THE REPUBLIC OF TURKEY

FEASIBILITY STUDY ON OLTU RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT

SUMMARY

OCTOBER 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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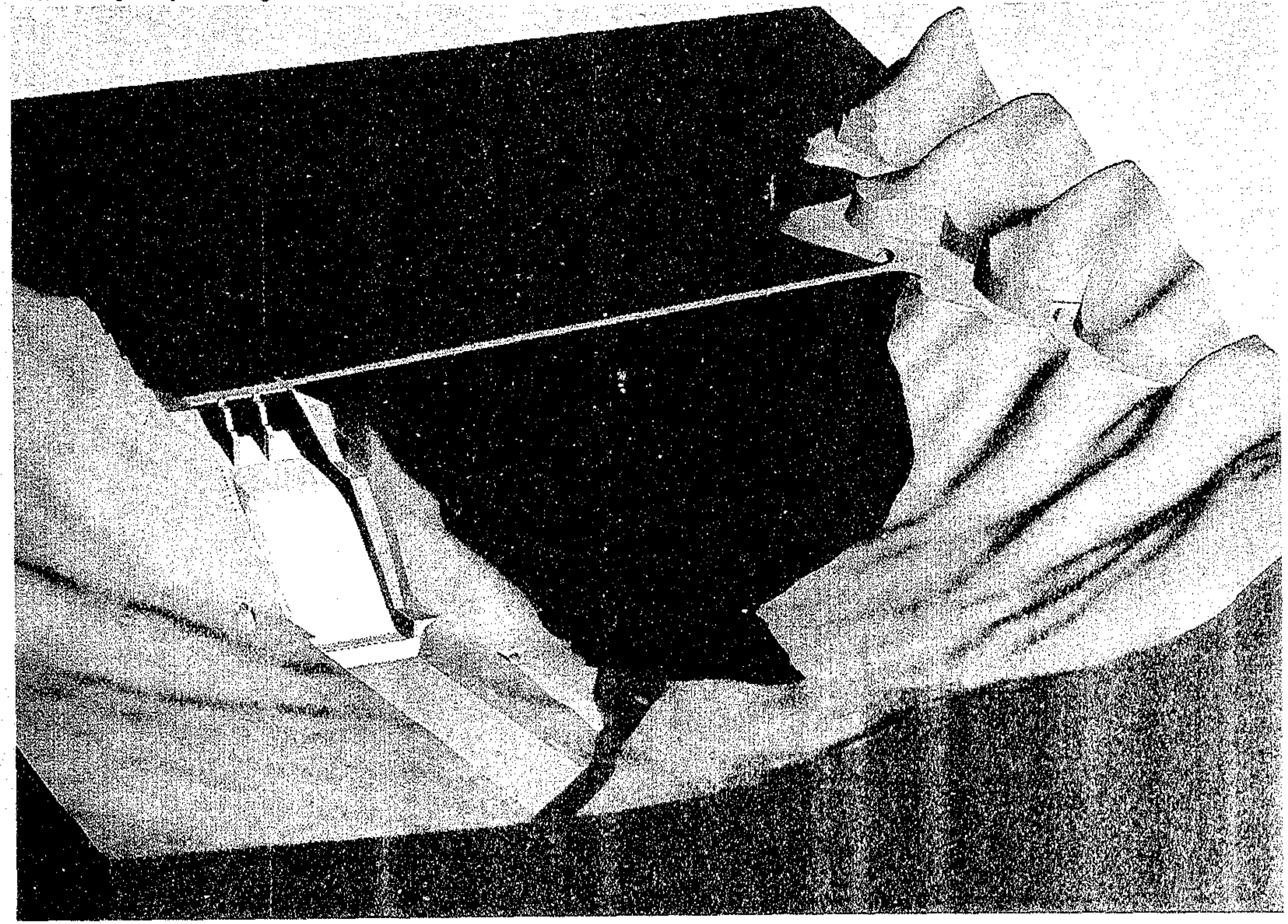
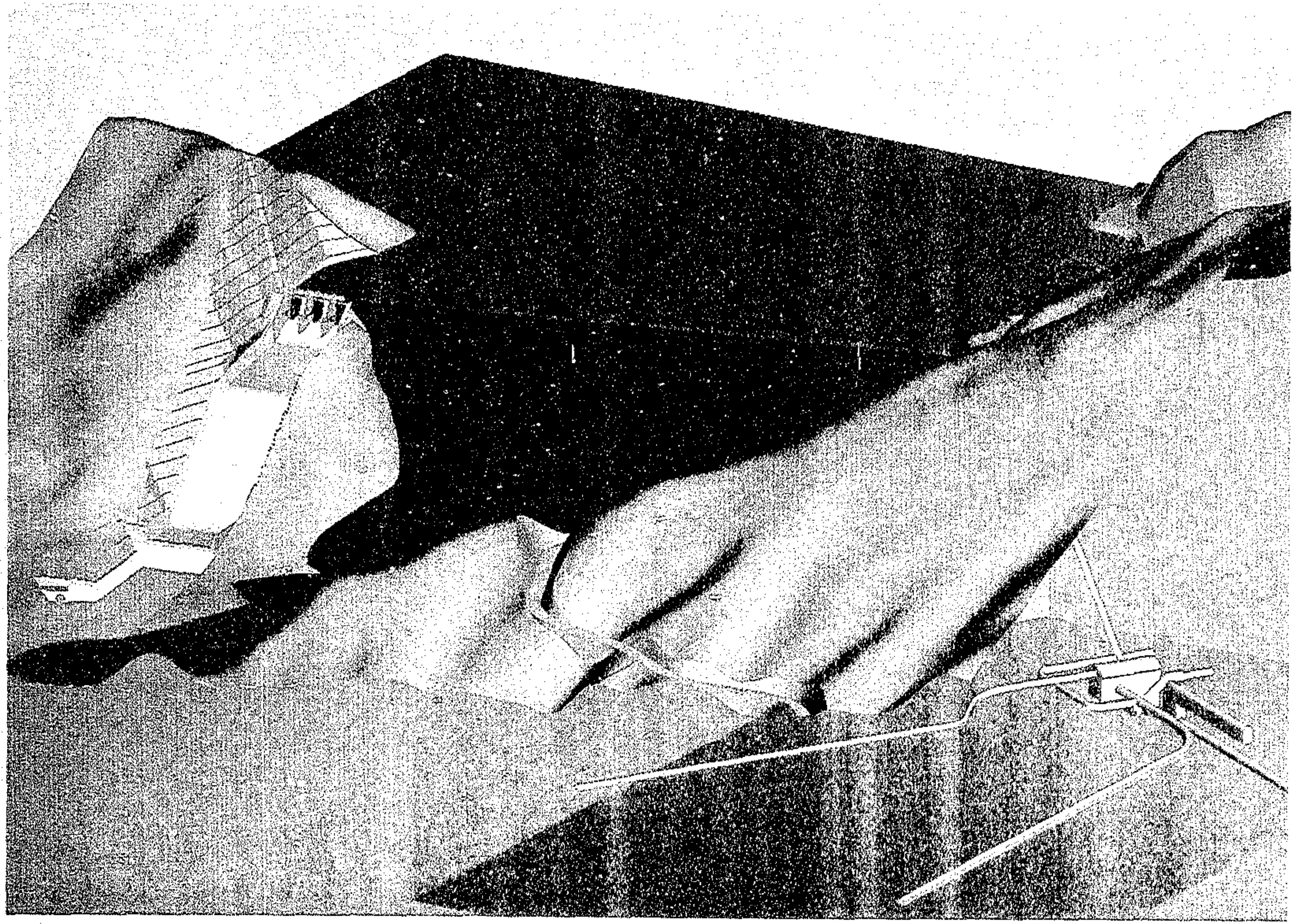
CADDS 4X Imagedesign Window

