interest rate	43,901	27,895	16,006

Note: Allocation of the cost into Foreign Currency and Domestic Currency was according to the Table 7 - 1.

Table 7-1 Foreign Exchange Needs in Percentage

Unit: %

		Foreign Exchange	Domestic Finance
1.	Large Canal and River Improvement Excavation (with Machinery)	50	50
2.	Level Construction	50	50
3.	Irrigation and Drainage Network Construction	25	75
4.	Arch Concrete Dam	40	60 *
5.	Rockfill Dams	40	60
6.	Power Plant and Large Pumping Station Buildings	15	85
7.	Power Plant and Large Pumping Stations (including the equipment)	60	40
8.	Turbines and Generators	90	10
9.	Penstocks	10	90
10.	Reinforced Concrete-pipes	5	95
11.	Transmission Lines (Power)	30	70
12.	Transformer (less than 500 KVA)	20	80
13.	Transformer (more than 5,000 KVA)	80	20
14.	Gates and Lifing Devices	15	85

* Refer to the studies of Ayvacık arch dam made by EPDC.

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Table 7-1 Foreign Exchange Needs in Percentage

Unit: %

		Foreign Exchange	Domestic Finance
1.	Large Canal and River Improvement Excavation (with Machinery)	50	50
2.	Level Construction	50	50
3.	Irrigation and Drainage Network Construction	25	75
4.	Arch Concrete Dam	40	60 *
5.	Rockfill Dams	40	60
6.	Power Plant and Large Pumping Station Buildings	15	85
7.	Power Plant and Large Pumping Stations (including the equipment)	60	40
8.	Turbines and Generators	90	10
9.	Penstocks	10	90
10.	Reinforced Concrete-pipes	5	95
11.	Transmission Lines (Power)	30	70
12.	Transformer (less than 500 KVA)	20	80
13.	Transformer (more than 5,000 KVA)	80	20
14.	Gates and Lifing Devices	15	85

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8.1 BASIC CONSIDERATION

So far as the optimum scale of the Kurtun Project is concerned, it is advantageous to combine the projects of the Akkoy and Dogankent with Kurtun Project since such combination could increase power production due to the increment of released firm discharge from the Kurtun reservoir. Therefore, economic justification was made on the basis of a combined development of the Kurtun, Akkoy and Dogankent power stations, provided that the latter include extension work only

The Aslancık Project was excluded from the combination The Dogankent Power Station under construction will produce more power and enlarge its dependable KW value when the Kürtün reservoir is constructed and increased firm discharge is made available. Besides, the reservoir which would be created by the proposed diversion dam of the Akköy Power Station will have a function of regulating pond for the Dogankent Power Station which has no such pond. Therefore, construction of the Akköy power station and extension of the Dogankent Power Station should be implemented simultaneously with the construction of the Kürtün Dam and Power Station.

The construction cost of the Akköy power station and extension of the Dogankent Power Station has been estimated based on the data made available in the reconnaissance study. Judging from engineering experiences, it is anticipated that substantial difference will not appear between the present cost estimate shown in the Appendix and that which will be studied in feasibility study in future

8.2 SALABLE ENERGY

As described in Chapter 5, the annual energy production of the Kürtün Power Station will be 200×10^6 kWh, and those of the Akköy and Dogankent Power Stations, after the completion of the Kürtün reservoir will be 197×10^6 and 330×10^6 kWh, respectively.

Since an annual energy production of the Dogankent Power Station in the first stage is 228×10^6 kWh, and down stream annual energy increment of the additional Dogankent Power Station will be as follows,

$$330 \times 330 \quad 228 = 102 \times 10^6 \text{kWh}$$

All of the energy will be sent to the system connecting Samsun with the Trabson Substation through transmission line immediately after the starts of operation The transmission losses on the lines from the Kürtun and Akkoy Power Station to the Samsun Substation and from the Dogankent Power Station to the Trabson Substation were estimated to be 1 3% and 1 8% respectively. Therefore, annual salable energy at sending end will be 392×10^6 kWh and 100×10^6 kWh on average for 30 years

8 3 ANNUAL COST

In general annual cost consists of depreciation of investment expenses for operation and maintenance of power generating facilities and replacement costs. Interest burden and depreciation were calculated on the basis of its serviceable life by the sinking fund method Operation and maintenance

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CHAPTER 8 ECONOMIC JUSTIFICATION

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The construction cost of the Akköy power station and extension of the Dogankent Power Station has been estimated based on the data made available in the reconnaissance study. Judging from engineering experiences, it is anticipated that substantial difference will not appear between the present cost estimate shown in the Appendix and that which will be studied in feasibility study in future.

