THE REPUBLIC OF TURKEY

FEASIBILITY STUDY ON ZAMANTI GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

SUMMARY REPORT

OCTOBER 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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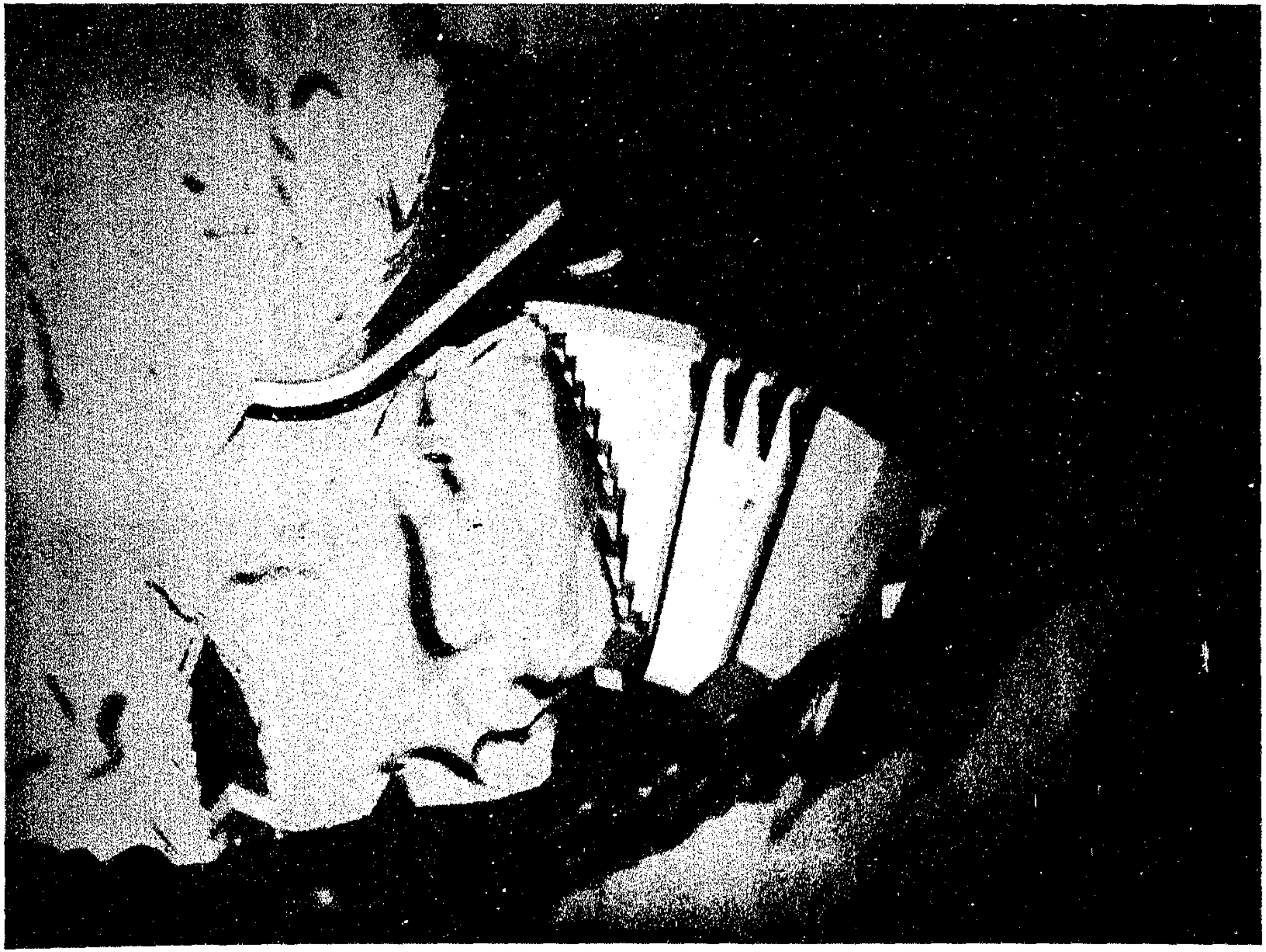
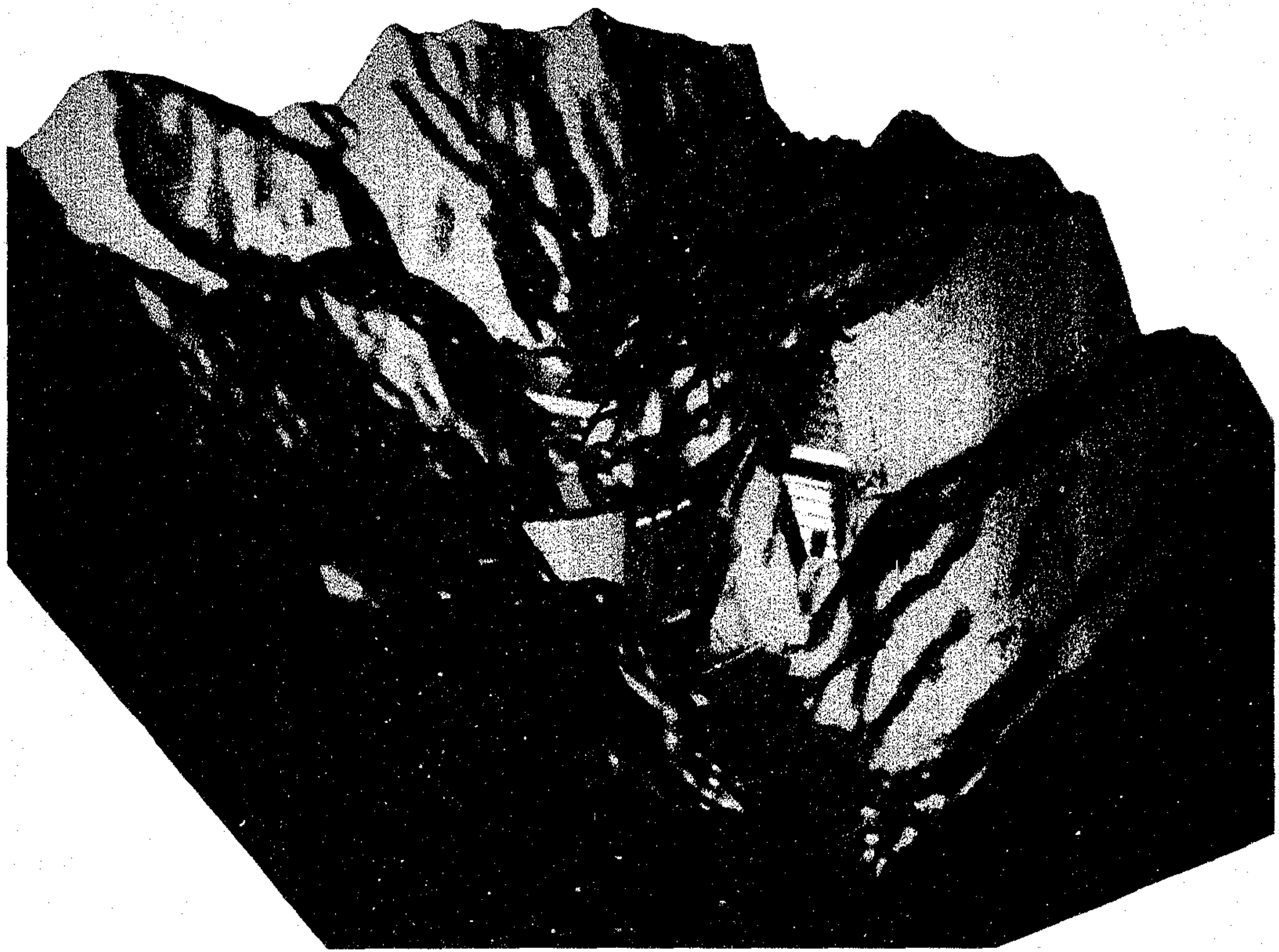
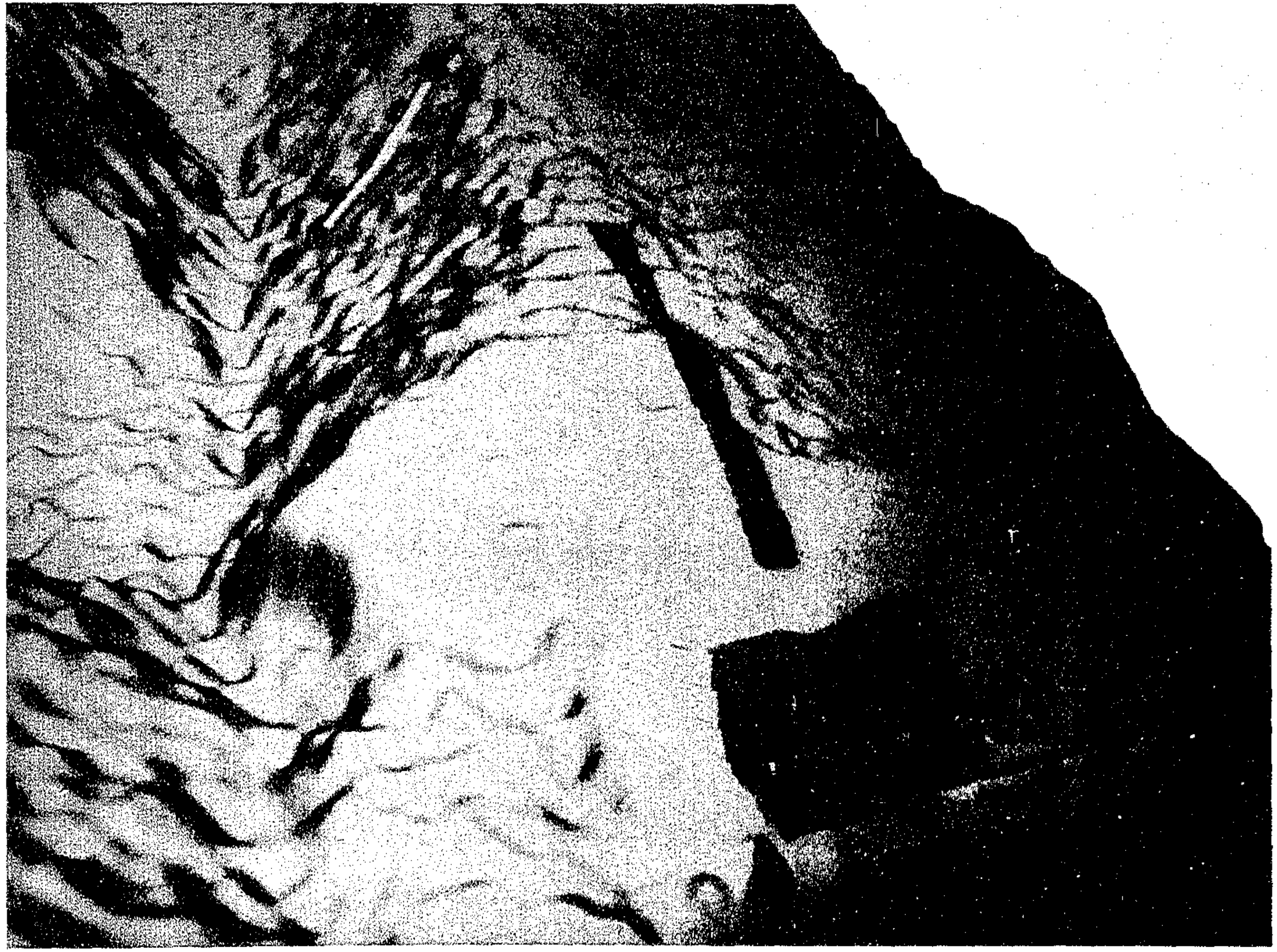


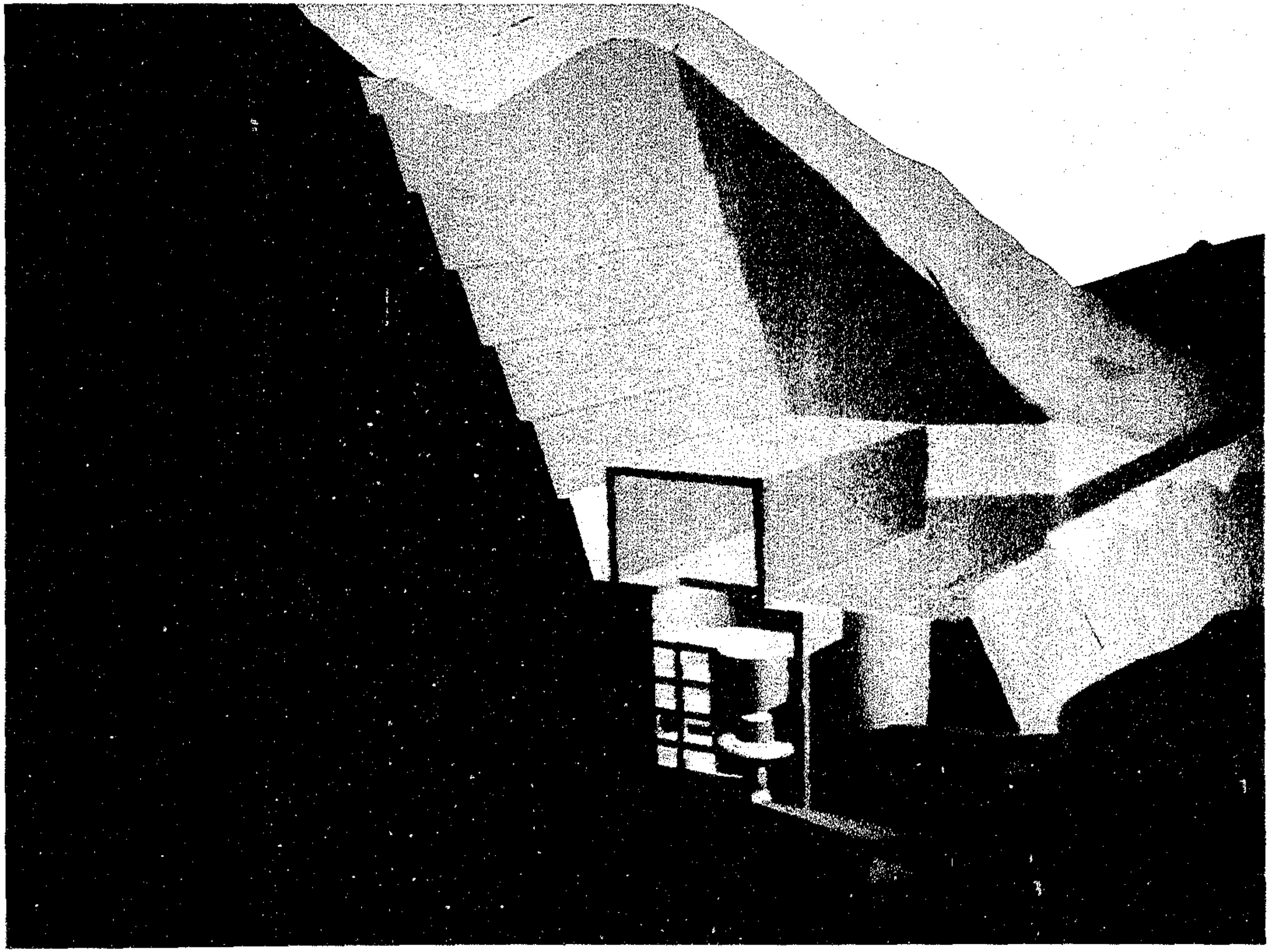
Downstream view of dam (Drawn with CAD)