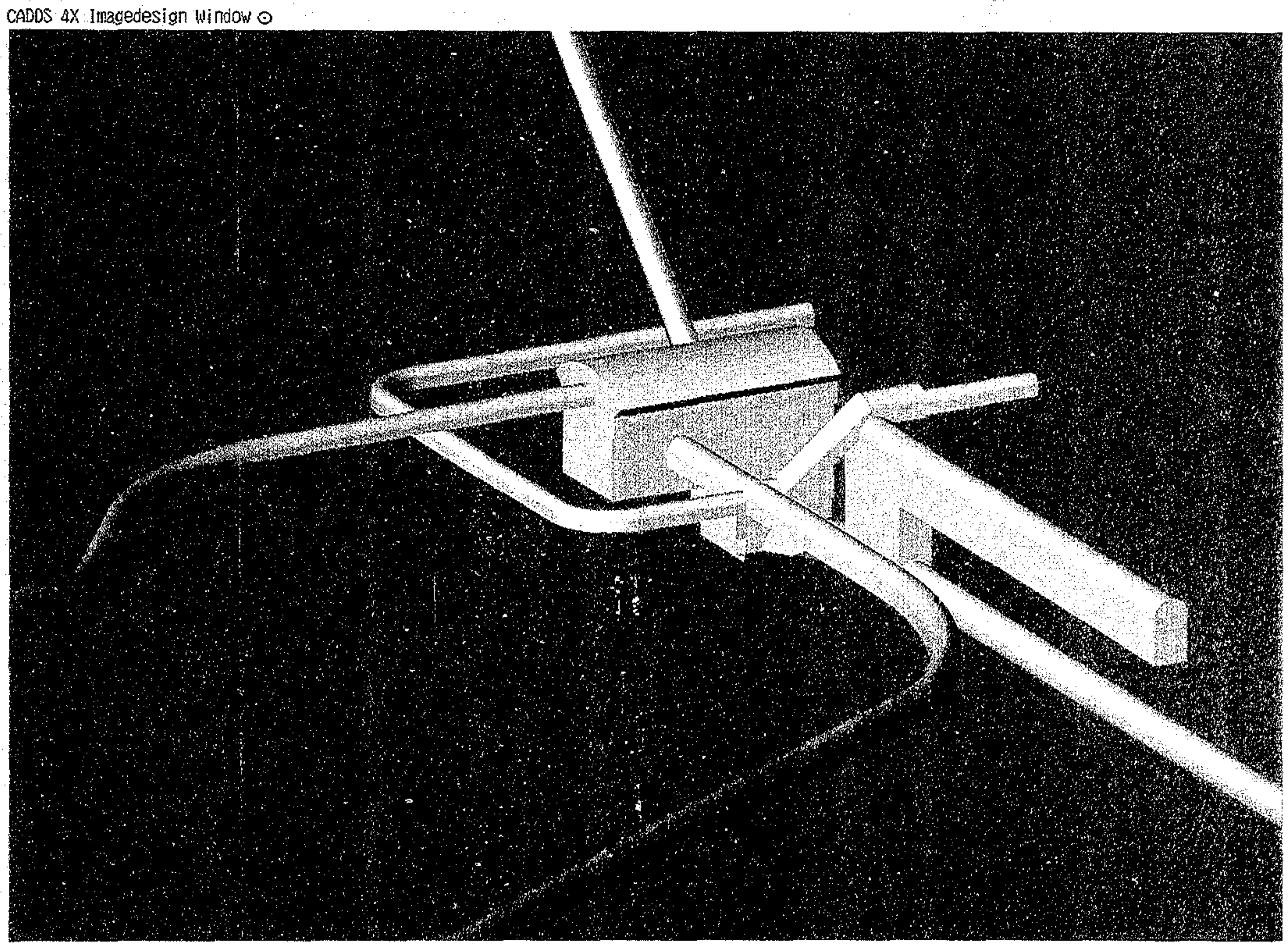


Bird Eye View of Olur Dam (Drawn with CAD)

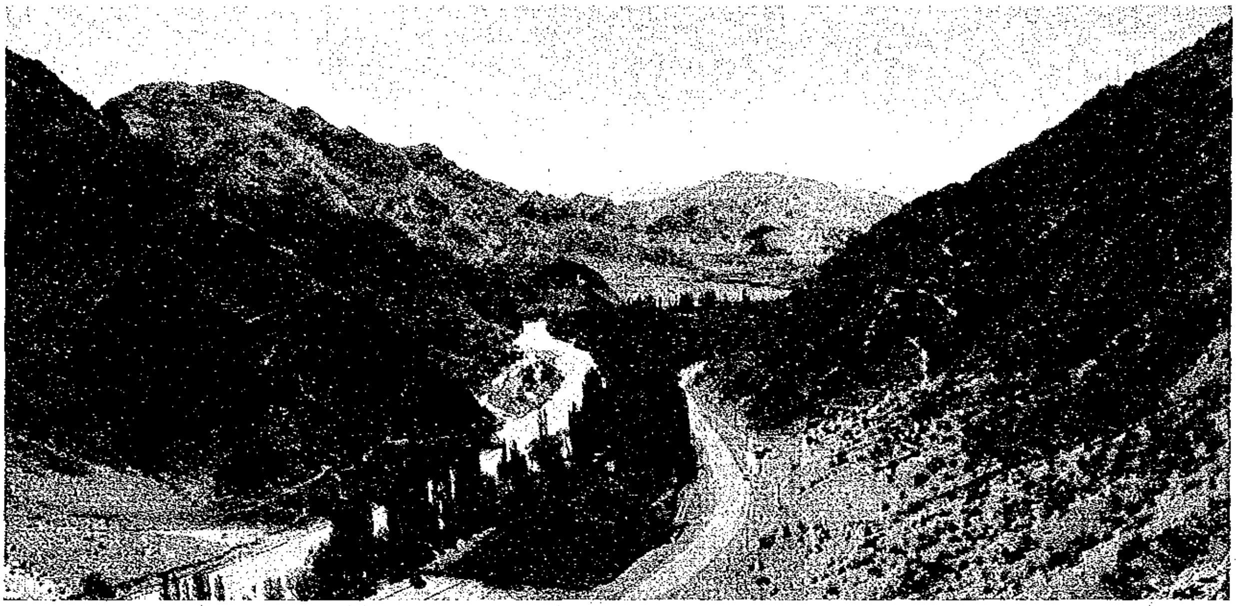
CADDS 4X Imagedesign Window ⊙



Bird Eye View of Ayvalı Dam (Drawn with CAD)



Three Dimensional View of Ayvalı Underground Powerhouse (Drawn with CAD)