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Since an annual energy production of the Dogankent Power Station in the first stage is 228 x 10^6 kWh, and down stream annual energy increment of the additional Dogankent Power Station will be as follows;

$$330 \times 330 - 228 = 102 \times 10^6 \text{kWh}$$

All of the energy will be sent to the system connecting Samsun with the Trabson Substation through transmission line immediately after the starts of operation. The transmission losses on the lines from the Kürtün and Akkoy Power Station to the Samsun Substation and from the Dogankent Power Station to the Trabson Substation were estimated to be 1.3% and 1.8% respectively. Therefore, annual salable energy at sending end will be 392 x 10^6 kWh and 100 x 10^6kWh on average for 30 years.

8.3 ANNUAL COST

In general, annual cost consists of depreciation of investment expenses for operation and maintenance of power generating facilities and replacement costs. Interest burden and depreciation were calculated on the basis of its serviceable life by the sinking fund method. Operation and maintenance costs and administration cost were estimated on the basis of available data in terms of percentage of the total investment cost derived from operation records of similar power plants. Equalized annual cost factors for this project are given in following table 8-1 and the results of calculation are shown in Table 8-2. The rate of interest adopted for the calculation were 5% and 8% per annum.

Table 8-1 Equalized Annual Cost F ctor

* Generating Facilities

Item	Interest Rate 5%	Interest Rate 8%
Serviceable Year	50	50
Equalized Annual Cost Factor	6.734	9.430
1. Capital Recovery Factor	5.478	8.174
2. Interim Replacements	0.200	0.200
3. Insurance	0.056	0.056
4. Operation and Maintenance of Administration Expenses	1.000	1.000

* Step-up Substation

Item	Interest Rate 5%	Interest Rate 8%
Serviceable Year	35	35
Equalized Annual Cost Factor	9.387	11.860
1. Capital Recovery Factor	6.107	8.580
2. Interim Replacements	0.050	0.050
3. Insurance	0.230	0.230
4. Operation and Maintenance of Administration Expenses	3.000	3.000

* Transmission Line between Akkoy Power Station and Set-up Substation

Item	Interest Rate 5%	Interest Rate 8%
Serviceable Year	50	50
Equalized Annual Cost Factor	8.525	11.224
1. Capital Recovery Factor	5.478	8.174
2. Interim Replacements	0.050	0.050
3. Insurance	-	-
4. Operation and Maintenance of Administration Expense	3.000	3.000

Table 8-2 Annual Cost of Kürtün, Akköy and Additional Dogankent Project

Unit : 10^3 TL

	Kürtün Generating Facility		Akköy Generating Facility		Additional Dogankent Generating Facility		Kürtün Step-up Substation		Transmission line between Akköy and Kürtün Substation	
Interest	5%	8%	5%	8%	5%	8%	5%	8%	5%	8%
Construction Cost	354,366	367,491	228,300	238,500	49,200	51,390	42,033	43,901	3,510	3,670
Capital Recovery	19,412	30,039	12,506	19,495	2,695	4,201	2,567	2,681	192	300
Interim Replacement	709	735	457	477	98	103	21	22	2	2
Insurence	198	206	127	134	28	29	97	101	-	-
Operation Maintenance & Administration	3,544	3,675	2,283	2,385	492	514	1,261	1,317	105	110
Total	23,863	34,655	15,373	22,391	3,313	4,847	3,946	4,121	299	412

8.4 COMPARISON WITH ALTERNATIVE SOURCE

8.4.1 Selection of Alternative Thermal Power Plant

The economic justification of the Kürtün Project was made on the basis of 100 MW and 300 MW thermal power plants, respectively. The following criteria were used in the selection of an alternative thermal power plant.

a) Alternative thermal power plant should be of a reasonable scale compatible with this project in the eastern Black Sea system.

b) Inshould be a modern thermal power plant which will have a main role in the Eastern Black Sea System in the future.

c) It should be operated under a high plant factor which is conceivable in the system.