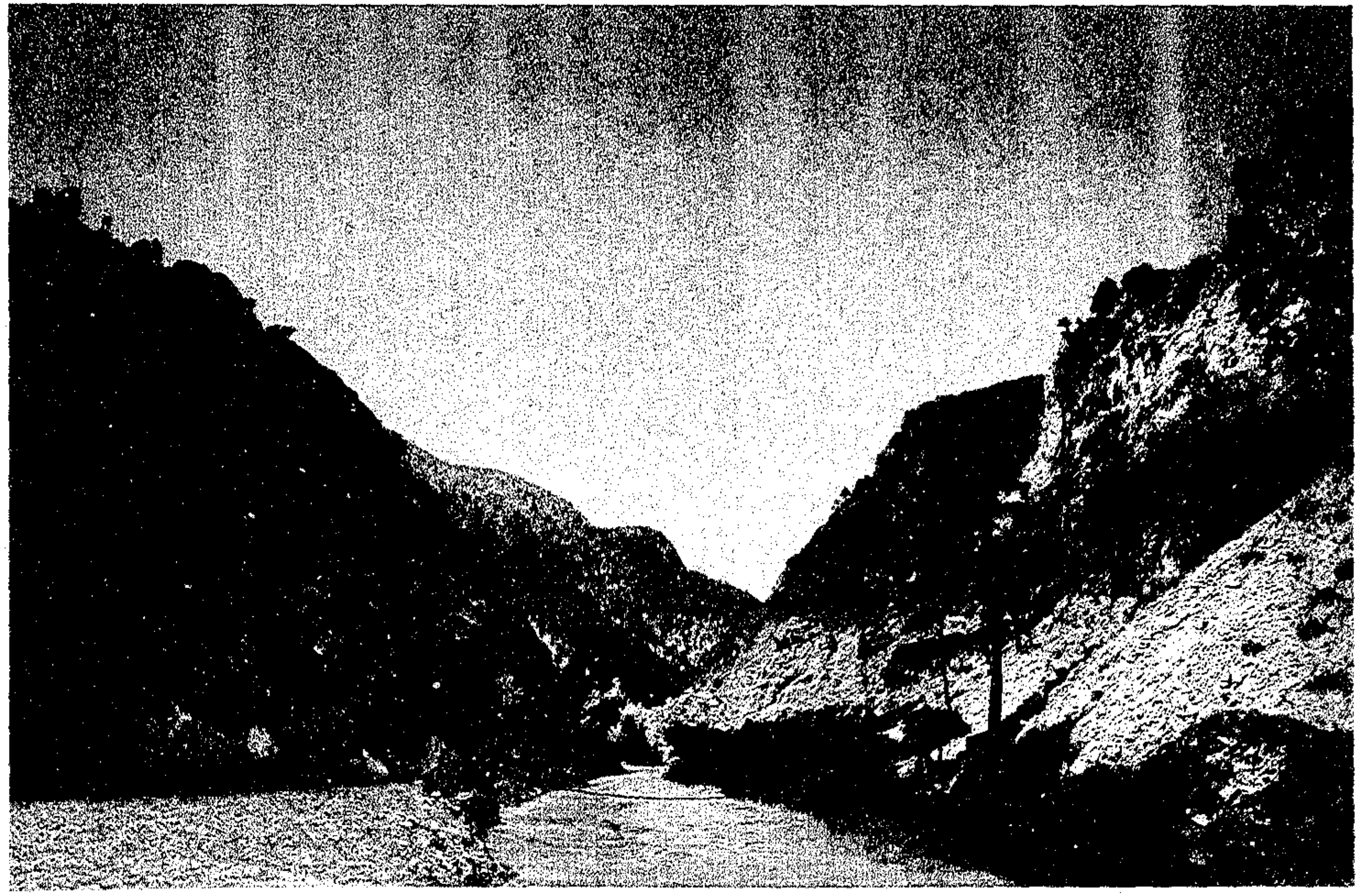
Upstream view of dam (Drawn with CAD)



Bird eye view of powerhouse [Drawn with CAD]



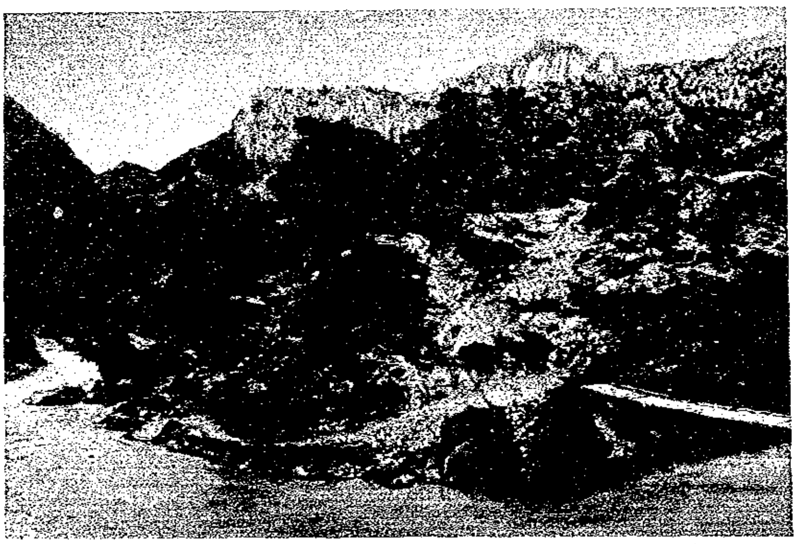
Transverse section of powerhouse (Drawn with CAD)