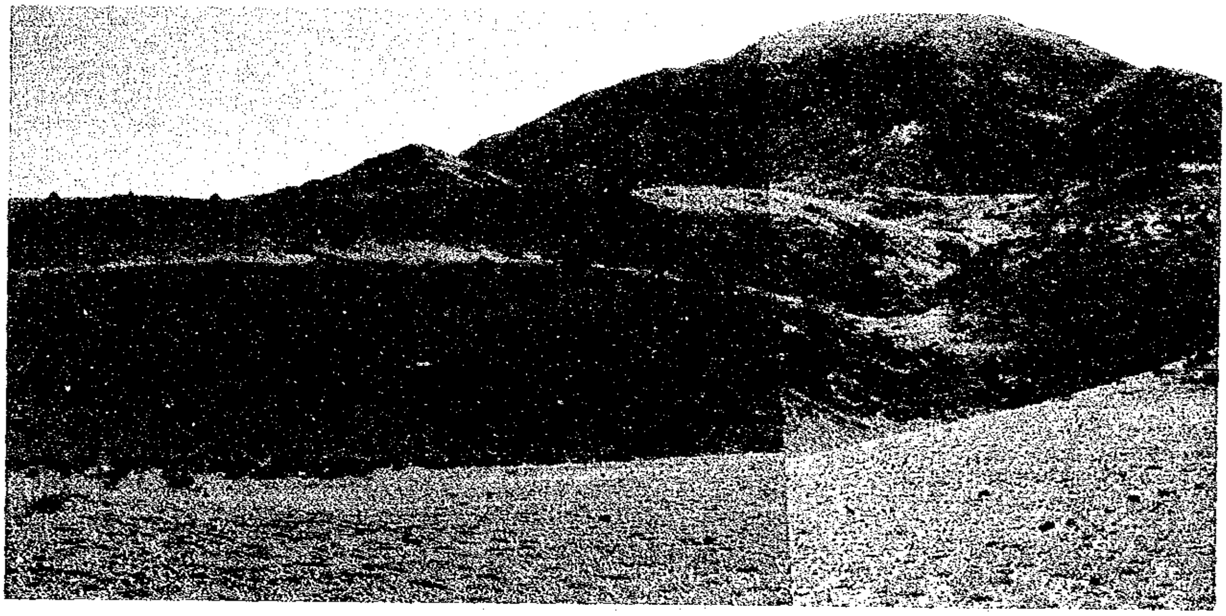


Olur Dam Site

- View from the Downstream Left Bank -

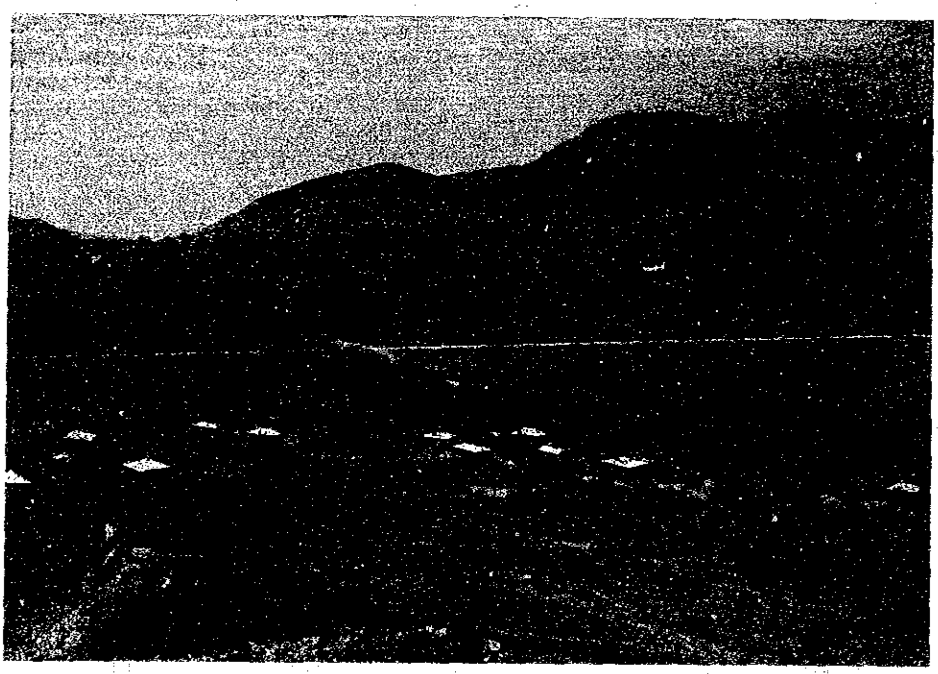
Olur Penstock and Powerhouse Sites

- View from the Upstream Right Bank -



Olur Dam Borrow Area

- Yolboyu Site -



Olur Dam Borrow Area

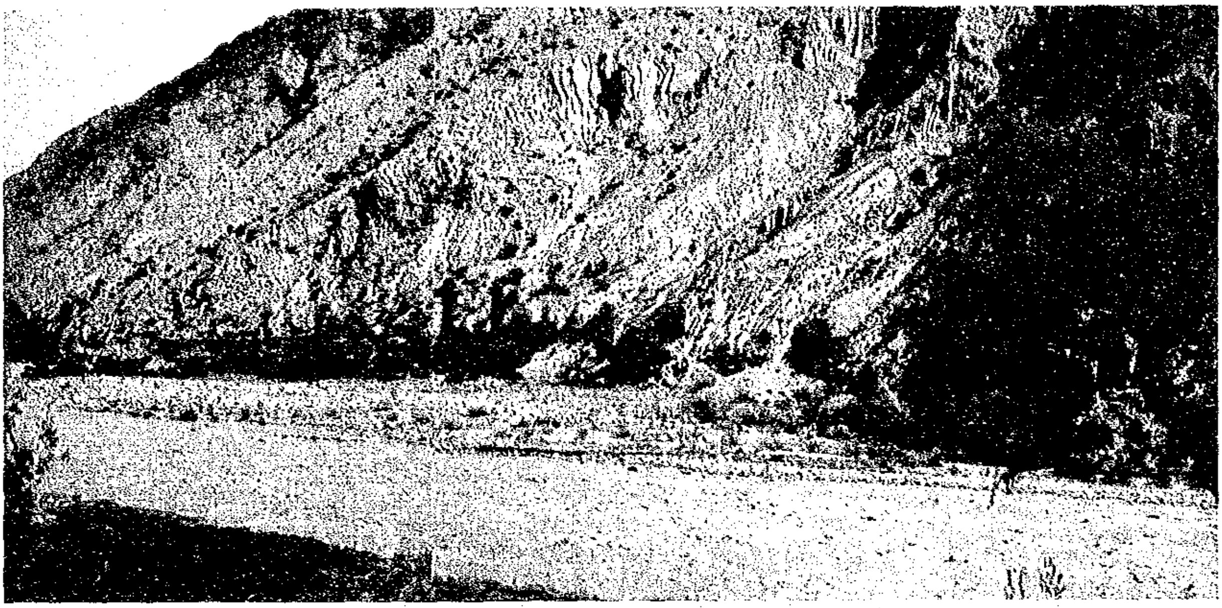
- Tekeli Site -