The construction cost and general features of the alternative thermal power plant are shown in table 8-3.

Table 8-3 Construction Cost and General Features of Standard Thermal Power Plant

	Unit	100 MW Alternative	300 MW Alternative
Installed Capacity	MW	100	300
Unit Capacity	MW	100	300
Annual Capacity Factor	%	70	70
Thermal Efficiency at Sending End	%	35.4	36.0
Annual Energy Generation	10^6 kWh	610	1,840
Fuel Consumption Rate	1/kWh	0.245	0.241
Fuel	10^3 kl	150	443
Construction Cost	10^6 TL	145	390
Serviceable Life	Year	35	35
Station Service	%	6	4

8.4.2 Annual Cost of Alternative Thermal Power Plant

Construction cost of the alternative thermal power plant was estimated at 145 million Turkish Lira. The annual cost of the alternative thermal power plant is broken down into fixed cost and variable cost. The fixed cost and the variable cost were estimated to be 151.5 (189.8). Turkish Lira per kW and 5.69 Turkish Lira per kWh at an interest rate of 5% . Figures in parentheses are for the 8% interest rate. They are shown in table 8-4 and table 8-5.

Table 8-4 Alternative Thermal Power Plant Cost

Output	Interest Rate	Capacity Factor	Fuel Cost	Power Cost	Energy Cost	Remarks
100 MW	5%	60%	228 TL/kl (253 TL/ton)	181.8 TL/KW	4.90 Kr/kWh 5.78	KW Coefficient Factor 1.20 100 MW 151.5 x 1.20 = 181.8
		70%		181.8	5.69	189.8 x 1.20 = 227.8
Eastern Black Sea System	8%	60%		227.8	5.78	300 MW 124.1 x 1.20 = 148.9
		70%		227.8	5.69	157.6 x 1.20 = 189.1
300 MW	5%	60%	228 TL/kl (253 TL/ton)	148.9	5.70	
Interconnected System		70%		148.9	5.59	
		80%		148.9	5.54	
	8%	60%		189.1	5.70	
		70%		189.1	5.59	
		80%		189.1	5.54	

Table 8-5 Fixed and Variable Cost of Standard Thermal Power Plant

Item	(100,000 KW) Fixed Costs	(100,000 KW) Variable Costs	(300,000 KW) Fixed Costs	(300,000 KW) Variable Costs
Interest and Depreciation	9,650 (13,240)		25,960 (35,610)	
Operation and Maintenance	4,260	600	9,060	1,680
Labour Cost	1,500		1,500	
Repair Expense	2,450	600	6,720	1,680
Miscellaneous Expense	310		840	
Administration Cost	340	50	720	130
Fuel Cost		34,070		101,100
Total	14,250 (17,840)	34,720	35,740 (45,390)	102,910
Annual Cost at Sending End				
Power Cost (TL/KW)	151.5 (189.8)		124.1 (157.6)	
Energy Cost (TL/KW)		0.0569		0.0559
	Net Power = 100x(1-0.06) = 94 MW		Net Power= 300x(1-0.04) = 288 MW	

Remarks

Interest rate 5%, 8%

	Capital Recovery Factor	+ Replacement	+ Insurance	Total
5%	6.107	0.35	0.2	6.65%
8%	8.580	0.35	0.2	9.13%

8.5 UNIT VALUE OF BENEFIT

Annual benefit of the Kürtün Power Station including the Akköy and additional works of the Dogankent Power Stations were estimated on the basis of benefit per kWh and per KW. In estimation of benefit per KW, a thermal power plant of 100,000 KW capacity was considered as alternative of the Kürtün Project. As for benefit per KW, annual fixed cost per KW of the alternative thermal power plant have larger outage factors than hydro power plants due to failuers and also scheduled maintenance. Therefore, if a thermal power plant is newly put into service, additional supply capacity must be provided to recover this outage factor. The necessity of additional capacity, which a hydro power plant does not need must be taken into consideration in the calculation of benefit. Thus, the cost of the alternative thermal power plant multiplied by 1.20 was considered for the additional capacity. The benefit per kWh is the annual variable cost per kWh of the alternative thermal power plant.