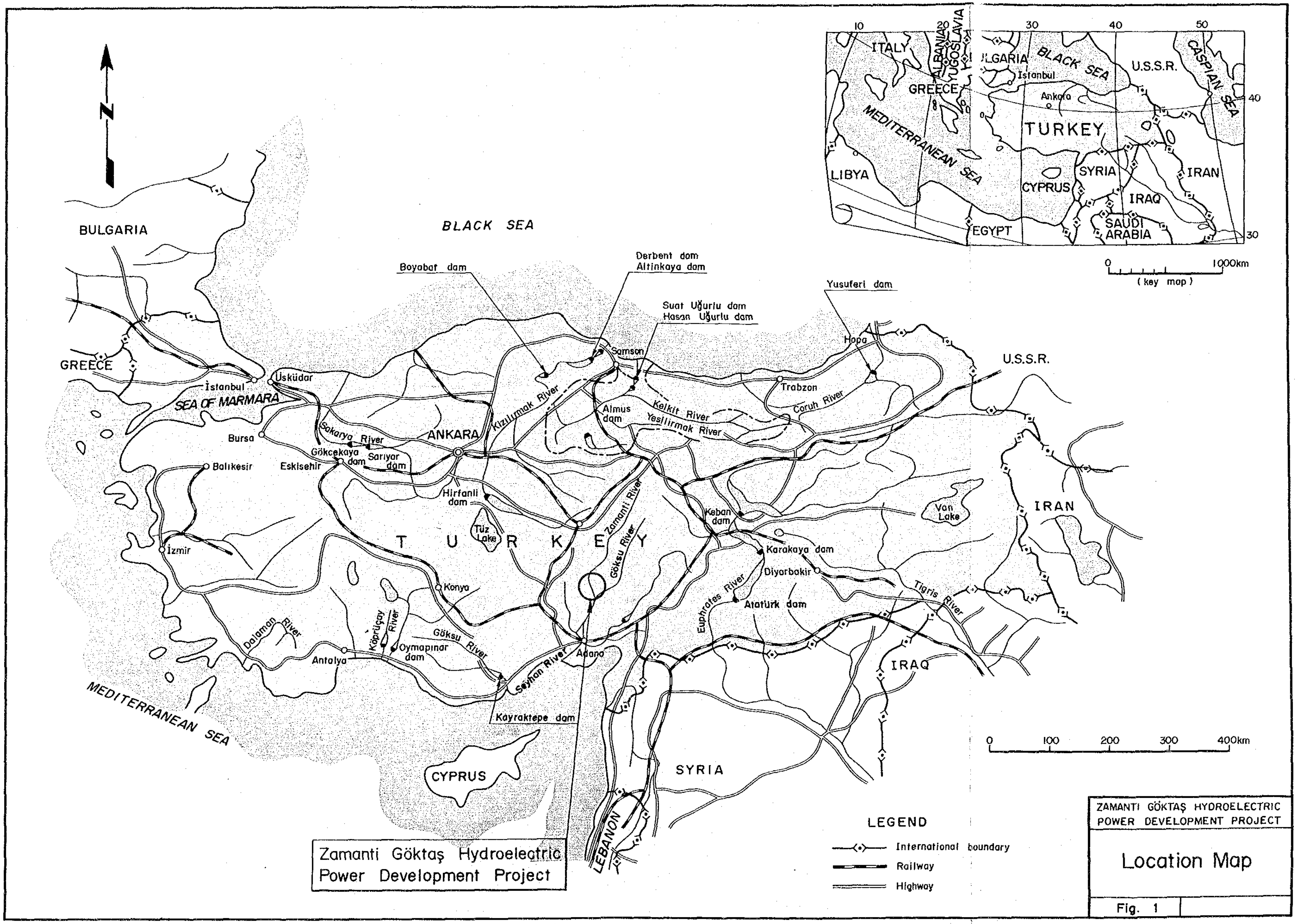
Göktaş Dam Site

—Looking from the Downstream Side—

Powerhouse Site



Quarry Site



ZAMANTI GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

Location Map

Fig. 1

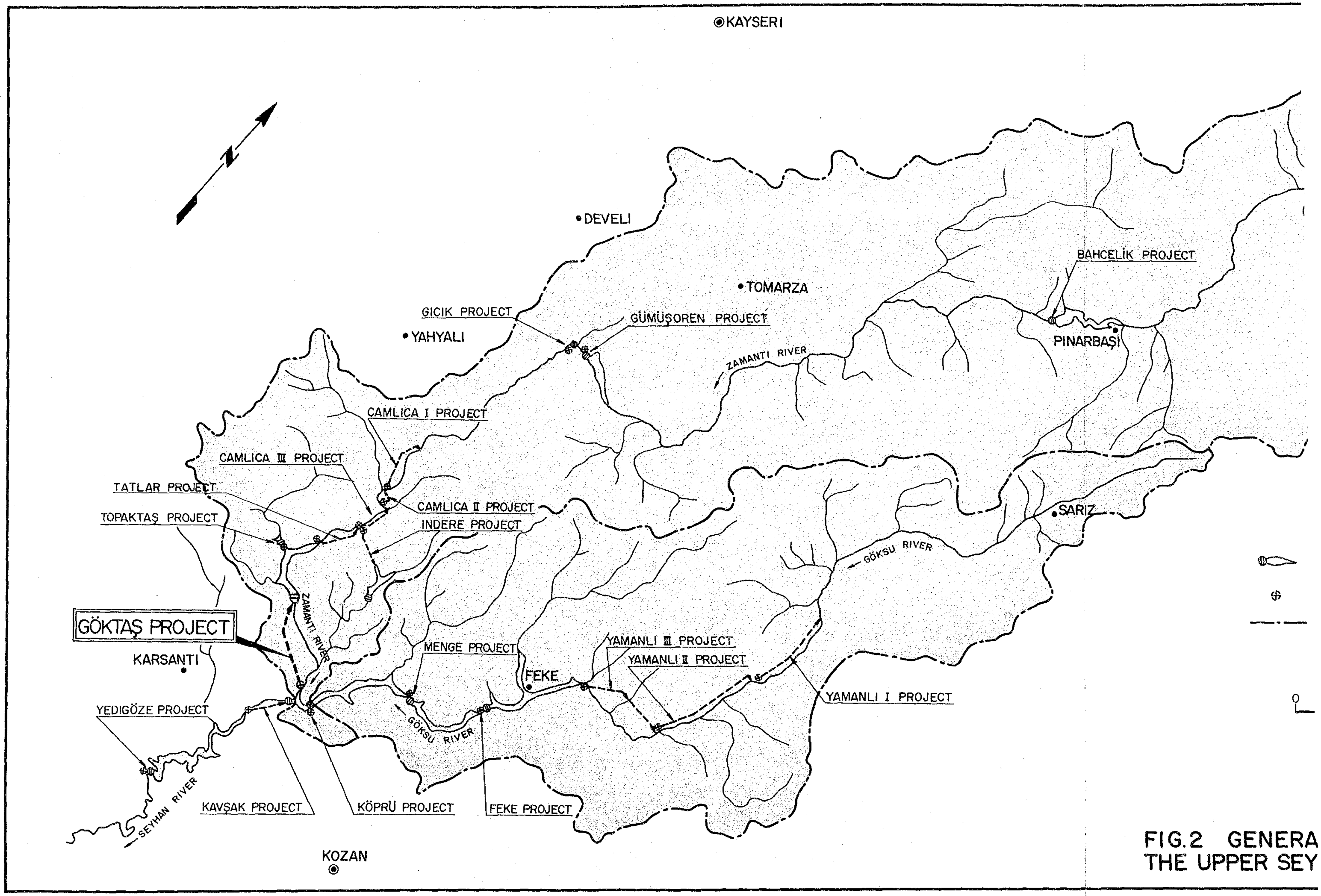


FIG.2 GENERA
THE UPPER SEY

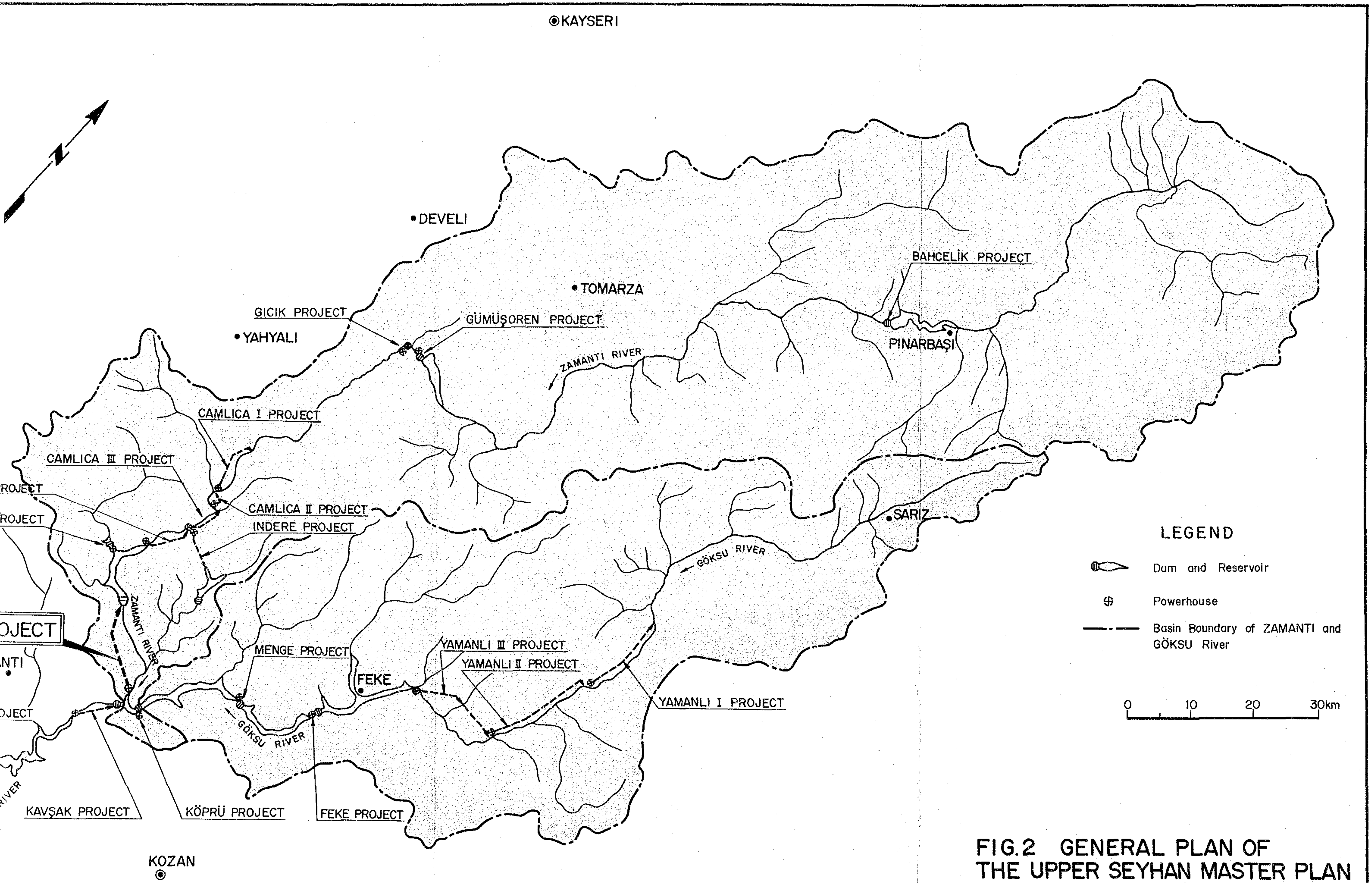
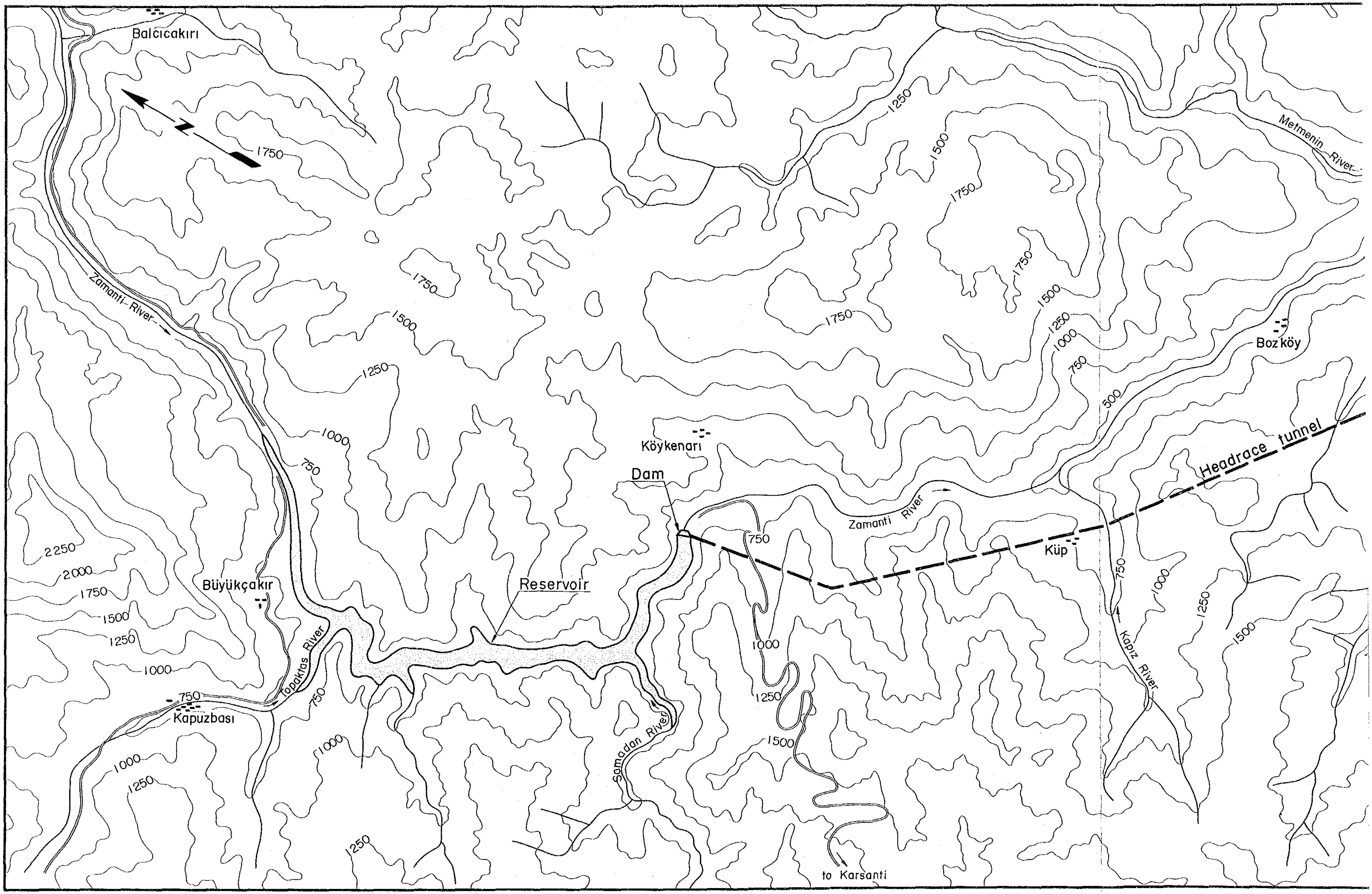


FIG.2 GENERAL PLAN OF THE UPPER SEYHAN MASTER PLAN



Balcicakırı
N
1750
Zamanti River
Metmenin River
1250
1500
1750
1750
1750
1500
1750
1500
1250
1000
750
500
Bozköy
1250
1000
750
Köykenarı
Dam
Headrace tunnel
Zamanti River
750
Küp
Reservoir
2250
2000
1750
1500
1250
1000
750
Büyükçakır
Topaktaş River
Kapuzbası
750
1000
1000
1250
1250
1000
1250
1500
Samadan River
750
1000
1250
1500
Kapız River
to Karsanti

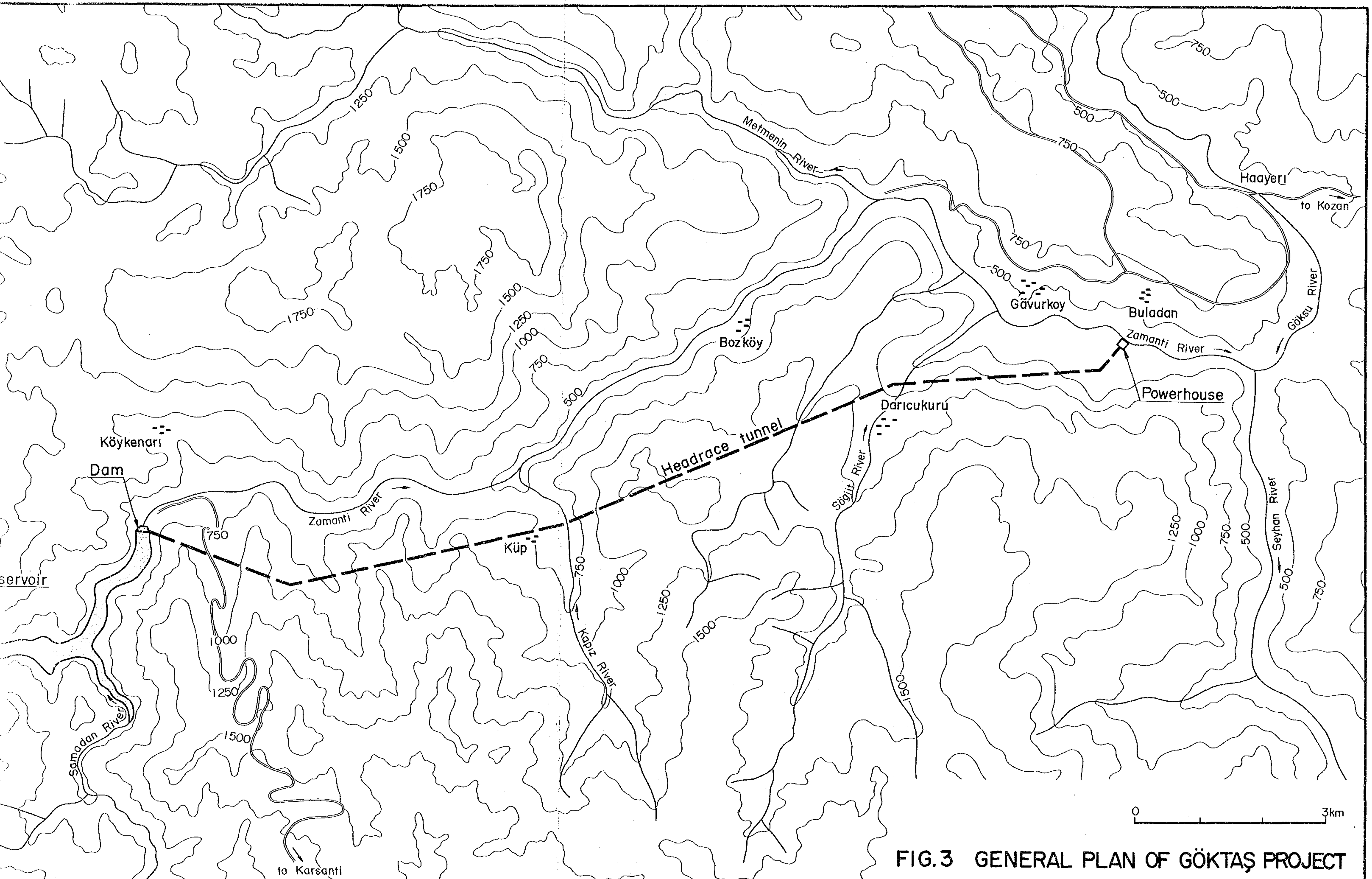


FIG.3 GENERAL PLAN OF GÖKTAŞ PROJECT

CONTENTS

1. INTRODUCTION

The efforts are being continued to achieve economic growth through industrialization by changing the industrial structure which had been based mainly on agriculture in the Republic of Turkey. Securing energy is an indispensable factor for this purpose, and with limited petroleum resources, the development of domestic energy resources has been given very high priority in order to achieve the established target of economic growth.

A growth rate in GNP of 8 percent was the target in the Fourth Five-Year Plan (1979-1983), but the result was far below it. In the current Fifth Five-Year Plan (1985-1989) which started in 1985, the target GNP growth rate is 6.3 percent. The growth rates in GNP from 1979 to 1987 and the growth rates in electric energy supply during those years are as shown below.

	1979	1980	1981	1982	1983	1984	1985	1986	1987
GNP (%)	-0.4	-1.1	4.1	4.6	3.2	5.9	5.1	8.1	7.4
Electric Energy supply growth (%)	5.5	4.5	6.8	7.7	4.4	12.5	9.3	11.3	11.0

This low growth rate in electric energy supply was due to the shortage of capital for investment in economic activity because of the second oil crisis which occurred in 1978 so that supply capability became insufficient in spite of the existence of latent demand, and this was manifested by the load shedding carried out from 1980 to 1983.

As an emergency measure against immediate electric power shortages, the Turkish Government imported from Bulgaria from 1975 to 1986, while since 1979 it has been importing from the Soviet, and since 1988 from Iraq. The quantity had been increasing yearly, and in 1984 it was 2,653 GWh, as much as 8.7 percent of the total energy production of 30,614 GWh. However, the quantity imported has decreased since 1985, it having been 572 GWh in 1987, approximately 1.3 percent of the total energy production of 45,000 GWh.

The installed electric power capacity of the Republic of Turkey in 1987 was 12,492 MW (5,003 MW hydro, 7,489 MW thermal).