Olur Dam Quarry Site

- Downstream Right Bank of Dam Site -

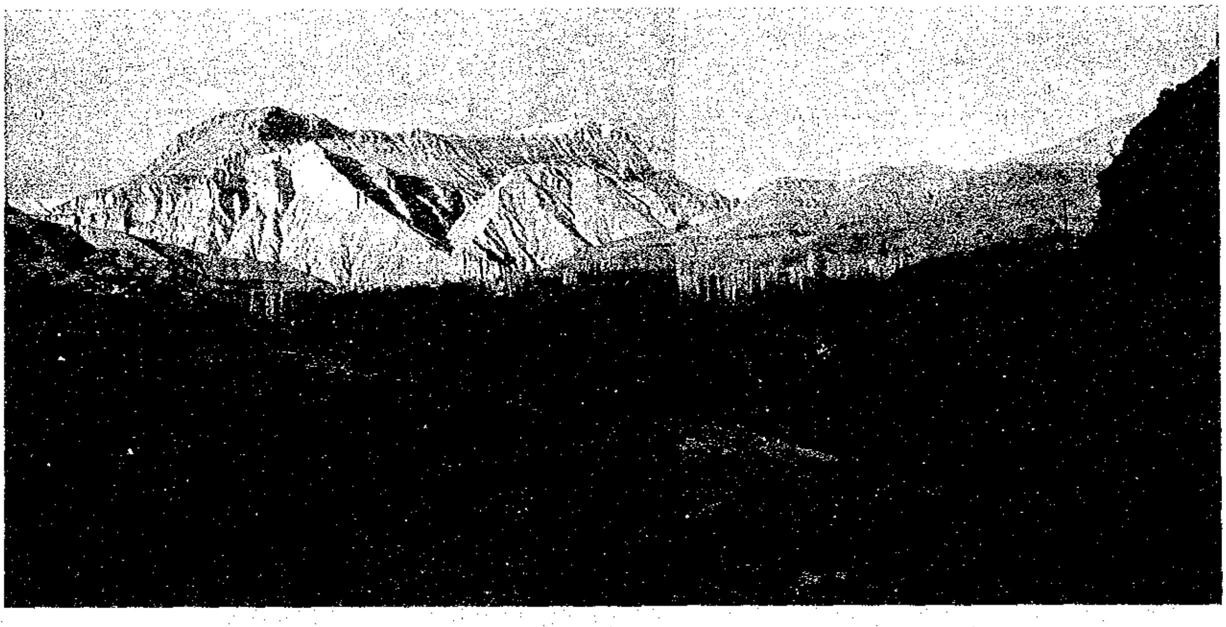
Ayvalı Dam Site

- View from the Downstream Left Bank -



Ayvalı Outlet Site

- View from the Downstream Right Bank -



Ayvalı Borrow Area

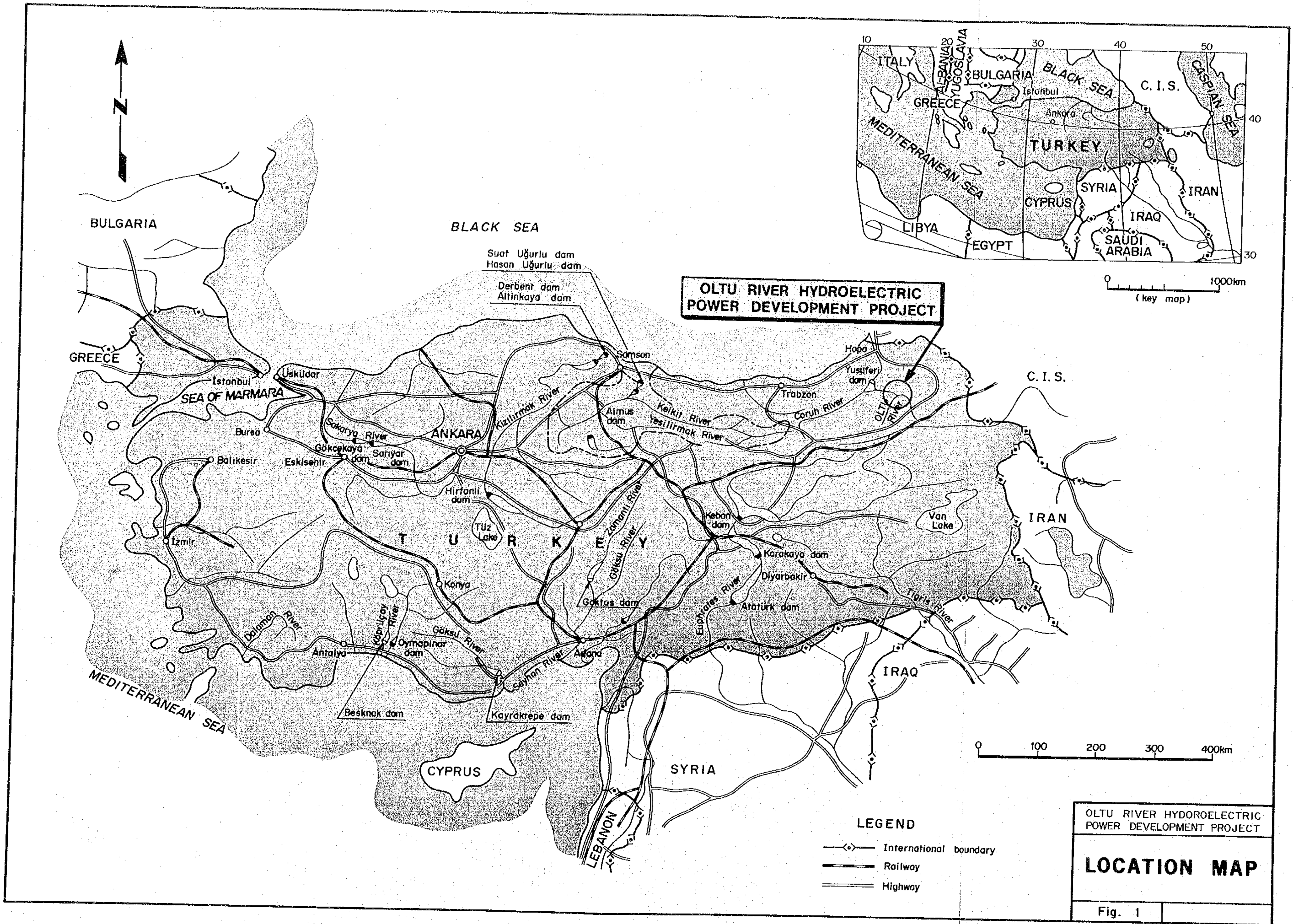
- Tavusker Site -

Ayvalı Borrow Area