Dependable output in December 46,000KW and 40,000KW of the Kürtün and Akkoy Power Stations was used in the estimation of benefit per KW. In additional Dogankent Power Station, 37.2MW (70MW less 32.8MW) was applied because 70,000 KW of output will be possible at the Dogankent Power Station due to its extension without additional diverted water from the Gunyuzu Power Station after the Kürtün Power Station is completed.

8.6 BENEFIT OF KURTUN PROJECT INCLUDING AKKOY AND ADDITIONAL DOGANKENT PROJECT

at 5% interest rate

1	Annual average power production	492	10^6 kWh
	Unit benefit per kWh	5.69	T.L/kWh
	Annual average benefit from kWh	27,995	10^3T L
2.	Output benefit in December	121,400	kW
	Unit benefit per kW	181.8	T.L/kW
	Benefit from kW	22,070	10^3 T.L
3.	Total annual benefit from power	50,065	10^3T.L

at 8% interest rate

1	Annual average power production	492	10^6 kWh
	Unit benefit per kWh	5.69	T.L/kWh
	Annual average benefit from kWh	27,995	10^3 T.L
2.	Output benefit in December	121,400	kW
	Unit benefit per kW	227.8	T.L/kW
	Benefit from kW	27,655	10^3 T.L
3.	Total annual benefit from power	55,650	10^3 T.L

In the benefit estimation it was assumed that all of the annual energy production of 492 x 10^6 kWh and 121,400 kW output of December would be consumed effectively and immediately after the start of operations of these power stations.

8.7 CALCULATION OF NET BENEFIT

x 10^3 T.L

Without Torul	
Benefit of Kürtün Project including Akköy and additional Dogankent Project	50,065 (55,650)
Annual Cost of Kürtün P.S. including Akköy and additional Dogankent P.S.	42,549 (61,893)
Annual Cost of Kürtün Step-up Substation and Transmission Line between Akköy P.S. and Kürtün S.S.	4,245 (4,533)
Net Benefit of Kürtün Project including Akköy and additional Dogankent Project	3,271 (- 10,776)
With Torul	
Benefit of Kürtün Project including Akköy additional Dogankent Project	54,275 (59,860)
Annual Cost of Kürtün P.S. including Akköy and additional Dogankent P.S.	42,549 (61,893)
Annual Cost of Kürtün and Transmission Line between Akköy P.S. and Kürtün S. S.	4,245 (4,533)
Net Benefit of Kürtün Project including Akköy and additional Dogankent Project	7,481 (- 6,566)

Note. Figures parenthesized are calculated at 8% interest rate

CHAPTER 9

FINANCIAL ANALYSIS

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CHAPTER 9 FINANCIAL ANALYSIS

Cash Flow Projection

9.1 FUND REQUIREMENT

The total construction cost of the Project has been estimated at 378,730 thousand Turkish Lira and the construction period will be 45 months.

9.2 PROCUREMENT OF FUNDS

a. Sources of Funds

Foreign loans, borrowing from domestic financial institutions and internal reserve can be considered as sources of funds. Loans from international banking institutions would cover the foreign currency requirements. As for the local currency requirements, investment of internal reserve and appropriation of the governmental fund were considered.

b. Interest Rate and Period of Redemption

(1) Foreign Currency Requirements.

With an assumption that loans would be obtained from the International Bank for Reconstruction and Development, the repayment terms and interest rate were adopted as follows in consideration of the recent performance of the Bank.