As an outlook from a long-range point of view, the Turkish Government has predicted that it will be necessary to additionally construct capacity of 64,400 MW (annual average growth rate 8.0 percent) and electric energy of 343,000 GWh (annual average growth rate 8.6 percent) according to the demand forecast for the 22-year period from 1989 to 2010. Of this amount, it is proposed to develop approximately 27,000 MW and 99,000 GWh, respectively, of hydro power.

It was under such circumstances that the Turkish Government selected the Seyhan River for large-scale development of the next generation, and prepared a Lower Seyhan Basin Master Plan in 1981 and an Upper Seyhan Basin Master Plan in 1984 for an integrated development scheme for the River in anticipation of its development.

The Seyhan River has approximately 6 percent (1,850 MW) of the hydroelectric potential in the country. The river basin is surrounded by steep mountains, while the runoff is on the large side compared with other rivers in Turkey, and so the river is ideal for hydroelectric power development.

According to the Master Plan, the Goktas Hydroelectric Power Development Project planned on the Zamanti River, a major tributary of the Seyhan River, is promising as part of the Seyhan River Development Plan. The project site is at a short distance from Adana City in Adana Province. In recent years, the demand for electric power has increased in the southwestern part of Turkey with Adana City at the center, the demand which in 1987 was 1,700 GWh/yr expected to increase approximately tenfold to 17,750 GWh/yr in the year 2000.

Under such circumstances, in order for the Goktas Hydroelectric Power Development Project to be realized, the Government of Turkey requested the Government of Japan for technical cooperation to conduct a feasibility study of the Project. The Government of Japan, responding to the request, commissioned the Japan International Cooperation Agency in August 1987 to conduct the study, and a preliminary survey team headed by Mr. Masatake Kitajima of the Public Utilities Department, Agency of Natural Resources and Energy, Ministry of International Trade and Industry, was dispatched to Turkey for exchanges of opinions with the Government of Turkey and to carry out a general reconnaissance in the field.

Based on the results of the above, an agreement was reached in August 1987 between the General Directorate of State Hydraulic Works (DSI), the Republic of Turkey and the Japan International Cooperation Agency (JICA), under the title of "Scope of Works for the Feasibility Study on the Zamanti Goktas Hydroelectric Power Development Project in the Republic of Turkey".

The objective of the Study was to study and assess the feasibility in technical, economical and financial points of view, of the Zamanti Goktas Hydroelectric Power Development Project (hereinafter referred to as the Project) located in the lower reaches of the Zamanti River, the tributary of the Seyhan River which flows into the Mediterranean Sea through Adana City located southeastern part of Turkey, using the collected data and the result of field investigation. The study result was summarized as the Feasibility Report.

The study consists of three stages: Preliminary Investigation Stage, Detailed Investigations Stage, and Feasibility Design Stage. The preliminary investigations of the first stage may be divided into the three parts of preliminary preparations in Japan, field investigations and analysis work in Japan. In Turkey, field reconnaissances, data collection, and analyses and evaluations were done. In Japan, analysis work was performed and the basic concept of development of this Project formulated. The detailed investigation Program and technical specifications were prepared based on this basic development concept.

The detailed investigations of the second stage were carried out for making the feasibility design based on the results of the preliminary investigations and consisted of field investigations, analysis work in Japan, and field investigation works. The investigation work was carried out by the DSI, and consisted of topographical surveying, geological investigation works, and various tests.

The third stage consisted of feasibility design, cost estimating, and economic and financial evaluation based on the results of the preliminary and detailed investigations.

In October 1987, JICA began the work based on the beforementioned "Scope of Works." JICA next dispatched the following survey teams for field investigations concerning the Project.

November 14 - December 28, 1987:		First Preliminary Investigation
March 14 - March 28, 1988:		Second Preliminary Investigation
June 18 - July 17, 1988:		First Detailed Investigation
September 6 - November 4, 1988:		Second Detailed Investigation
March 18 - March 31, 1989:		Discussion of Interim Report
August 19 - September 2, 1989:		Discussion of Draft Final Report

During this time, the Survey Team submitted the following reports to the DSI.

November 1987:	Inception Report
March 1988:	First Progress Report, Detailed Investigation Program, and Technical Specifications
November 1988:	Second Progress Report
March 1989:	Interim Report
June 1989:	Third Progress Report
August 1989:	Draft Final Report

From April 1988 to December 1988, the DSI carried out field investigations and investigation works based on the abovementioned Detailed Investigation Program. The outlines of the field investigations and investigation works are as shown in Table 1-1.

This report is submitted by JICA, through the Ministry of Foreign Affairs of the Japanese Government, to the DSI of the Government of Turkey.

A brief summary of the results of the feasibility study is presented in the following part of this section.

Table 1-1 Investigation Works

Items		Description
Topographic Survey		
Powerplant Site	:	1/1,000 (3.68 km^2)
Area A	:	" (1.24 km^2)
Area B	:	" (2.44 km^2)
Geological Investigation and Material Tests		
Drilling Work and permeability Tests		
Dam Site	:	450 m
Powerplant Site	:	141 m
Tunnel Route	:	280 m
Exploratory Adits		
Dam Site	:	100 m
In-Situ Tests		
Dam Site		
Plate Bearing	:	7 Points
Rock Shear	:	8 Points
Seismic Prospecting		
Powerplant Site	:	865 m
Field/Laboratory Test for Material		
Quarry Site	:	8 Samples
River Deposit Sites	:	22 Samples
Social and Environmental Aspect		
Investigation for Compensation		

2. RESULTS OF EXAMINATIONS OF BASIC DATA

2.1 Features of the Project

The Zamanti Goktas Hydroelectric Power Development Project described in this Report consists of a power generation project including a dam, waterway, and powerhouse, and a transmission line construction from Goktas Power Station to the entrance of Adana Substation.

The Seyhan River has the two large tributaries of the Zamanti River and the Goksu River for a total catchment area of approximately 20,730 km^2 and a length of approximately 506 km, the annual average runoff being approximately 7,100 x 10^6 m^3.

There are as many as 20 projected development sites on the Seyhan River including this Goktas project site for a total output of 1,849.5 MW (including the existing Seyhan 54 MW, and Catalan 156 MW under construction).

Among these, there are nine projected development sites on the Zamanti River for a total output of 593.5 MW, the Goktas site being of the largest scale among these. This project site is located at the most downstream part of the Zamanti River, and it is looked forward to that development will be carried out at an early time.

There are three power plants planned downstream of this Project, while there is also one each of an existing power plant and a power plant under construction.

Consequently, runoff regulation to be achieved with this Project will make possible increased utilization efficiency of these five downstream power plant.

2.2 Rationale for the Development

The electric power generating facilities of the Republic of Turkey amount to 12,492 MW (44,353 GWh) with the ratio between hydroelectric power plants (5,003 MW) and thermal power plants (7,489 MW) being 40:60. Meanwhile, importation of electric power from the Soviet Union was started in 1979 and from Iraq in 1988, both of which are still going on today. On the other hand, imports from Bulgaria which were started in 1975 were terminated in 1986. Importation of electric power which recorded a peak of 2,653 GWh in 1984 has decreased since then, but the Turkish Government is planning to continue importing 1,600 GWh annually until 1996.

The power demands for the future (1989 - 2008) as forecast by Turkish Electricity Authority (TEK) and by the macroscopic method are as shown below.

	TEK Forecast		Macro Method Forecast	
	(GWh)	(MW)	(GWh)	(MW)
1989	57,925	9,250	56,520	9,249
1990	64,910	10,370	63,049	10,317
1995	105,930	17,060	95,981	15,934
2000	166,830	26,955	142,453	23,997
2005	231,530	37,700	205,663	35,161
2008	283,170	46,110	252,861	43,231

In order to cope with these power demands, Altinkaya Hydro (175 MW x 4 = 700 MW) started operation from 1987 to 1988, while Karakaya Hydro (300 MW x 6 = 1,800 MW) with its first unit having started operation in 1987 will continue with operation starts until 1989. Elbistan Thermal (4,200 MW), Ataturk Hydro (2,400 MW), and Catalan Hydro (156 MW) are under construction. Furthermore, Kayraktepe Hydro (420 MW), Ilisu Hydro (1,200 MW), Boyabat Hydro (510 MW), Birecik Hydro (670 MW), and Yedigoze Hydro (300 MW) are being prepared for start of construction in immediate years in the future.

Cukurova Electric Power Company is a private electric power sector supplying electric power to three provinces around Adana. The Cukurova Power System is interconnected with the power system of TEK and power shortages are being filled with purchases from TEK.

Since this Project will be located in the service area of Cukurova Electric Power, there is a high probability that the electricity produced will be allocated to meet the power demand of the Cukurova Region.

Considering the physical development schedule, it is thought the commissioning of the Goktas Hydro Power Plant will be achieved around the year 2000. This will be a time when the proportion of hydro among the power generating facilities of Turkey as a whole will temporarily decline. Consequently, it is desirable for the Goktas Hydro to be commissioned as early as possible in the 2000s. The development of the Goktas hydro will also contribute to economic development of the Region.

2.3 Meteorology and Hydrology

The basin of the Zamanti River in which the Goktas project site is located is divided into an area of Central Anatolian climate on the upstream side and an area of Mediterranean climate on the downstream side by the Toros Mountain Range cutting across the southern part of the basin, with most of the basin in the area of Central Anatolian climate. The characteristics of the respective areas are listed below:

- Central Anatolian Climate Area
  - Annual precipitation is low at about 400 mm.
  - The average elevation is high at 1,700 m with snow cover occurring in the winter.
  - The topography is comparatively gentle with gentle river gradients.

- Mediterranean Climate Area
  - The annual precipitation is fairly high at 800 to 1,200 mm to constitute an area of high precipitation. There are some places where ground water is seen springing from limestone distributed in the basin and a sharp increase in river discharge occurs.
  - The rainy season is from November to May while there is a fairly large amount of snowfall in January-February.
  - The topography is rugged as this area is on the southern slopes of the Toros Mountain Range and the river gradient is also steep.

According to discharge data of runoff gaging stations upstream and downstream of the Goktas dam site, the increase in discharge between the two gaging stations is larger than the amount of precipitation in the downstream catchment area of the Zamanti River. The reliability of discharge data was questioned because of this. However, the appropriateness of discharge data was confirmed by the results of hydrologic data analyses and runoff surveys made by the DSI and General Directorate of Electrical Power Resources Survey and Development Administration (EIE) in 1988. This increase in discharge is considered to be due to rain and snow falling inside and outside the basin supplied in the form of ground water through limestone veins with this water being discharged in the downstream basin of the Zamanti River.

The meteorological and hydrological quantities at the Goktas dam site obtained through analyses of meteorology and hydrology data are as follows:

∘ Temperature	:	Maximum 39.7°C Minimum -4.9°C Mean 15.3°C
∘ Annual evaporation from reservoir surface	:	767 mm
∘ Annual inflow	:	$1,704 \times 10^6$ m^3
∘ Annual average discharge	:	54 m^3/s
∘ Suspended Load	:	152 $ton/yr/km^2$
∘ Design sedimentation	:	$22,020 \times 10^3$ m^3/50 yr (in case of Gumusoren Dam existing upstream) $57,820 \times 10^3$ m^3/50 yr (in case of no dam upstream)
∘ 10-year return period flood	:	525 m^3/s (according to Gumbel distribution)
∘ Probable maximum flood (PMF)	:	3,900 m^3/s

2.4 Geology and Materials

(1) Geology

The site of the Goktas Project is mainly composed of Paleozoic sedimentary rocks such as sandstone and shale containing limestone, Mesozoic limestone, and also Mesozoic ophiolite (peridotite). The basement rocks of the various principal structures planned are roughly as listed below:

Uppermost reaches of reservoir	- Mesozoic limestone
Reservoir, dam	- Mesozoic ophiolite (peridotite)
Headrace tunnel	- Mesozoic ophiolite (peridotite) and limestone, paleozoic limestone, sandstone, shale, etc.
Powerhouse	- Paleozoic sandstone, shale, limestone, etc.

In the area of the reservoir (normal high water level 630 m), limestone is distributed close to the reservoir backwater level only above 610 m, with ophiolite (peridotite) widely distributed elsewhere. There is no landslide location in the reservoir area and it is judged there will be no problem about stability of the reservoir slopes. With regard to watertightness of the reservoir, even though there is distribution of limestone at the uppermost reaches, geological or hydrogeological data to indicate large amounts of leakage from this part have not been obtained as a result of surface reconnaissances and it is judged possible for water to be impounded up to EL. 630 m. For the sake of safety, however, it is thought necessary for supplementary investigations to be made such as drilling in the limestone distribution area and continuous measurements of groundwater levels utilizing drillholes.

The dam site is composed of ophiolite (peridotite), and although slight serpentinization can be observed along cracks, construction of an arch-gravity concrete dam of 150 m height class is recommendable.

As for the sites of other principal structures such as the headrace tunnel, penstock, and powerhouse, no geological defect that could be fatal to the Project is recognizable.

(2) Materials

For concrete aggregates, it is considered optimum to use crushed rock made from limestone widely distributed at the left bank of the Zamanti River approximately 1.5 km downstream from the dam site. This limestone possesses a suitable character for concrete aggregate in the aspects of both quality and quantity.

2.5 Results of In-situ Tests and Evaluations

(1) In-situ Rock Tests at Dam Site

(a) Plate Bearing Tests

Coefficients of deformation are 107,700 to 132,100 kgf/cm^2 for Class ⓑ rock with predominant distribution within the exploratory adits, and 39,900 to 103,000 kgf/cm^2 for Class ⓒ rock with slightly more cracking than Class ⓑ, to indicate that the bedrock has little deformability.

Tangential moduli of elasticity are 189,200 to 239,600 kgf/cm^2 for Class ⓑ rock and 57,500 to 167,700 kgf/cm^2 for Class ⓒ, which are very high moduli of elasticity, so that the characteristics are those of good, hard bedrock.