-Bulanik Site -

Ayvalı Quarry Site

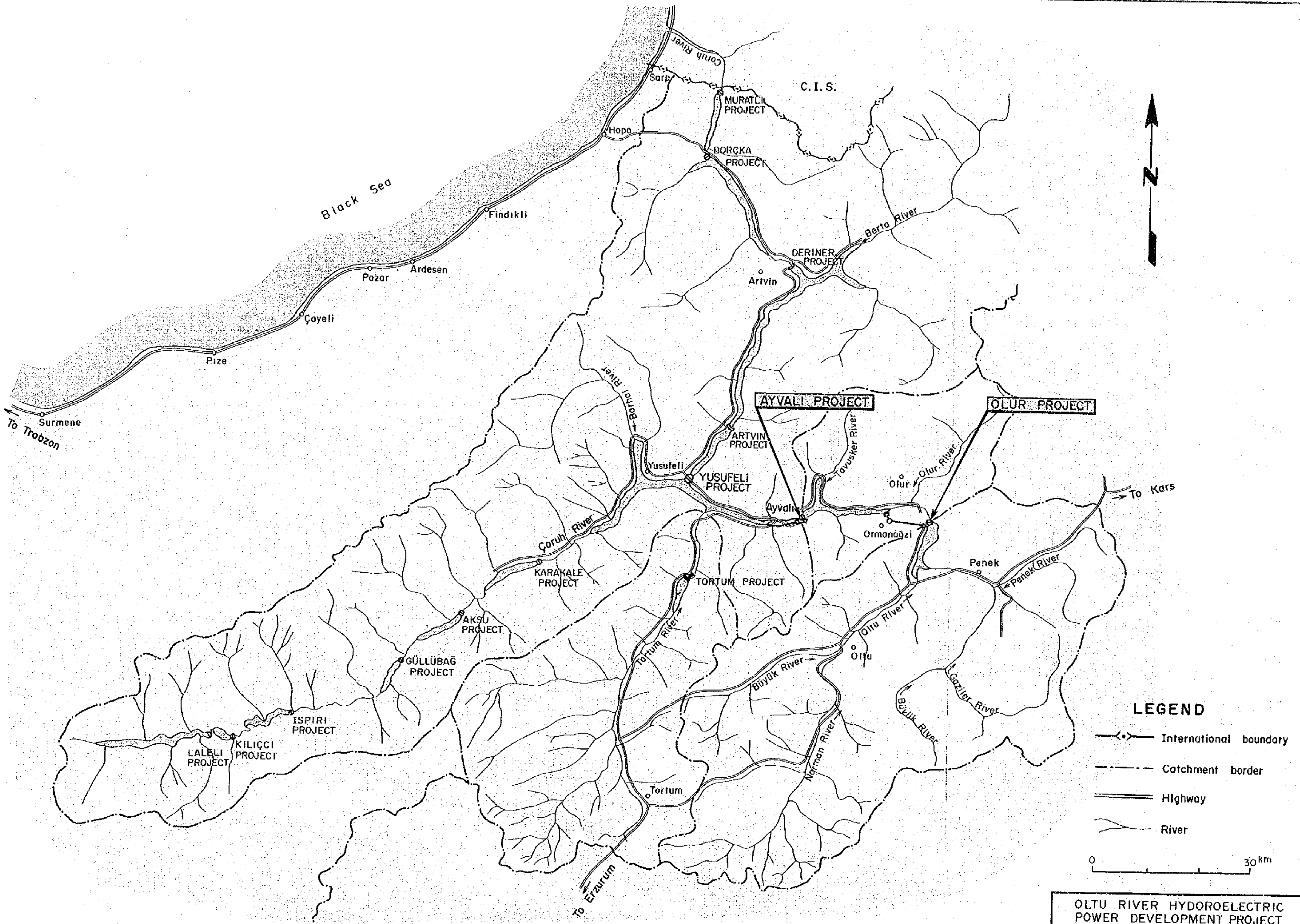
-Upstream of Dam Site -



OLTU RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

LOCATION MAP

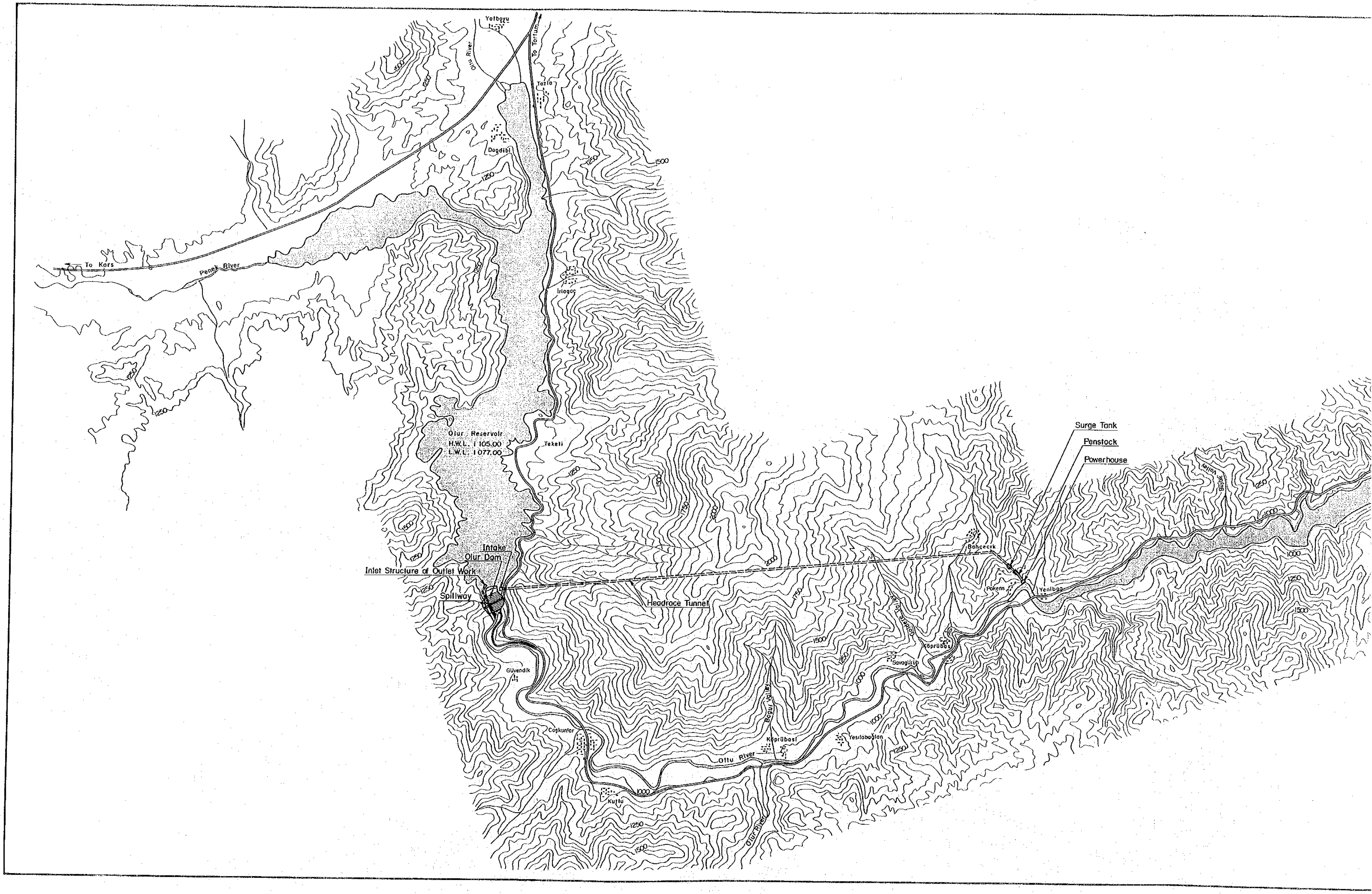
Fig. 1



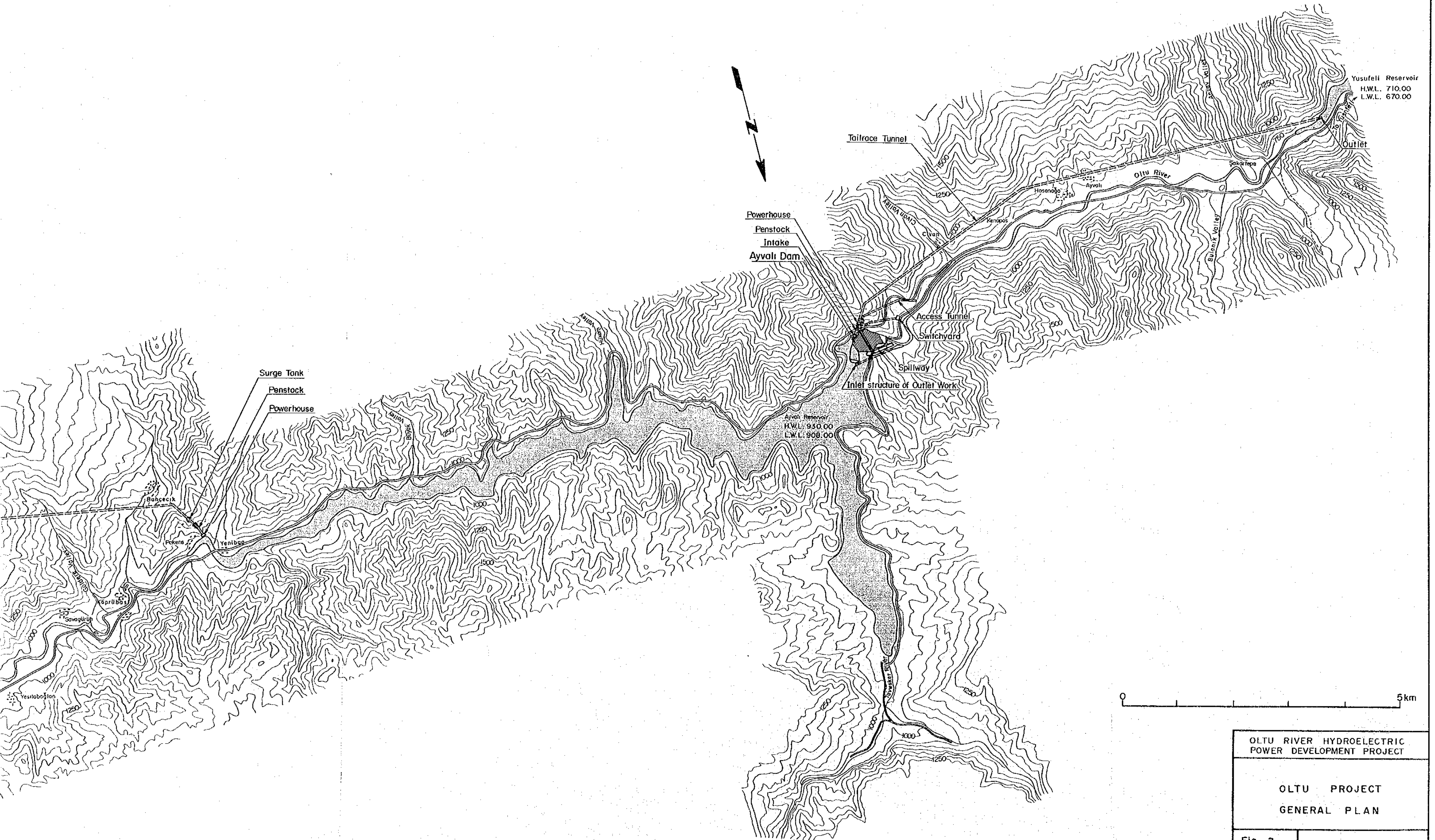
OLTU RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