Interest rate	6.5% per annum
Period of redemption	20 years from beginning of operation in uniform annual installments of principal plus interest

(2) Local Currency Requirements

Taking into account the rates of borrowing from city banks, government funds and internal reserve, the following conditions are assumed.

Interest rate	5% per annum
Period of redemption	20 years from beginning of operation in uniform annual installments of principal plus interest

9.3 INCOME AND EXPENSES

a. Income from Energy Sales

The unit price of energy delivered at a primary substation was estimated at 13 kr/kWh.

b. Salable Energy

Salable energy at the primary substation deducting transmission losses will be as given in Table 9-2, after transmission losses being deducted.

c. Operation and Maintenance Costs and Depreciation Charges

For operation and maintenance costs and depreciation, the amount as given in Chapter 8 "Annual Cost" was used.

d. Net Income

Net income is gross operating revenue less operation and maintenance costs, depreciation and interest payable on foreign and local loans. The result is shown in Table 9-2 "Income Statement."

9.4 AMORTIZATION SCHEDULE

The sources of funds for repayment of borrowings will be the net income and the depreciation reserve. Annual repayment of pnncipal and interest payment is indicated in Table 9-3, "Cash Flow Statement".

It will be noted that according to the above tables there will be deficite in running account for the period of 20 years after 1983 if the Kurtun Project is independently considered.

Therefore, the shortage should be covered by the income or proceeds of energy sales of the Akkoy and Dogankent Power Stations for this period.

Table 9-1 Amortization Schedule

Unit: 1000 TL

Foreign Currency

Year	Borrowing	Redemption Principal	Redemption Interest	Total	Outstanding Balance	Remarks
1982	157,800				157,800	Interest rate 6.5%
3		4,064	10,257	14,321	153,736	redeemable in
4		4,328	9,993	14,321	149,408	equal annual
5		4,609	9,712	14,321	144,799	installments in
6		4,909	9,412	14,321	139,890	20 years
7		5,228	9,093	14,321	134,662	Amortization rate
8		5,568	8,753	14,321	129,094	0.09075640
9		5,930	8,391	14,321	123,164	
1990		6,315	8,006	14,321	116,849	
1		6,726	7,595	14,321	110,123	
2		7,163	7,158	14,321	102,960	
3		7,629	6,692	14,321	95,331	
4		8,124	6,197	14,321	87,207	
5		8,653	5,668	14,321	78,554	
6		9,215	5,106	14,321	69,339	
7		9,814	4,507	14,321	59,525	
8		10,452	3,869	14,321	49,073	
9		11,131	3,190	14,321	37,942	
2000		11,855	2,466	14,321	26,087	
1		12,625	1,696	14,321	13,462	
2		13,462	859	14,321	0	
3						
4						
5						
6						
7						
8						
9						
2010						

Local Currency

Year	Barrowing	Redemption Principal	Redemption Interest	Total	Outstanding Balance	Remarks
1982	237,698				237,699	Interest rate 5%
3		7,189	11,885	19,074	230,510	redeemable in
4		7,548	11,526	19,074	222,962	equal annual
5		7,925	11,148	19,074	215,036	installments in
6		8,322	10,752	19,074	206,714	20 years
7		8,738	10,336	19,074	197,976	Amortization rate
8		9,175	9,899	19,074	188,801	0.08024259
9		9,634	9,440	19,074	179,167	
1990		10,116	8,958	19,074	169,057	
1		10,621	8,453	19,074	158,430	
2		11,152	7,922	19,074	147,278	
3		11,710	7,364	19,074	135,568	
4		12,296	6,778	19,074	123,272	
5		12,910	6,164	19,074	110,362	
6		13,556	5,518	19,074	96,806	
7		14,234	4,840	19,074	82,572	
8		14,945	4,129	19,074	67,627	
9		15,693	3,381	19,074	51,934	
2000		16,477	2,597	19,074	35,457	
1		17,301	1,773	19,074	18,156	
2		18,156	918	19,074	0	
3						
4						
5						
6						
7						
8						
9						
2010						