(b) Block Shear Tests

Although it was not possible for shear strengths to be measured directly for reasons of strengths of concrete blocks and loosening of bedrock, the following estimated shear strengths were obtained from the correlations of coefficients of deformation and moduli of elasticity with shear strengths:

	Internal Angle of Friction (ϕ)	Cohesion (C)
Class ⓑ rock	60°	50 kgf/cm^2
Class ⓒ rock	55°	40 kgf/cm^2

(2) Seismic Prospecting at Powerhouse Site

The following velocity layers were obtained by 3-traverse-line seismic prospecting (diffraction method) as elastic wave velocities (P waves) of the bedrock comprising the powerhouse site.

	Velocity (km/s)	Layer Thickness (m)	Estimated Geological Properties
1st Layer	0.35	0 - 5	Talus deposit
2nd Layer	(0.80)	0 - 5	Weathered rock
	(2.20)	23 - 50	Slightly weathered rock
3rd Layer	3.70	-	Fresh rock

2.6 Seismicity

The estimation of the maximum ground acceleration at Goktas site by probability analysis was performed to determine the design seismic coefficient. The seismicity data used in this study are those compiled by NOAA (National Oceanic and atmospheric Administration Environmental Data Service) and are 5,980 in number during the period 1901 - 1985.

The Zamanti Goktas Project site is located in the 4th degree zone, but near the 3rd degree zone delineated in the Seismic Risk Map for Turkey (IMAR ve ISKAN BAKANLIGI, 1972). The design seismic coefficient 0.10 can be applied for the Project.

However, it is necessary that the long return period expectancy should be checked, taking the uncertainties of the earthquake occurrence into account.

Therefore, 0.12 is to be adopted as the design seismic coefficient of Goktas site in the light of the probability analysis results.

2.7 Environmental Evaluations

Based on the field survey and literature study carried out by DSI for the natural and social environments of the Goktas project area and it's surroundings, the effects of the Goktas project on it's environments are qualitatively evaluated.

(1) Natural Environmental Conditions

There are no national parks, environment conservation areas, or wild life protection areas in the Project area. Therefore, all such protection areas are outside the project area and are not affected thereby.

° Natural Scenery

Most of the area around the reservoir is forest and remaining part is rocky abondoned land and small farm land. Most of the forest consists of the pine tree. River stream is rapid.

The existence of dam and reservoir seems to make a new natural scenery.

° Vegetation

Most of the forest around the reservoir is pine tree and there is no forest tree to be protected. Forest will be felled for setting up the Power Plant structure, but impacts can be reduced by utmost minimizing the felling forest area, tree planting after the construction, etc.

° Animals

Land animals that inhabit the reservoir area are boars, foxes, hawks, snakes, frogs and dragonflys, etc., but there is no rare animal to be designated for protection.

Aquatic animals that inhabit the reservoir area are trouts, carps and crabs, etc. However, there is no rare aquatic animal species conserved in the reservoir area.

° Water Quality

Major sources of impact on the water quality during construction are concrete plant, water discharging and excavation from the temporary plants such as spray plant, etc., water discharging from concrete production. Impacts of discharged water can be reduced by water treatment before discharging.

It is considered that frequency of water exchange in the reservoir after starting operation is very much and there is no remarkable contamination source coming into the flow. Therefore, there are no possibilities for changing water temperature, long term discharging of turbid water and entrophication.

Accordingly, creation of new environment for aquatic animals is expected by the existence of the reservoir.

◦ Noise and Air Pollution

Major sound and air pollution sources are construction equipment and trucks for transporting materials; but for enforcement of construction, these impacts can be reduced by using equipments of low noise type.

As there is little equipment generating sound and there is no equipment causing air pollution after starting operation, no impact is expected.

(2) Social Environmental Conditions

◦ Industrial Activities and Land Use

Total cultivated area submerged by the reservoir is 43 da (1,000 m^2/da), 29 da of which is farm land and 14 da vineyard.

For enforcement of the Project, it is desirable to deliberate fully with the persons concerned and to make optimum compensation.

There are only small commercial activities at the reservoir area, but it is expected that traffic will become busy and commerce will be in full activity during construction and after starting operation.

◦ Transportation and Public Facilities

New construction road is expected to be made along a river from the powerhouse to dam site, to transport main materials for construction. The existing road might be used under enforcement of the construction.

Although the traffic volume is temporarily expected to increase, there is no serious impact on the general traffic, as recent traffic volume is not so high.

There is no major public facility except a primary school in each village center around the reservoir. These primary schools are located far from the dam site and roads for construction.

There is no serious impact on public facilities under construction.

- Water Utilization

Water consumption in the surroundings of reservoir is not in question. There is no expected requirement for water consumption in surrounding areas in the future except the up-river part of the reservoir. There are three mills working with water power located at Kopuzbasi Springs. Two of them are between elevations 640 and 650 m, the other is at a higher elevation. These mills are releasing the water back to the bed after using it.

As shown above, there is no serious impact on recent water utilization for enforcement of the Project. It is expected to fish newly by existence of the reservoir.

- Cultural Assets and Recreational Facilities

There are no relics, cultural assets and recreational facilities around the reservoir area.

After starting operation, dam site, powerhouse and their surrounding areas are expected to be used for recreational facilities.

(3) Evaluation Results

According to evaluation results, there is no serious impact on natural and social environments, except impact on the people whose farm lands are submerged by the reservoir.

3. OUTLINE OF OPTIMUM DEVELOPMENT PLAN

3.1 Outline of the Project

An outline of the Goktas Project is as given below.

This Project is situated on the downstream part of the Zamanti River, a tributary of the Seyhan River. It is planned for a concrete arch-gravity dam 148 m in height and 800,000 m^3 in volume to be constructed at a point approximately 22 km upstream from the confluence with the Goksu River to obtain a gross storage capacity of 109.3 x 10^6 m^3 and effective storage capacity of 24.7 x 10^6 m^3. An annual average inflow of 1,704 x 10^6 m^3 is to be regulated by means of this reservoir.

A maximum available discharge of 108 m3/s is to be drawn from an intake provided at the right-bank side immediately upstream of the dam, this water being conducted to a powerhouse provided at the right bank through a headrace tunnel and penstock approximately 16.3 km in length to obtain a maximum output of 270 MW and annual energy production of 1,160 GWh. The electric power generated by Goktas Power Plant is to be sent to Yedigoze Substation via Akarca Substation by means of a 154-kV and 380-kV transmission line. The power is to be transmitted further from Yedigoze Substation to Adana Substation.

3.2 Construction Cost and Economic Evaluation

The construction cost of this Project will be 583,315 x 10^6 TL (US$448.7 x 10^6) and the period required for construction will be approximately 6 years.

The construction costs per kW and kWh at the generating end will be 2,084.4 x 10^3 TL (US$1,603.4) and 485.3 TL (US$0.37), respectively. Also, energy cost is 52.2 TL/kWh (0.04 $/kWh) (at the entrance of Yedigoze Substation).

The net present value (B - C) and benefit-cost ratio (B/C) of this Project in case of using an imported-coal thermal as the alternative power generating facility will be 227,476 x 10^6 TL (US$174.98 x 10^6) and 1.69, respectively.

The financial internal rate of return (FIRR) and the economic internal rate of return (EIRR) of the Project are 14.02 percent and 14.38 percent, respectively.

Summary of Zamanti Goktas Hydroelectric Power Development Project

Item	Unit	Description
Location	-	Zamanti River
Catchment Area	km^2	8,290
Annual Inflow	10^6 m^3	1,703.92
Design Flood	m^3/sec	3,900
Reservoir		
Normal High Water Level	m	630
Low Water Level	m	620
Available Drawdown	m	10
Sedimentation Level	m	607
Reservoir Area	km^2	2.67
Gross Storage Capacity	10^6 m^3	109
Effective Storage Capacity	10^6 m^3	25
Diversion Tunnel		
Diameter	m	6.8
Length	m	370
Design Flood	m^3/sec	530
Number	-	1
Dam		
Type	-	Concrete-arch gravity
Elevation of Crest	m	635
Height of Dam	m	148
Length of Crest	m	242
Volume of Dam	10^3 m^3	800

Item	Unit	Description
Spillway		
Type	-	Chute
Capacity	m^3/sec	3,900
Number of Gate	set	3
Size of Gate	m	14 x 13
Power Intake		
Type	-	Vertical shaft with gate
Number of Gates	set	Roller gate. 1.
Headrace Tunnel		
Type		Circle (Pressure)
Length	m	15,680
Diameter	m	6.8
Surge Tank		
Type	-	Lower Portion: Chamber Upper Portion: Overflow
Penstock		
Type	-	Lower Portion: Embedded Upper Portion: Exposed
Length	m	600
Diameter	m	6.8 - 2.6
Number	-	1 (2 bifurcated at end)
Powerhouse		
Type	-	Semi-underground
Size	m	∅22 m Depth 29 m

Item	Unit	Description
Power Generation Facilities		
Number of Units	unit	2
Unit Capacity	MW	135
Installed Capacity	MW	270
Turbine		
Number	unit	2
Type	-	Vertical Shaft Francis Turbine
Rated Intake Water Level	m	626.7
Rated Tail Water Level	m	321.8
Gross Head	m	304.9
Normal Effective Head	m	284.4
Maximum Discharge	m^3/sec/unit	54.0
Standard Output	MW	137.5
Revolving Speed	rpm	300
Generator		
Number of Units	unit	2
Type	-	AC 3-phase Synchronous Generator
Output	MVA	150
Voltage	kV	14.4
Power Factor	-	0.9 (lagging)
Frequency	Hz	50
Revolving Speed	rpm	300
Main Transformer		
Number of Units	unit	7 (including one set for spare use)

Item	Unit	Description
Type	-	Outdoor type single phase Transformer
Capacity	MVA	50
Voltage	kV	14.4 : 154 / 3
Switchyard		
Bus System	-	Main Bus and Transfer Bus
Normal Voltage	kV	154
Type of Circuit Breaker	-	Gas Circuit Breaker
Tie Transmission Line		
Section	-	Powerhouse - Switchyard
Number of Circuit	cct	2
Nominal Voltage	kV	154
Transmission Line		
Section	-	Switchyard to entrance of Yedigoze Substation
Number of Circuit and Nominal Voltage	cct x kV	3 x 154 and 1 x 380
Construction Period	years	6
Annual Energy Production		
Total Energy	GWh	1,159.7
Firm Energy	GWh	586.0
Secondary Energy	GWh	573.7
Project Cost		
Dam and Power Facility	10^6 T.L	562,788 (US\$432.9 x 10^6 \$)
Transmission Line (Goktas P.P to Yedigoze S.S)	"	20,527 (US\$15.8 x 10^6 \$)
Total	"	583,315 (US\$448.7 x 10^6 \$)

Item	Unit	Description	
Construction Cost at Sending End			
Per kW	10^3 T.L/kW	2,084.4	(1,603 US$/kW)
Per kWh	T.L/kWh	485.3	(0.37 US$/kWh)
Net Present Value (B-C)	10^6 T.L	227,476	(US$174.98 x 10^6)
Benefit Cost Ratio (B/C)	-	1.69	
Financial Internal Rate of Return (FIRR)	%	14.02	
Economic Internal Rate of Return (EIRR)	%	14.38	
Equalized Discount Rate (EDR)	%	23.82	
Exchange Rate		1 US$ = 1,300 T.L (as of June, 1988)	

4. CONSTRUCTION SCHEDULE AND CONSTRUCTION COST

4.1 Construction Schedule

Considering the year of commissioning of the Project as 2001 A.D., it will be necessary for preparations to start construction to be made roughly according to the schedule below.

Nov. 1987 - Oct. 1989	Feasibility Study (2 years)
Jan. 1990 - Dec. 1990	Provision and Award of Final Design (1 year)
Jan. 1991 - Dec. 1992	Final Design (2 years)
Jan. 1993 - Jun. 1994	Financing Formalities (1.5 years)
Jul. 1994 - Dec. 1995	Bidding and Award of Contract for Construction (1.5 years)
Jan. 1996	Start of Construction
- Dec. 2001	End of Construction

The construction work of the Project will require a period of approximately 6 years as a result of studying the scale of construction, layout of structures, preparatory works, etc. The work schedule of the Project is given in Fig. 5.

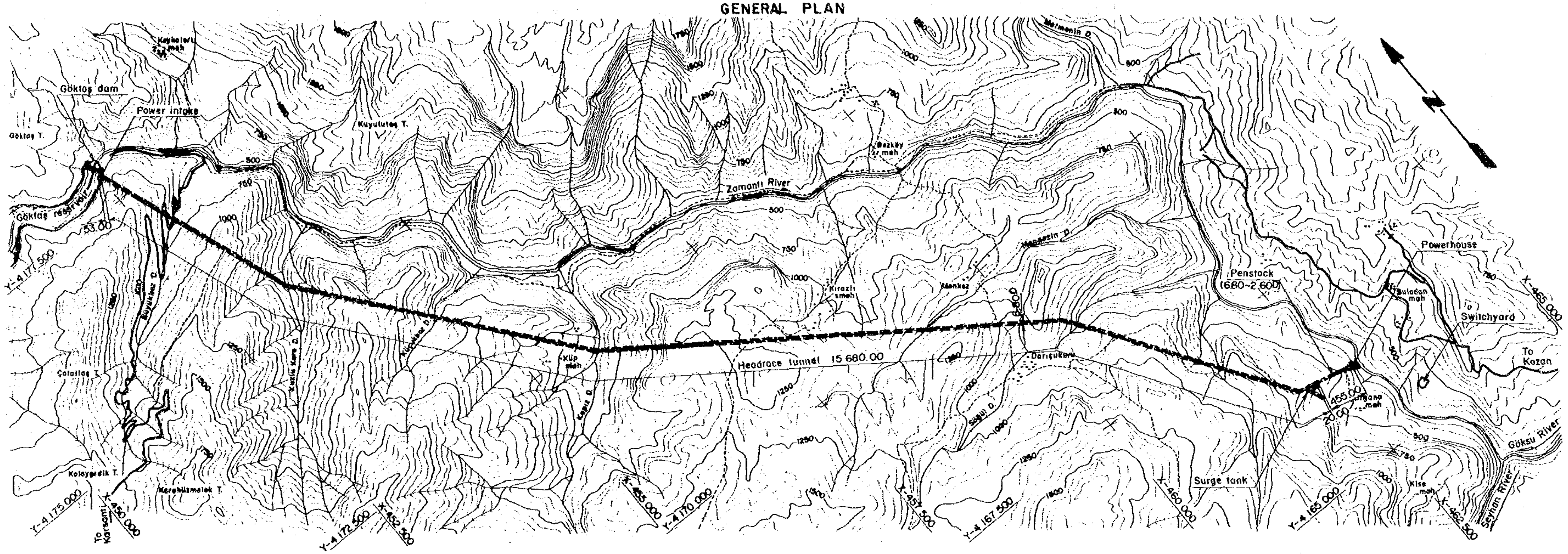
4.2 Construction Cost

It was assumed for the construction cost of the Project that designs and construction methods, and materials and products of the levels that can be expected at this time would be used. Furthermore, estimates were made giving consideration to geological conditions, topographical conditions, and project scale. The time of estimation was taken to be June 1988. (The exchange rate used was US$1.00 = 1,300 TL)