CORUH – OLTU RIVER GENERAL PLAN

Fig. 2



Yolboyu
To Tortum
Oltu River
Tozla
Dagdibi
To Kars
Penek River
Iriagac
Olur Reservoir
H.W.L. 1 105.00
L.W.L. 1 077.00
Tekeli
Intake
Olur Dam
Inlet Structure of Outlet Work
Spillway
Headrace Tunnel
Surge Tank
Penstock
Powerhouse
Bahcecik
Yenibaş
Köprübaşı
Savaşlıyüp
Güvendik
Coşkunlar
Köprübaşı
Yeşilbağlar
Oltu River
Kutlu
Bagu Valley
Oltu River



OLTU RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

OLTU PROJECT

GENERAL PLAN

Fig. 3

CONTENTS

1. INTRODUCTION

The Republic of Turkey had developed in the past as an agricultural country, but in recent years it has switched emphasis to industrialization and efforts are being continued for growth of the national economy. Providing energy, particularly electric energy, is of great importance for industrialization, and the Turkish Government has given priority to development of domestic energy resources, and efforts are being made for development of lignite-fired thermal power and hydroelectric power based on purely indigenous resources.

Growth in GNP and growth of electric power will be more or less proportionate when industrialization progresses. Up to around 1980, this relationship was not necessarily linear in Turkey because of the shortage of electric power facilities, but with the favorable development of the Turkish economy on entering the 1990s, the relationship has become roughly linear. The growths in population, GNP, and electric power supply from 1979 to 1990 are given below.

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1987	1988	1989	1990
GNP growth (%)	-0.4	-1.1	4.2	4.5	3.3	5.9	5.1	8.1	7.5	7.5	3.6	1.9	9.2
Electric Energy Supply Growth (%)	5.5	4.5	6.8	7.7	4.4	12.5	9.3	11.3	11.0	11.0	7.8	8.6	9.5

The Turkish economy up to 1983 had been sluggish having been affected by the second oil crisis which occurred in 1978, but picked up from around 1984 and since then development has been favourable, and this has been indicated by the smooth growth in electric power demand. As principle energy resources produced in the Republic of Turkey, there are the 5.7×10^6 ton of petroleum reserves, 12.9×10^9 ton of lignite reserves and 30,800 MW of hydroelectric power potential. Of this hydro-electric power potential, only 6,755 MW, 22%, had been developed as of the end of 1990, and there is much being expected of development hereafter of this clean and purely domestic energy resource.

The installed capacity for power generation as of the end of 1990 consisted of 9,519 MW in thermal power plants and 6.755 MW in hydroelectric power station facilities for a total output of 16,274 MW. The Turkish Government, as a long-range outlook has forecast an electric power demand of approximately 139,000 GWh in 2000, and 307,963 GWh in 2010 (annual growth rate 8%), and has planned an annual development quantity of an average of 3,000 MW of which hydroelectric development would be an average of 1,000 MW.

Under such circumstances the Turkish Government selected the Çoruh River as a river for large-scale hydroelectric power development and has been pushing forward with development projects. As a part of these projects, master plans were prepared in 1982 and 1990 for development of the Oltu River, a major tributary on the right-bank side of the Çoruh, and preparations have been made for development. The Çoruh has more than 10% of the hydroelectric potential of Turkey, and is a river greatly suited for hydroelectric power generation.

Investigations concerning the Oltu River Hydroelectric Power development Project were started by the EIE of Turkey at the end of 1970 and these resulted in the Master Plan Report, Çoruh-Oltu River Basin in 1982. In this Master Plan, various development alternatives were proposed and studied between high water level of EL. 1,100 m of Olur Reservoir, and high water level of EL. 710 m of Yusufeli Reservoir, and in the end, a two-stage development plant consisting of the Olur Hydroelectric Power Development Project and the Ayvalı Hydroelectric Power Development Project was taken up as being optimum.

The General Directorate of Elektrik İsleri Etüd İdaresi (EİE), with the aim of making a feasibility study for upgrading the Oltu River Hydroelectric Power Development Project, requested the Government of Japan through the Government of the Republic of Turkey to make the study, and the Japan International Cooperation Agency (JICA) was designated to undertake the study. The

Japanese Government, based on the request of the Turkish Government, signed "Scope of Work for Feasibility Study on the Oltu River Hydroelectric Power Development in the Republic of Turkey Agreed upon between the Japan International Cooperation Agency and the General Directorate of Electrik İsleri Etüd İdaresi" on September 3, 1990, and the Feasibility Study was started from November 28, 1990.

The objectives of the investigation work are to carry out field studies concerning the Oltu River Hydroelectric Power Development Project, gather data and perform investigation works, based on which the appropriateness of the Project would be studied technically, economically, and financially, and a feasibility report prepared.

The investigation work was carried out divided into the three stages of preliminary investigation, additional detailed field investigations, and feasibility design. The preliminary investigation of the first stage consisted of preparations in Japan, field investigations, data collection, review of existing plans, study of alternative plans, and formulation of additional detailed field investigation. Field reconnaissances, data collection and reviews of existing reports were carried out in Turkey, while reviews of existing development schemes, formulation of alternative development schemes and comparison studies, formulation of additional detailed investigations and preparation of related technical specifications were carried out in japan. The additional detailed field investigations corresponding to the second stage consisted of carrying out detailed additional investigation works regarding the scheme selected upon comparison studies at the first stage. The additional detailed field investigations were formulated by JICA and carried out by the EIE. The third stage consisted of optimization of plans, basic designs, estimate of construction costs, formulation of construction plans, economic evaluations and financial analyses carried out based on materials obtained

in preliminary studies and the additional detailed field investigations.

In November 1990, JICA began the work based on the beforementioned "Scope of Works." JICA next dispatched the following survey teams for field investigations concerning the Project.

Nov. 18 - Dec. 17, 1990	:	First Preliminary Investigation
Apr. 22 - May 5, 1991	:	Second Preliminary Investigation
Jul. 14 - Aug. 12, 1991	:	First Detailed Investigation
Aug. 26 - Sep. 9, 1991	:	Second Detailed Investigation
Nov. 16 - Nov. 29, 1991	:	Discussion Interim Report
Aug. 1 - Aug. 15, 1991	:	Discussion of Draft Final Report

During this period, the Survey Team submitted the following reports to the EİE.

Dec. 1990	:	Inception Report
Apr. 1991	:	First Progress Report, Detailed Investigation Program, and Technical Specifications
Jul. 1991	:	Second Progress Report
Nov. 1991	:	Interim Report
Aug. 1992	:	Draft Final Report

From May 1991 to August 1991, the EIE carried out field investigations and investigation works based on the above mentioned Detailed Investigation Program. The outlines of the field investigation and investigations works are as shown in Table 1.