Table 9-2 Income Statement

Unit: 1,000 TL

Year	Salable Energy (10^3 kWh)	(A) Revenues Cost per Unit delivered at Substation (TL per kWh)	Operation Revenue	(B) Expenses Operation & Maintenance Cost	Depreciation	Total Operation Cost	(C) Operation Income	(D) Financial Expenses Foreign Loans	Local Loans	Total	Net Income	Remarks
1982	115,000	0.13	14,950	2,445	13,145	15,590	-640				-640	Depreciation and Interest 5.478%
3	197,000	0.13	25,610	4,186	22,508	26,694	-1,084	10,257	11,885	22,142	-23,226	
4	197,000	0.13	25,610	4,186	22,508	26,694	-1,084	9,993	11,526	21,519	-22,603	Interim Replacement 0.200
5	197,000	0.13	25,610	4,186	22,508	26,694	-1,084	9,712	11,148	20,860	-21,944	Total 5.678%
6	197,000	0.13	25,610	4,186	22,508	26,694	-1,084	9,412	10,752	20,164	-21,248	
7								9,093	10,336	19,429	-20,513	Operation and Maintenance Cost
8								8,753	9,899	18,652	-19,736	
9								8,391	9,440	17,831	-18,915	Insurance 0.056
1990								8,006	8,958	16,964	-18,048	O & M 0.700
1								7,595	8,453	16,048	-17,132	Administration 0.300
2								7,158	7,922	15,080	-16,164	
3								6,692	7,364	14,056	-15,140	Total 1.056%
4								6,197	6,778	12,975	-14,059	
5								5,668	6,164	11,832	-12,916	
6								5,106	5,518	10,624	-11,708	
7								4,507	4,840	9,347	-10,431	
8								3,869	4,129	7,998	-9,082	
9								3,190	3,381	6,571	-7,655	
2000								2,466	2,597	5,063	-6,147	
1								1,696	1,773	3,469	-4,553	
2								859	918	1,777	-2,861	
3											-1,084	
4											-1,084	
5											-1,084	
6											-1,084	
7											-1,084	
8											-1,084	
9												
2010												

Table 9-3 Statement of Cash Flow

Year	(A) Cash from Income			(B) Proceed from Finance			(C)=(A+B)	(D) Capital Expenditure			Cash Balance
	Net income	Depreciation	Total	Foreign	Local	Total	Grand Total	Const. Cost	Repayment of borrowing	Total	
1982	-640	13,145	12,505	157,800	237,699	396,399	408,904	396,399		396,399	12;505
3	-23,226	22,508	-718				-718		11,253	11,253	11,971
4	-22,603	22,508	-95				-95		11,876	11,816	11,971
5	-21,945	22,508	563				563		12,534	12,534	11,971
6	-21,248	22,508	1,260				1,260		13,231	13,231	11,971
7	-20,513	22,508	1,995				1,995		13,966	13,966	11,971
8	-19,736	22,508	2,772				2,772		14,743	14,743	11,971
9	-18,915	22,508	3,593				3,593		15,564	15,564	11,971
1990	-18,048	22,508	4,460				4,460		16,431	16,431	11,971
1	-17,132	22,508	5,376				5,376		17,347	17,347	11,971
2	-16,164	22,508	6,344				6,344		18,315	18,315	11,971
3	-15,140	22,508	7,368				7,368		19,339	19,339	11,971
4	-14,059	22,508	8,449				8,449		20,420	20,420	11,971
5	-12,916	22,508	9,592				9,592		21,563	21,563	11,971
6	-11,708	22,508	10,800				10,800		22,771	22,771	11,971
7	-10,431	22,508	12,077				12,077		24,048	24,048	11,971
8	-9,082	22,508	13,426				13,426		25,397	25,397	11,971
9	-7,655	22,508	14,853				14,853		26,824	26,824	11,971
2000	-6,147	22,508	16,361				16,361		28,332	28,332	11,971
1	-4,553	22,508	17,955				17,955		29,926	29,926	11,971
2	-2,861	22,508	19,647				19,647		31,618	31,618	11,971
3	-1,084	22,508	21,424				21,424				21,424
⋮											
2010											