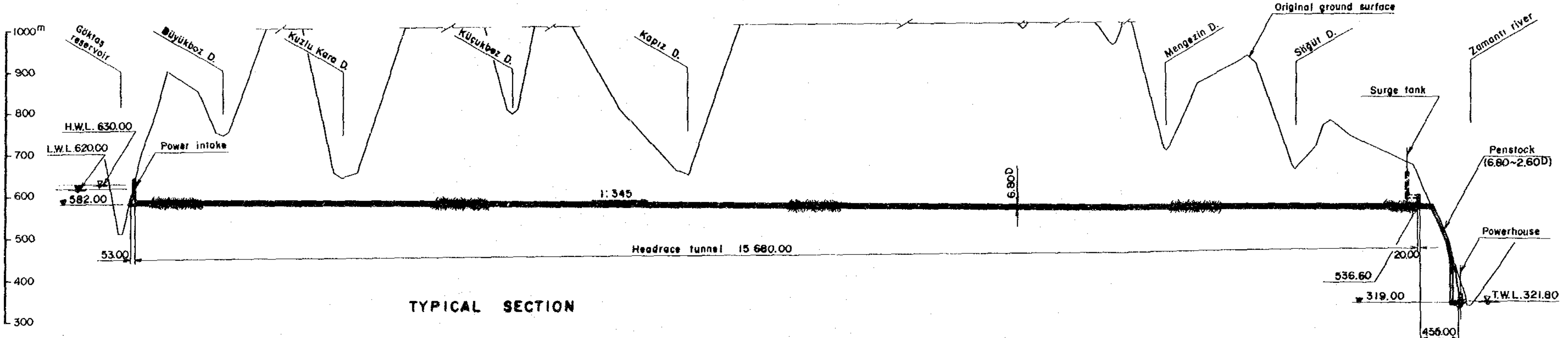
With the construction cost as 583,315 x 10^6 TL (US$448.7 x 10^6) the breakdown of local and foreign currency requirements is as follows:

Local currency : 329,458 x 10^6 TL (US$253.4 x 10^6)
Foreign currency: 253,857 x 10^6 TL (US$195.3 x 10^6)

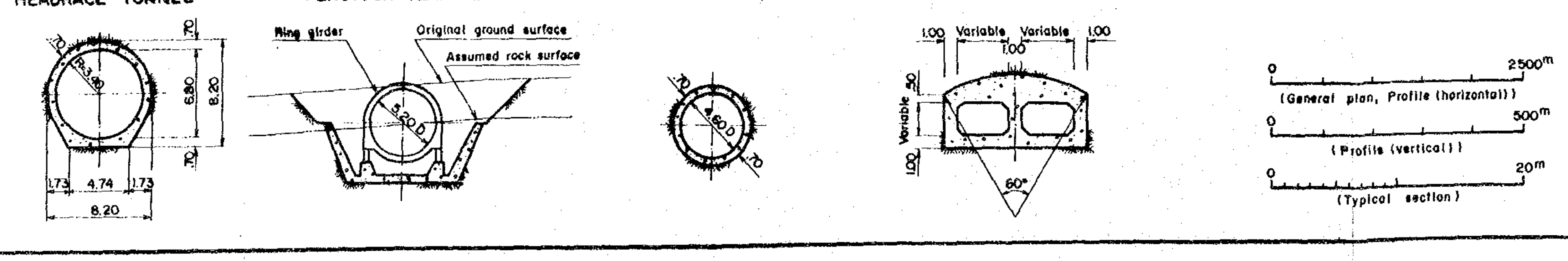
GENERAL PLAN



PROFILE



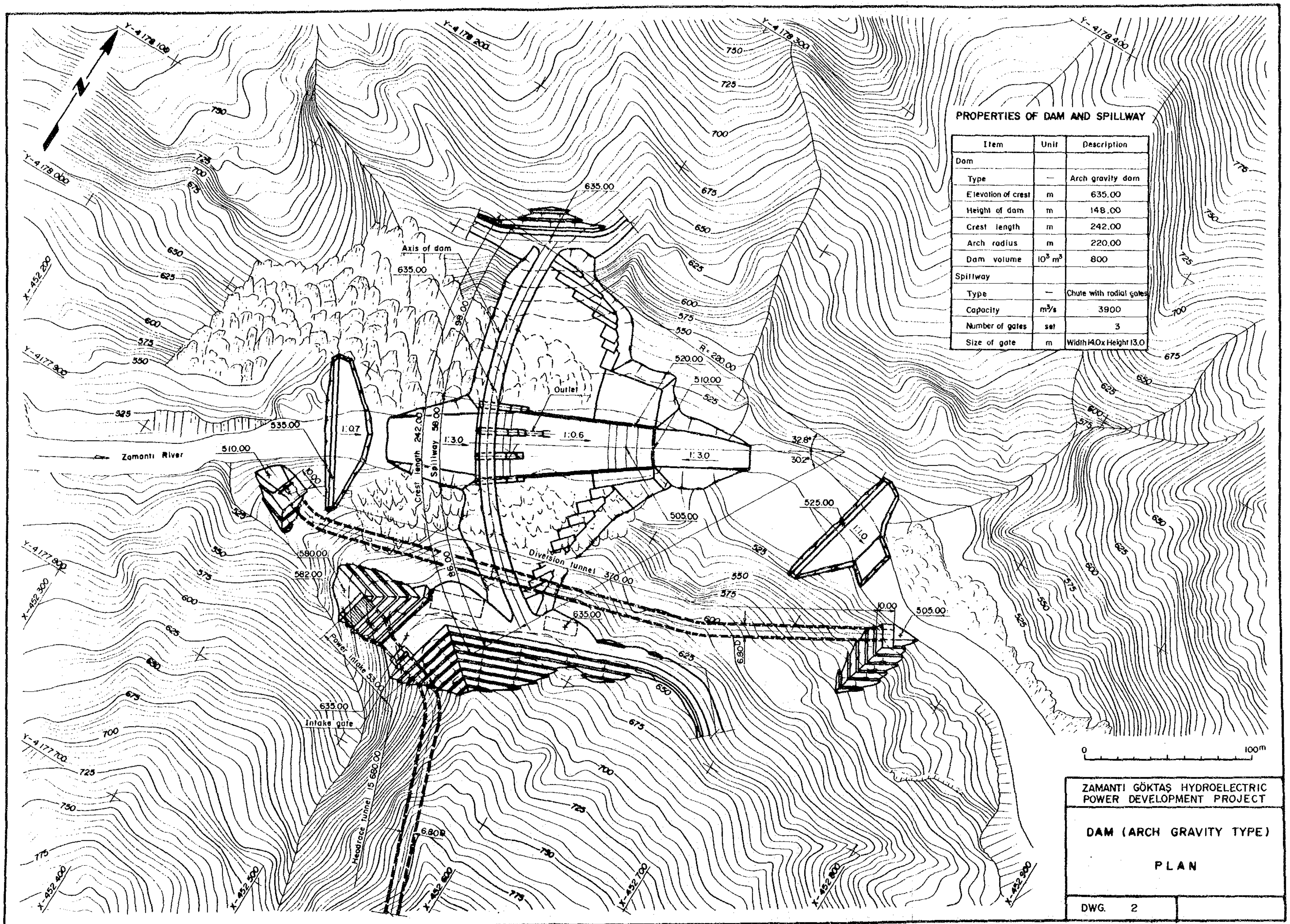
TYPICAL SECTION



ZAMANTI GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

GENERAL PLAN, PROFILE AND TYPICAL SECTION

DWG. 1



PROPERTIES OF DAM AND SPILLWAY

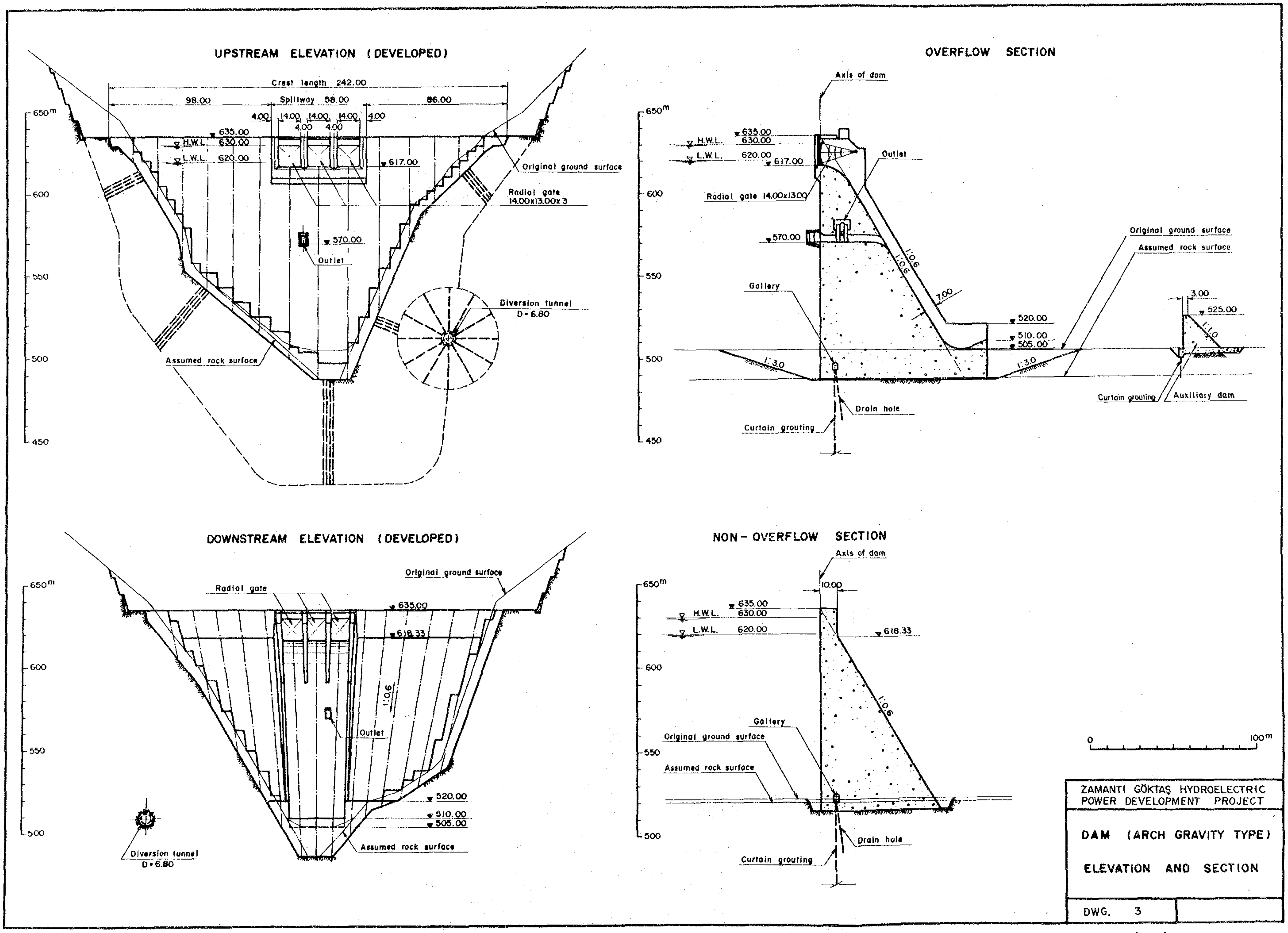
Item	Unit	Description
Dam		
Type	—	Arch gravity dam
Elevation of crest	m	635.00
Height of dam	m	148.00
Crest length	m	242.00
Arch radius	m	220.00
Dam volume	10^3 m^3	800
Spillway		
Type	—	Chute with radial gates
Capacity	m^3/s	3900
Number of gates	set	3
Size of gate	m	Width 14.0 x Height 13.0

ZAMANTI GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

DAM (ARCH GRAVITY TYPE)