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

Table 1 Investigation Works by EIE

	Olur Project		Ayvalı Project	
1. Topographic Survey				
Dam 1/1,000	20,000 m^2		-	
Power station 1/1,000	500,000 m^2		590,000 m^2	
Tailrace 1/1,000	-		120,000 m^2	
2. Geological Investigation				
i. Drilling and permeability test				
a. Damsite	10 holes	869.6 m	10 holes	1,200.2 m
b. Powerhouse site	1 holes	30 m	-	
c. Headrace tunnel	4 holes (Baçecik)	390 m	-	
d. Tailrace tunnel	-		1 hole (Anzav)	70 m
ii. Seismic prospecting				
a. Damsite	3 lines (spillway)	1,530 m		
b. Power station site	4 lines (OPT Site)	1,240 m	2 lines (Access tunnel)	1,210 m
c. Headrace tunnel	3 lines (Bahçecik)	1,950 m		
d. Tailrace tunnel	-		3 lines (Anzav Dere)	1,050 m
iii. Electrical Prospecting				
a. Borrow area	30 points (kaledibi)		20 points (Bahçecik)	
b. Headrace tunnel	600 m (Bahçecik)		-	
3. Material Test				
i. Impervious core material	12 pits	38.5 m	18 pits	79.2 m
ii. Aggregate	7 pits	13.5 m	8 pits	17.7 m
4. Social and Environmental Aspect	Implemented		Implemented	
5. Compensation	Implemented		Implemented	

2. STUDY OF FUNDAMENTAL DATA

2.1 Necessity for Development

The electric power facilities in the Republic of Turkey as of the end of 1990 amounted to 16,274 MW (86,761 GWh planned) of which hydroelectric power generating facilities were 6,755 MW (24,805 GWh planned) and thermal power generating facilities 9,519 MW (61,956 GWh), the ratio of the two being 42:58.

The results of forecasts made of future power demands (1991 to 2010) by the Turkish Electricity Authority (TEK) recently, and the results of forecasts made by the JICA Team are as follows:

	Macro Method Forecast		TEK Forecast	
	(MW)	(GWh)	(MW)	(GWh)
1990	9,281	57,116	9,340	57,563
1995	14,161	85,595	15,005	92,984
2000	21,032	125,285	33,435	139,213
2005	30,477	178,874	34,025	207,056
2010	37,707*	218,962*	50,600	307,964

* at 2008

In order to cope with these demands, it is necessary for development of about 3,000 MW to be continued hereafter up to the year 2010, and for this purpose, it is planned for supply to be made not only by lignite fired thermal, but also by thermal power using imported coal and imported gas, while it is necessary for hydroelectric power development to be aggressively pushed to meet about a half of the total power demand. Hydroelectric power stations to be commissioned in the near future are Atatürk (300 MW x 8 = 2,400 MW) in 1994, Batman (64 x 3 = 192 MW) in 1994, and Çatalan (56 x 3 = 168 MW), Gezende (53 x 3 = 159 MW), and Menzelet (31 MW x 4 = 124 MW) in 1993. Meanwhile, hydroelectric sites such as Berke (510 MW), Kayraktepe (420 MW), Ilısu (1,200 MW), Boyabat (510 MW), Birecik (670 MW), and Yedigöze (300 MW) are being prepared for start of construction. Also, in

succession to the above, preparations for hydroelectric power development at Deriner (670 MW) and Yusufeli (560 MW) are scheduled to be started aiming for commissioning in the first half of the 2000s. However, it is desirable for a power transmission network to be built up for smooth transmission of power from these power stations to demand areas.

With regard to the Oltu hydroelectric power stations it may be considered that start-up should be around the year 2005 as soon as possible after start-up of Yusufeli Hydro in view of the physical schedule that electric power obtained from development of the Çoruh River is to be sent to the western and southern parts of Turkey. Furthermore, it is thought that the series of development according to the Oltu Hydroelectric Project will greatly contribute to economic development of the area concerned.

2.2 Meteorology and Hydrology

The Oltu River Basin in which the Oltu project sites are located is closed off from the Black Sea by the Doğu Karada which runs parallel to the Çoruh River Mountain Range, and belongs to a region of typical continental climate having little rainfall and severe highs and lows of temperature.

The meteorological characteristics of this region are as mentioned above with annual average rainfall 400 mm, 50% of annual rainfall, or 200 mm falling in the rainy season from April to July. Snowfall has been recorded between November and April. The mean annual temperature is 9.8°C with a rise to a maximum of 39°C in the summertime, while in the wintertime the minimum temperature becomes lower than -20°C.

The runoff of the Oltu River is small due to the above-mentioned meteorological conditions, the average annual inflow at the Olur dam site being 655×10^6 m^3 and that at the Ayvalı dam site 813×10^6 m^3.

The meteorological and hydrological quantities at the individual project sites according to analyses of meteorological and hydrological data are as given below.

	Olur Project	Ayvalı Project
Catchment area :	3,509 Km^2	4,517 Km^2
Elevation of riverbed:	1,025 m	810
Temperature Maximum :	39°C	
Minimum :	-24°C	
Annual Average Pre-capitation :	300 - 500 mm	
Annual Inflow :	655 x 10^6m^3	813 x 10^6m^3
Annual average discharge :	20.8 m^3/s	25.8 m^3/s
Annual evaporation from reservoir surface :	843 mm	867 mm
Suspended load :	279 ton/yer/km^2	279 ton/yer/km^2
Design sedimentation 50 years :	47 x 10^6m^3	61 x 10^6m^3
100 years :	94 x 10^6m^3	121 x 10^6m^3
Probable maximum flood (PMF)	4,750 m^3/sec	5,270 m^3/sec
25-year return period flood :	332 m^3/sec	376 m^3/sec

2.3 Topography

Of the Olur project area, the part to become the reservoir has a topography which is comparatively gentle, but the topography of the area from the dam to the powerhouse is extremely steeply sloped and other than the river-bed portion there is hardly any vegetation, volcanic rocks being exposed to present a very rugged appearance. There are river terrace flats and fans developed, upon which there is social life going on. Inside the river-bed it is fairly wide with sand-gravel deposited in large quantity, the thickness being estimated to be considerable.

The river from the dam site to the powerhouse runs north at first, after which it changes course making a large bend to go west, and after passing the Ayvalı dam site, merges with the Çoruh River. The river gradient from the dam site to the powerhouse is fairly steep at 1/200 to 1/130.

Almost all the area of the Ayvalı project, including the reservoir, dam, powerhouse, and tailrace, lies in an area of the Ayvalı Formation which consists of volcanic rocks, with a part of the tailrace passing through the Pügey Formation of sedimentary rocks. The topography of the project area is very steeply sloped similarly to the topography of the Olur Project from the dam to the powerhouse with practically no vegetation other than the river-bed portion, rocks being completely exposed, and mountains closing in on the river to present a very rugged appearance.

The river-bed portion, excepting the sedimentary plain dammed up by the narrow gorge at Şakartepe, is very narrow. The thickness of river deposits is also fairly great. River-bank terraces exist at parts along the river bank from the dam to the tailrace outlet, and social activities are going on at the terraces. The river from the dam site to the outlet runs roughly westward while meandering down to join the Çoruh river. The river gradient from the dam site to the tailrace outlet is about 1/90, while especially, the river gradient from Şakartepe to the outlet is approximately 1/40.

Between the dam site and the tailrace outlet site, there is the Civan Dere merging from the left-bank side 2 km downstream from the dam, and 5 km further downstream the Anzav Dere (downstream of Şakartepe) joins in, while at the right-bank side, there is the Bulanik Dere 7 km downstream from the dam (upstream of Şakartepe).

2.4 Geology and Materials

(1) Geology

The geology of the project area was affected by the Hercynian orogeny in the Paleozoic Carboniferous Period and the Alpine orogeny in the Cenozoic Era. The geology is composed of Quaternary deposits, the Tertiary Oltu Formation (sedimentary rocks), the Mesozoic Pugey Formation (sedimentary rocks), Ayvalı (volcanic rocks), and Yusufeli Formation (igneous rocks and metamorphic rocks).

The foundation rocks at the principal structures projected are roughly as given below.

1) Olu Project

SITE	GEOLOGY
Reservoir	Yusfelı formation (gabbro, greenschist etc.) Ayvalı volcanic rocks (rhyolite, tuff) Oltu formation (claystone, sandstone, conglomerate)
Damsite	Ayvalı volcanic rocks (rhyolite, diabase, granite porphyry) * River deposit is thick
Headrace Tunnel	Ayvalı volcanic rocks (lava, rhyolite, tuff, volcanic breccia)
Surge Tank Penstock Powerhouse	Ayvalı volcanic rocks (lava, volcanic breccia)

The geology of Olur Reservoir and its vicinity is composed of gabbro and green schist of the Yusufeli Formation, lava, rhyolite, and tuffs of the Ayvalı Formation, and claystone, sandstone, and conglomerate

of the Oltu Formation. Rocks which may cause leakage from the reservoir as pure limestone are not distributed around the reservoir area. Large-scale landslides expected to cause waves such as would affect safety of the dam are not seen in the surroundings of the reservoir.

The geology at the dam site consists of granite porphyry, rhyolite and diabase, and there are no problems from the standpoints of securing strength and impermeability as a foundation for a dam of 136 m height. River deposits would be the foundations for rock zones of a rockfill dam, but it is thought there will be no problem from the standpoint of strength.

The sites of principal structures such as the headrace, surge tank, penstock, and powerhouse are in the Ayvalı volcanic rocks, and it is considered there is no problem geology-wise that would be an obstacle to implementation of the project.

2) Ayvalı Project

SITE	GEOLOGY
Reservoir	Ayvalı volcanic rocks (lava, rhyolite, tuff, volcanic breccia) Pügey formation (alternation of marl and limestone)
Damsite	Ayvalı volcanic rocks (volcanic breccia, tuff, rhyolite) * River deposit is thick
Powerhouse	Ayvalı volcanic rocks (tuff breccia, rhyolite)
Tailrace Tunnel	Ayvalı volcanic rocks (lava, tuff, volcanic breccia, rhyolite) Pügey formation (alternation of marl and limestone)

The geology of Ayvalı Reservoir and its vicinity is composed of lava, rhyolite, tuff, and volcanic breccias of the Ayvalı volcanic rocks. Large-scale landslides expected to cause waves such as would affect safety of the dam are not seen in the surroundings of the reservoir. Furthermore, there are no places seen where leakage from the reservoir would occur.

The geology of the dam site consists of tuff, volcanic breccias, and rhyolite, and there will be no problem about securing strength and impermeability as the foundation for a dam of height around 175 m. River deposits would be the foundations for rock zones of a rockfill dam, but it is thought there will be no problem from the standpoint of strength.

The powerhouse would be provided in the tuff breccias and rhyolite of the Ayvalı volcanic rocks as an

underground structure, and it will be amply possible for excavation of a large cavern to be performed.

Approximately 7 km on the upstream side the tailrace tunnel would be provided in the Ayvalı volcanic rocks, and approximately 2.5 km on the down stream side in the Pügey Formation. Both formations are very sound and there will be no problem about providing the waterway. The tailrace tunnel passes the large Anzav valley. However, the bedrock above the tunnel location is confirmed to be more than 30 m by geological investigations and it is considered that construction can be done with ample safety.

(2) Materials

1) Olur Project

The Kaledibi Borrow Area approximately 3 km upstream of the dam and the Yolboyu Borrow Area approximately 8 km upstream are planned to be used to obtain impervious solid core material of the dam. The material of the former is slightly on the coarse-grained side and that of the latter slightly on the fine-grained side. If necessary, it is conceivable for the two to be blended and used. Material excavated from the river-bed sand-gravel would be used for the fine-grained filter of the dam, while for the coarse-grained filter, material excavated from the spillway and sites would be used.

Material excavated from the river-bed sand-gravel would be used for the fine-grained filter of the dam, while for the coarse-grained filter, material excavated from the spillway and sites would be used.

For rock embankment materials, granite porphyry at the right bank downstream of the dam would be excavated, collected, and banked.

For concrete aggregates, the river-bed sand-gravel excavated from the dam site can be screened and used. Furthermore, there is a large amount of sand-gravel existing in the river bed around the dam, and this can be amply used.

2) Ayvalı Project

Borrow areas are planned at the Bulanik Dere 8 km downstream of the dam and Tavusker 8 km upstream of the dam for impervious soil core material of the dam. The material of the former borrow area has scattering of properties depending on the stratum and the location,and it will be necessary for improvement to be made by blending before use. The material of Tavusker is high in the content of fines.

As fine-grained filter for the dam, excavated material from the river-bed sand-gravel, and as coarse-grained filter, excavated material from the spillway, dam, etc. are to be used.

For rock embankment material of the dam a quarry is to be provided immediately upstream of the dam.

As concrete aggregate the river-bed sand-gravel at the dam can be screened and used. There are also large amounts of sand-gravel at the river bed in the surroundings of the dam, and these can be amply used.

2.5 Earthquakes

In order to decide on the design seismic coefficient a predictive evaluation was made by statistical analysis of the maximum acceleration at the ground surface at the Oltu site. The earthquake data used in this predictive evaluation had been gathered by the Environmental Data Service of NOAA (National Oceanic and Atmospheric Administration) of the United States, and the numbers of earthquake data during the period from 1901 to 1987 within radii of 200 km from the dam sites were 3,742 for Olur Dam and 3,402 for Ayvalı Dam.

The Oltu sites are located in an earthquake risk zone of [II] in the seismicity map prepared by the Government of the Republic of Turkey (IMAR ve ISKAN BAKANLIGI, 1972).

Therefore, considering here the results of stochastic analyses also, it was decided to set the design horizontal seismic coefficient of the Oltu sites (Olur Dam and Ayvalı Dam) as 0.15.

2.6 Survey for Environmental Assessment

The effect of the project on the natural and social environments in and around the project area was qualitatively studied by surveying the present situation through the site survey of and the literature search for the natural and social environments.

(1) Natural Environment

1) Nature Conservation

There is no national park and no nature conservation area in and around the project area. A game reserve is located north of National Road 060, but a part of this reserve located inside the project site is very small. There is an area with restrictions on the

catch of fishes, but the area is not located inside the project site. Therefore, the execution of the project will have almost no effect on the natural environment.

2) Natural Scenery

The natural scenery in and around the project area consists of a brown and turbid river, houses which dot flat land along the river, pastures, cultivated land, its deep gorge and dry mountainsides.

The appearance of the dam and its reservoir seems to create a new waterfront beauty spot.

3) Vegetation

As for flora in and around the reservoir area, forests are limited and vegetation is poor except forest zones on the summits of mountains and orchards and poplar lines along the river. Plants regarded as precious are not seen either.

Trees in orchards and poplar lines along the river will be cut down to locate the power station building and the reservoir.

4) Animals

As for land animals living in and around the reservoir area, there are rabbits, goats, sparrows, crows, snakes, lizards, frogs, and others, but no precious land animals specified to be protected.

As for aquatic animals, there are carp, trout, aquatic insects, and so on. There is an area with

restrictions on the catch of fishes. But it is not located inside the project site.

5) Water Quality

The main causes of water pollution during the construction work period are imagined to be waste water from temporary facilities such as concrete plant and spray plant as well as waste water from earth excavation and concrete work. It is possible to decrease the effect of waste water on the natural environment by discharging waste water after being treated as much as possible.

There will definitely be no eutrophication after the power station starts to be in operation since large-scale artificial pollution sources are not seen upstream from the project site. However, great care should be given to the amount of nitrogen compound which may be artificially added to daily living waste water from the power station and others since the concentration of phosphorus compound from nature is high now. The river will not be turbid for a long time since pollutant in the river mainly consists of silt which is expected to sink almost completely in the reservoir.

The appearance of the reservoir is expected to create a new living environment for aquatic life.

6) Noise, Vibration and Air Pollution

The main noise and vibration sources as well as air pollution sources during the construction work period seem to be construction equipment, trucks used for transporting equipment and materials, and dust from bare land such as excavation places. It is possible