PLAN

DWG. 2



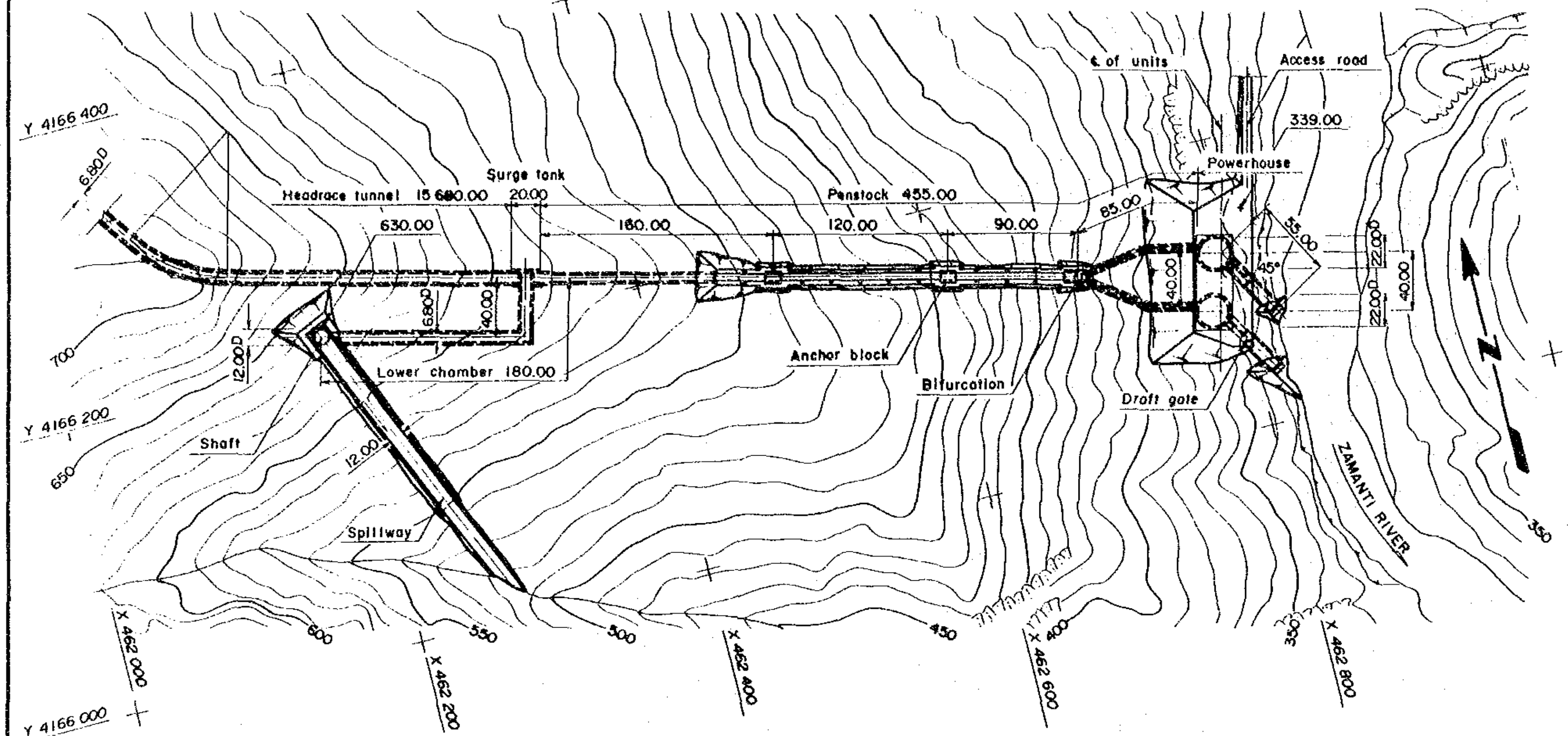
ZAMANTI GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

DAM (ARCH GRAVITY TYPE)

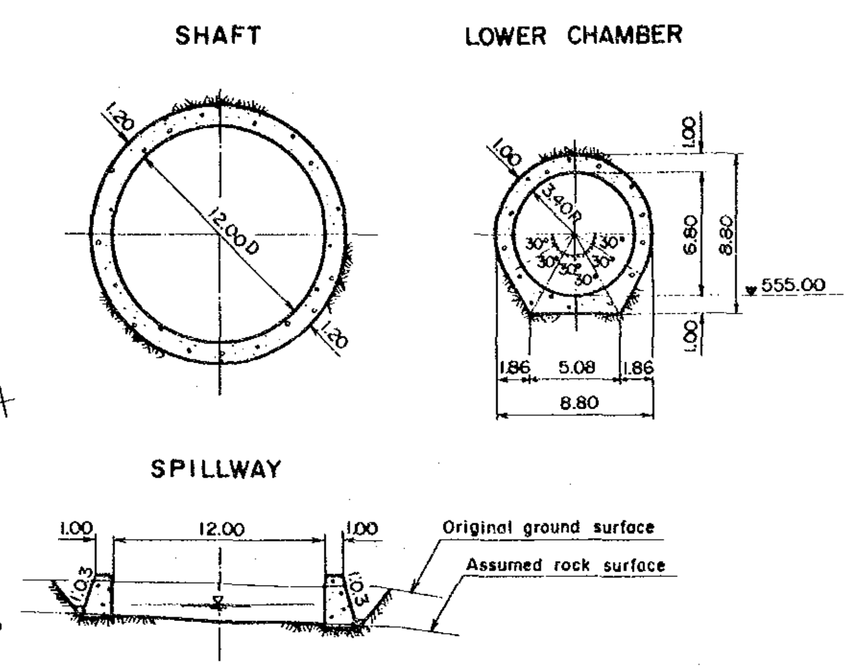
ELEVATION AND SECTION

DWG. 3

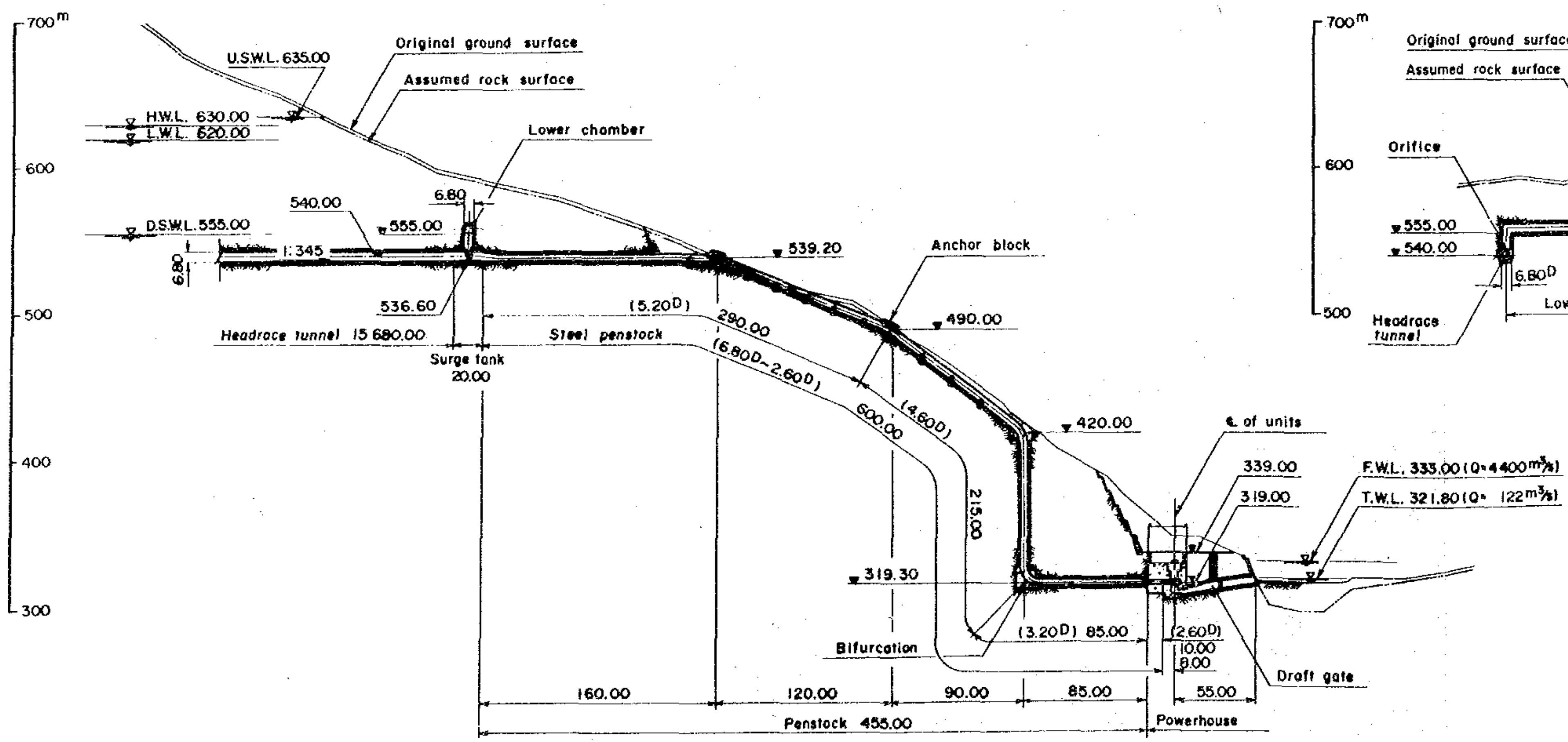
PLAN



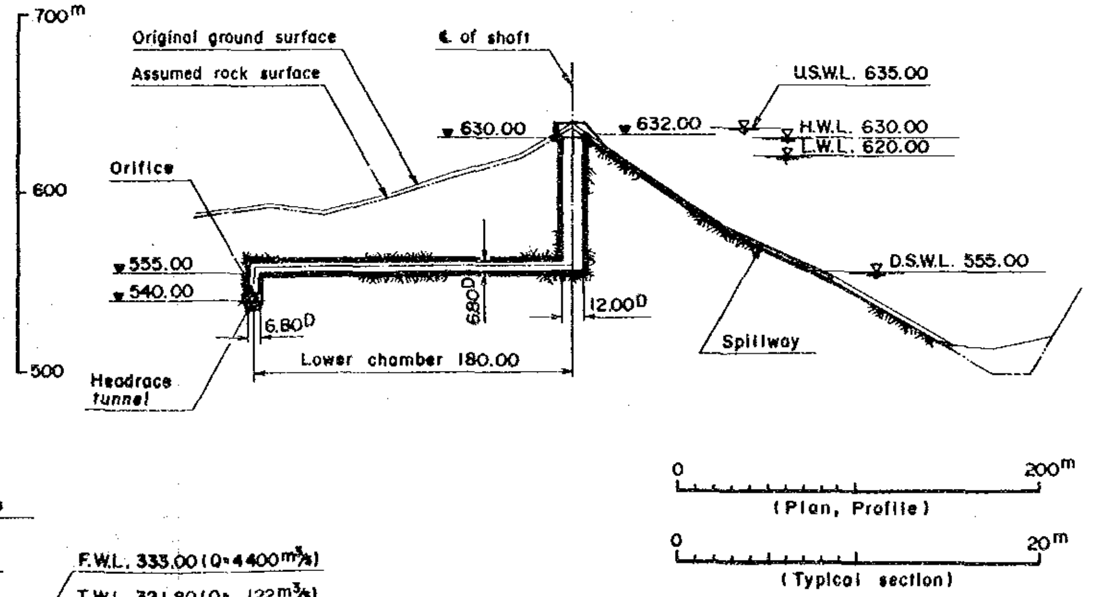
TYPICAL SECTION OF SURGE TANK



PROFILE OF PENSTOCK



PROFILE OF SURGE TANK

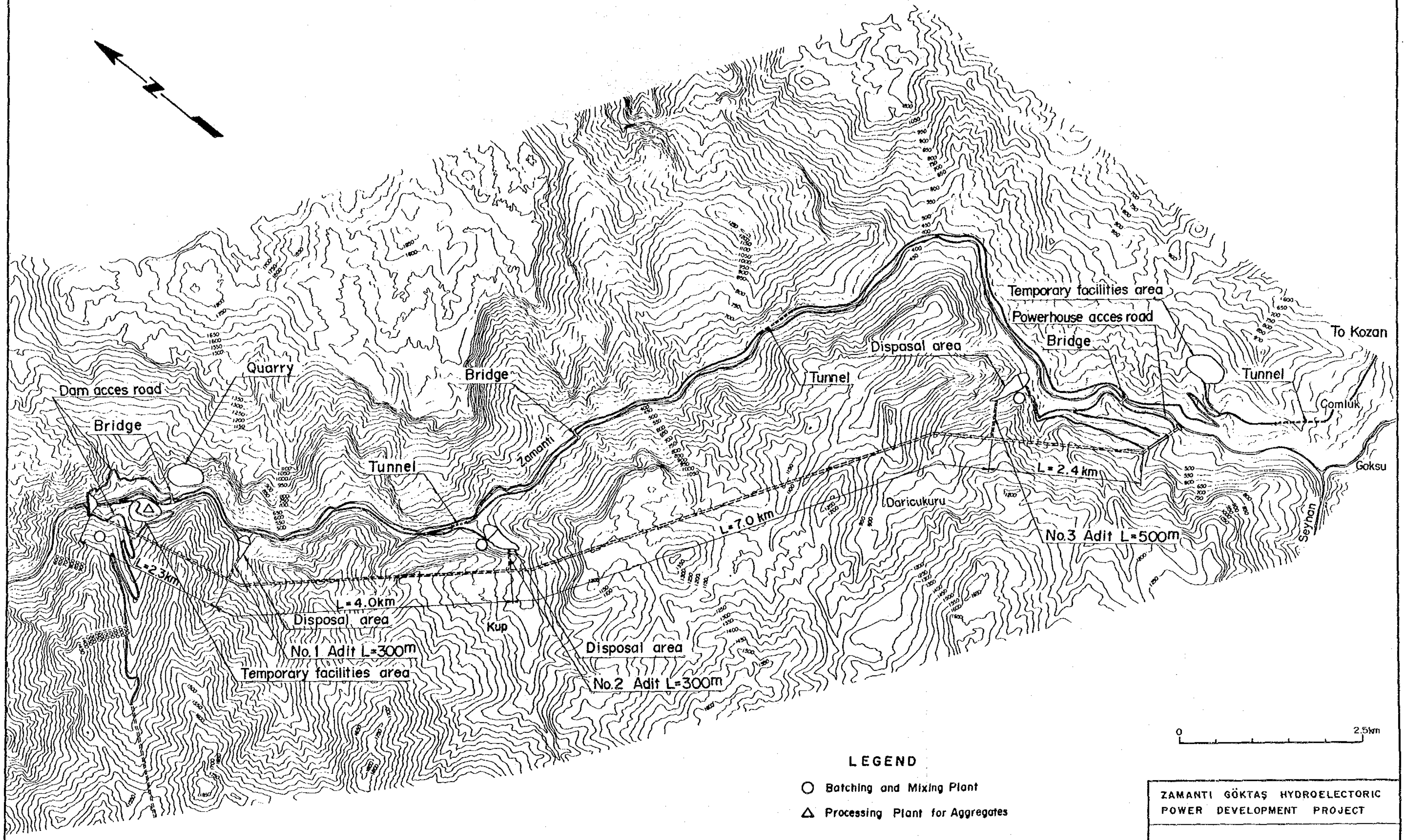


ZAMANTI GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

PENSTOCK AND SURGE TANK

PLAN, PROFILE AND TYPICAL SECTION

DWG. 4



LEGEND

○ Batching and Mixing Plant

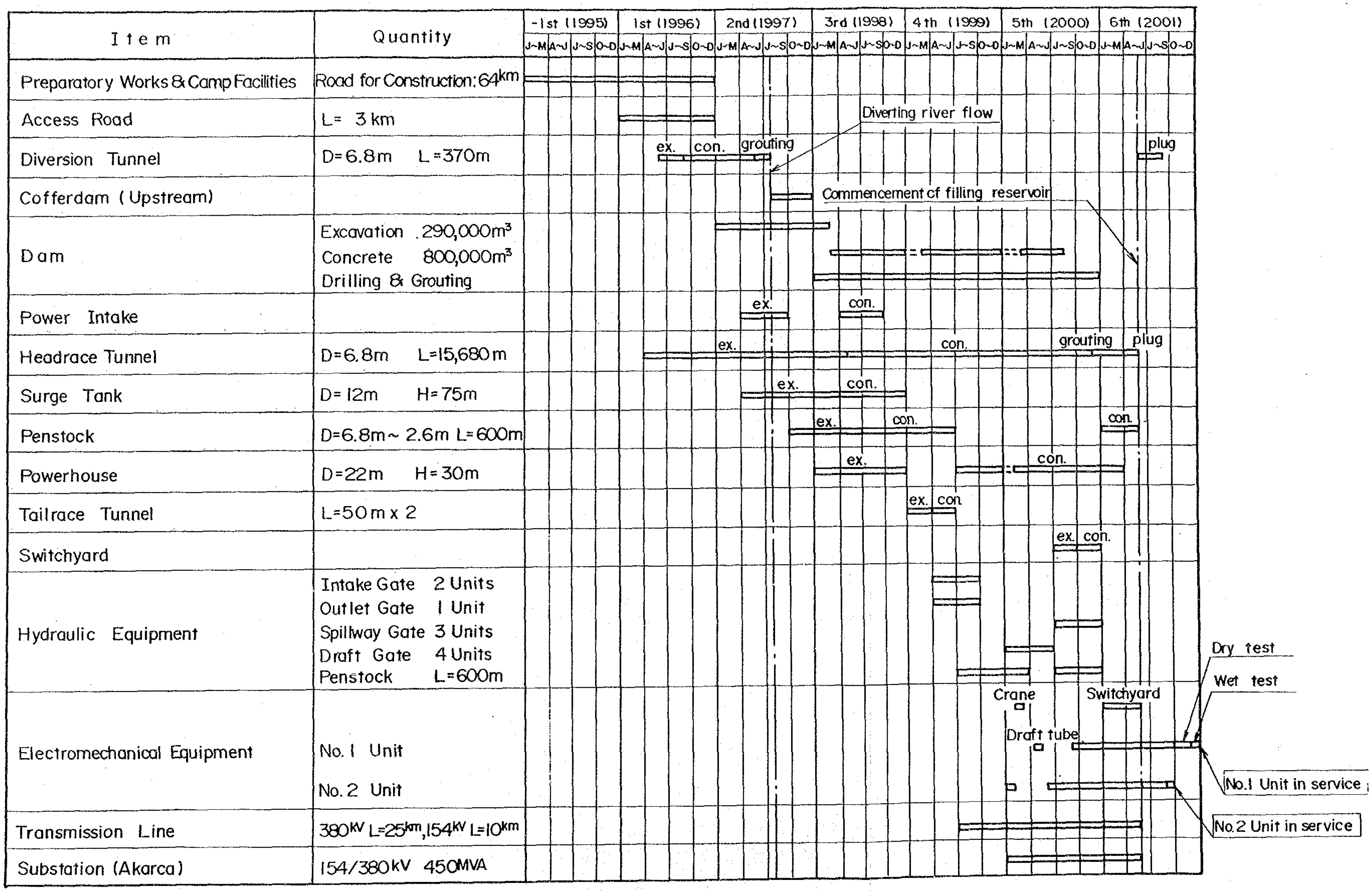
△ Processing Plant for Aggregates

ZAMANTI GÖKTAŞ HYDROELECTORIC POWER DEVELOPMENT PROJECT

LOCATION OF TEMPORARY FACILITIES

Fig. 4

Fig. 5 Construction Schedule



5. CONCLUSIONS

The Project is the Zamanti Goktas Hydroelectric Power Development Project to be constructed at the downstreammost part of the Zamanti River, a tributary of the Seyhan River in the southeastern part of the Republic of Turkey which empties into the Mediterranean Sea.

According to the results of studies based on data obtained up to the present time, it may be concluded that the Project is feasible from technical and economic points of view. The contents of the conclusions are described below.

(1) The objective of the Project is to construct a large-scale hydroelectric power plant effectively utilizing water power, which is one of the domestic resources of Turkey, to supply plentiful and stable electric power to satisfy demand.

By carrying out the Project, it will be possible also to contribute to the economic development of the region.

(2) The growth of power demand in the Republic of Turkey was blunted by scheduled load shedding from 1980 to around 1983 because of the insufficiency of power supply capability. However, a growth at the 12-percent level was indicated in 1984 as a result of increase in supply capacity and imports of electric power from foreign countries.

Since then, power demand had increased steadily every year and since 1986 double-digit growth rates have been recorded. The installed capacity as of 1987 was 12,493 MW (44,353 GWh, imports not included). The Turkish Government is presently proceeding with construction of large-scale power plants utilizing domestic resources.

According to the load forecast made by TEK under the Turkish Government using the MAED (Model of Analysis of the Energy Demand) Method, it is calculated that the demands will be 10,370 MW (64,910 GWh) in 1990, 26,955 MW (166,830 GWh) in 2000, and 52,730 MW (323,850 GWh) in 2010.

(3) Regarding the timing for commissioning of the Project in the national power system, it is judged reasonable for operation to be started

around the year 2000 considering the period required for further investigations, definite design, and construction.

(4) The Project is situated at the downstreammost part of the Zamanti River proposed in the Upper Seyhan Master Plan, the river gradient being steep and the river banks on both sides also steep in the area. Accordingly, the site characteristics are advantageous for dam-and-conduit type schemes combining medium-scale reservoirs and tunnels.

Two routes are conceivable for transportation from Adana to the dam site. One is a route starting from Adana and going through Imamoglu and the powerhouse site to reach the dam site going upstream along the Zamanti River. The other is a route from Adana which goes through Catalan and Karsanti to reach the dam site going over a pass of EL. 1,500 m. Studies were made of the two routes. On consideration of the economics, construction planning, and future maintenance and administration of the dam and the powerhouse will be more suitable.

(5) With regard to the development of the effective head from the Goktas dam site to the end of Kavsak Reservoir, the four alternatives of single-stage, two-stage, and three-stage (two proposals) were studied and the single-stage development which is the best in economics was selected as the basic development plan.

(6) For the high water level of Goktas Reservoir, comparison studies were made of the three cases of elevation 630 m, 620 m, and 610 m giving consideration to geology in the reservoir area, sedimentation, and effective storage capacity.

For the effective storage capacity, comparison studies were made of available drawdowns of 40 m, 30 m, 20 m, 10 m, and 0 m, a total of five cases.

As a result of these comparison studies, and taking into overall account the economic, topographic and geologic conditions, it was judged optimum for the reservoir high water level to be 630 m and available drawdown 10 m. The gross storage capacity and the effective storage capacity of the reservoir in this case will be 109.33 x 10^6 m^3 and 24.7 x 10^6 m^3, respectively.

(7) For the optimum scale of the Goktas Power Plant comparison studies were made of the three cases of peak durations of 6, 8, and 10 hours, and five cases of maximum power discharge varied between 81 m^3/s and 162 m^3/s. As a result of the studies, a maximum power discharge of 108 m^3/s and installed capacity of 270 MW (annual energy production: 1,160 GWh) will be the most advantageous.

(8) It is considered there will be no problem about the watertightness of the reservoir from the fact that ophiolite (peridotite) making up most of the reservoir area except for the upstreammost part of the reservoir are impermeable and groundwater levels are high. There is distribution of limestone at the end of the reservoir, upstream from the river-bed water level of EL. 610 m. For high water level of the reservoir at EL. 630 m, a maximum of 20 m in water depth and approximately 600 m in length will be a limestone distribution area. Signs that leakage would occur from the limestone distribution area of this part have not been discovered in surface geological explorations. However, for the sake of safety, it will be necessary for additional investigations to be made to confirm the watertightness of the upstreammost part of the reservoir.

(9) The geology of the Goktas dam site is composed of hard peridotite. There are small-scale faults at the surface layer, while cracks are developed and serpentinization can be seen to have occurred in parts, but all of these are discontinuous and would not extend deep underground.

The topography of the dam site is one of a V-shaped gorge with continuous steep slopes close to perpendicular, while the river width is narrow at only about 40 m.

(10) Regarding the type of Goktas Dam, a comprehensive study was made taking into consideration topography, geology, meteorology, availability of concrete aggregates, rock and soil materials, etc., and as a result it was judged that a concrete gravity dam or a concrete arch-gravity dam would be suitable. Since these two dam types were thought to be promising, feasibility designs were made of the two, and a comparison study was carried out. As a result of examination it was judged that a concrete arch-gravity type would be desirable

from economic and technical points of view. The height and volume of the dam selected were 148 m and 800,000 m^3, respectively.

The spillway would be located at roughly the middle of the dam body with three radial gates 14.0 m in width and 13.0 m in height installed.

(11) The intake is to be installed at the right-bank side approximately 100 m upstream from the dam and is to be a gated vertical shaft. The headrace tunnel route was selected to connect the intake site and the surge tank site by the shortest distance within limits of satisfying the condition that there would be adequate rock cover and work adits could be easily provided. The length and inside diameter of the headrace would be 15.7 km and 6.8 m, respectively. An overflow type was adopted for the surge tank. The penstock is to be a surface type at the upper part with the lower part below EL. 410 m an embedded type in consideration of constructibility and economy. The penstock would be 600 m in length with the end portion bifurcated.

(12) For the powerhouse type, a comparison study was made of a surface type and a semi-underground type taking into consideration topography, geology, workability, and economy. As a result of the study, a semi-underground type was selected. The number of main electro-mechanical equipment units is to be two with vertical-shaft Francis turbines (137.5 MW) and 3-phase alternating-current synchronous generators (150 MVA).

(13) The switchyard is to be provided at a terrace on the opposite bank from the powerhouse in consideration of topography and geology. The powerhouse and the switchyard are to be connected by a 154-kV x 2-cct tie tranmission line.

(14) The electric power generated at Goktas Power Plant is to be sent from Goktas Switchyard to Yedigoze Substation via Akarca Substation by means of a 154-kV and 380-kV transmission line (length approximately 35 km). The electric power is to be transmitted further from Yedigoze Substation to Adana Substation.

(15) Environments survey is qualitatively performed based on the limited field survey and collected materials.

According to evaluation results, there is no serious impact on natural and social environments, except impact on the people whose farm lands are submerged by the reservoir.

It is necessary to accomplish the Project successfully, lest the environment should be affected unexpectedly, and the fundamental living rights of the people concerned be violated by executing the Project.

Therefore, impacts on the natural environment during construction have to be reduced. In addition, it is desirable to perform optimum monitoring mainly for the water quality during construction and after starting operations.

(16) The initial investment required as of June 1988 will be 583,315 x 10^6 TL (US$448.7 x 10^6), the breakdown being as follows:

Dam, powerhouse and appurtenant facilities		
Local currency	320,872 x 10^6 TL	(US$246.8 x 10^6)
Foreign currency	241,916 x 10^6 TL	(US$186.1 x 10^6)
Subtotal	562,788 x 10^6 TL	(US$432.9 x 10^6)
Transmission line facilities		
Local currency	8,586 x 10^6 TL	(US$6.6 x 10^6)
Foreign currency	11,941 x 10^6 TL	(US$9.2 x 10^6)
Subtotal	20,527 x 10^6 TL	(US$15.8 x 10^6)
Total		
Local currency	329,458 x 10^6 TL	(US$253.4 x 10^6)
Foreign currency	253,857 x 10^6 TL	(US$195.3 x 10^6)
Total	583,315 x 10^6 TL	(US$448.7 x 10^6)

The construction costs per kW and kWh at the generating end for Goktas Power Plant are 2,084.4 x 10^3 TL (US$1,603.4) and 485.3 TL (US$0.37), respectively. The construction period for the Project was assumed to be 6 years.

(17) For the purpose of benefit-cost analysis, an imported-coal fired thermal power plant capable of substituting the Project was assumed,

and the costs compared. The result of the study indicated that the net present value (B - C) and the benefit cost ratio (B/C) are 227,476 x 10^6 TL (US$174.98 x 10^6) and 1.69 respectively.

(18) The financial soundness of the Project was evaluated by comparing the financial internal rate of return (FIRR) based on the market prices with the borrowing interest rate expected for the Project. The financial internal rate of return of the Project is 14.02%, exceeding the expected borrowing interest rate of 9.5%.

Next the economic internal rate of return (EIRR) was calculated by the modification market price (conversion to border price), which were obtained by modifying the market price used in the FIRR. Then this economic internal rate of return was compared to the opportunity cost of capital within the Republic of Turkey to evaluate the economic value of the Project. the economic internal rate of return of the Project is 14.38%, exceeding the capital opportunity cost in Turkey of 12%. Thus it can be concluded that the Project is feasible from both financial and economic points of view.

(19) The Project described above (hereafter referred to as "Basic Development Plan") was selected as the optimum plan from the viewpoint of the economics. Meanwhile, an alternative plan next best to this Basic Development Plan is described in Chapter 17, "Studies on Alternative Development Plans." The alternative Plan is for construction of Goktas Dam and Reservoir (the same as the Basic Development Plan) and three power Plants (total output 264.5 MW). This alternative, in contrast to the Basic Development Plan, makes it possible for individual power Plants to be developed in order from the upstream side in accordance with the amount of funds procurable, but the technical and economical condition will be inferior.

6. RECOMMENDATIONS

The Zamanti Goktas Hydroelectric Power Development Project is feasible both technically and economically, and it is recommended that the Project be implemented.

It is necessary for the following to be done in order to carry out the Project:

(1) Preparations required for construction such as definite design and composition of bid documents.

(2) Additional investigations and tests on the items cited in Chapter 16, "Further Investigations" of the Report in order to proceed with definite design, the results of the investigations to be thoroughly reflected in the definite design.

(3) Although adoption of the alternative plan in place of the Project (Basic Development Plan) is not desirable from an economic standpoint, in case of implementing the alternative, further field investigations and technical studies will be necessary before proceeding with definite design.

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