to decrease the effect of them on the natural environment by using low-noise and low-vibration machines as much as possible and by taking proper measures against exhaust gas and dust.

There will be no effect on the natural environment after the power station starts to be in operation since few machines which may cause noise and vibration are expected to be used and facilities and machines which may become air pollution sources are expected to be hardly used.

(2) Social Environment

1) Industrial Activities and Land Utilization

The number of households inside the planned reservoir site is about 600, and the area of land required to be obtained is about 6,500Da. The land required to be obtained is now used as cultivated land with an area of about 3,500Da., pastures with an area of about 1,500Da., and orchards with an area of about 1,000Da.

It is desirable to deliberate with the persons concerned about land acquirement and give adequate compensation to them in carrying out the project.

There are almost no commercial activities in this area. Their economy is expected to become activated during the construction work period and after the power station starts to be in operation since more people are expected to come to this area, then commercial activities are expected to be carried out and employment is expected to be given to residents.

2) Transportation and Public Facilities

The transport of equipment and materials for construction work is expected to increase the volume of traffic temporarily. There seems no big effect on the volume of general traffic since the volume of traffic is generally not so big. However, great care should be given to traffic safety measures such as the strict observance of safety speed since big trucks are expected to run.

A part of the national road and others will be submerged and then substitute roads will be constructed. Public facilities such as schools and mosques inside the area planned to be submerged should be relocated according to residents' intention.

3) River System Utilization

River water inside the project area is mainly used as irrigation water. It is necessary to exercise temperature control before discharging water from the reservoir. The formation of the reservoir will give a new living space for fishes.

4) Cultural Assets and Recreational Facilities

There are no historical remains and no recreational facilities, which are expected to be submerged together with the appearance of the reservoir. After the power station starts to be in operation, the project site for the dam and the power station and its vicinity seem to be used as recreational facilities.

(3) Conclusion

According to the results of the survey, the execution of the project seems not to have a big effect on the natural environment except residents who are now using the future submerged area as their living places.

As for the execution of the project, it is desirable to deliberate sufficiently with residents who have to leave the submerged area or the organization concerned, to give adequate proper compensation to them and to give consideration to residents who will remain to live in the vicinity of the submerged area.

The required expenses are estimated in the compensation cost.

3. OUTLINE OF OPTIMUM DEVELOPMENT PLANS

Review was made of the existing Master Plan, and studies were carried out based on existing investigation data and detailed additional data, and the optimum development plans described below were selected from among a number of development plans.

The Oltu Hydroelectric Power Development Project consists of a two-stage development plan made up of the two projects of Olur Hydroelectric Power Station and Ayvalı Hydroelectric Power Station, therefore optimization of the Oltu Project was carried out in the manner that the combination of the two projects as a whole would be most optimum.

(1) Olur Project

The Olur Project is the upstream project in the two-stage development of the Oltu River.

It is planned for a rockfill dam 136 m in height and 3.8 x $10^6 m^3$ in volume to be constructed at the point of catchment area of 3,539 Km^2 to obtain a effective storage capacity of 200 x $10^6 m^3$. An annual average inflow of 565 x $10^6 m^3$ is to be regulated by means of this reservoir.

A maximum discharge of 48 m^3/s is to be drawn from an intake provided at the left bank side immediately upstream of the dam, this water is conducted to a powerhouse provided at a left bank through a headrace tunnel approximately 9 km in length and penstock to obtain a maximum output of 65 MW and annual energy production of 242 GWh by utilizing effective head of 154.7 m. Fig. 4 shows the result of the optimization study on the effective storage capacity and the high water level. Fig. 5 shows the result of the optimization study on the installed capacity. Fig. 6 shows reservoir operation result and Fig. 7 shows monthly peak power and annual energy production. The energy generated

at the Olur Project is to be sent to Yusufeli Swtchyard via the Ayvalı Switchyard by a 154 kV transmission line, from where transmission is to be made to load area by 380 kV transmission line.

(2) Ayvali Project

The Ayvalı Project is the downstream project in the two stage development of the Oltu River.

It is planned for a rockfill dam 175 m in height and 9.3 x $10^6 m^3$ in volume to be constructed at the point of catchment area of 4,517 km^2 to obtain a effective storage capacity of 150 x $10^6 m^3$. An annual average inflow of 813 x $10^6 m^3$ is to be regulated by means of this reservoir.

A maximum discharge of 67 m^3/s is to be drawn from an intake provided at the left bank side immediately upstream of the dam, this water being conducted to a underground powerhouse provided at the left bank through a penstock to obtain a maximum output of 125 MW and annual energy production of 409 GWh by utilizing effective head of 211.8 m. After generation, this water is discharged to the Yusufeli Reservoir through a tailrace tunnel approximately 10 km in length. Fig. 8 shows the result of the optimization study on the effective storage capacity and the high water level. Fig. 9 shows the result of the optimization study on the installed capacity. Fig. 10 shows reservoir operation result and Fig. 11 shows monthly peak power and annual energy productions. The energy generated at the Ayvalı Project is to be sent to Yusufeli Switchyard by a 154 kV transmission line, from where transmission is to be made to load area by 380 kV transmission line.

Summary of Olur Hydroelectric Power Development Project

Item	Unit	Description
Location		Oltu River
Catchment Area	km^2	3,509
Annual Inflow	10^6 m^3	655.7
Design Flood	m^3/sec	4,750
Reservoir		
Normal High Water Level	m	1,105
Low Water Level	m	1,077
Available Drawdown	m	28
Sedimentation Level	m	1,077.2
Gross Storage Capacity	10^6 m^3	293.5
Effective Storage Capacity	10^6 m^3	200.0
Reservoir Area	km^2	10.7
Diversion Tunnel		
Diameter	m	6.0
Length	m	530
Design Flood Discharge	m^3/sec	332
Number		1
Dam		
Type		Rockfill with center core
Crest Elevation	m	1,110
Dam Height	m	136
Crest Length	m	328
Dam Volume	10^3 m^3	3,818

Item	Unit	Description
Spillway		
Type		Gated Chute
Spillway Capacity	m^3/sec	4,750
Number of Gate	set	3
Dimension of Gate	m	13.5 x 16.5
Intake		
Type		Inclined type made of reinforced concrete
Gate	set	Loller Gate 1
Headrace Tunnel		
Number		1
Type		Circular pressure
Diameter	m	4.9
Length	m	9,659
Surge Tank		
Type		Orifice
Diameter	m	12
Penstock		
Type		Steel penstock supported by ring-girder
Diameter	m	4.9 ~ 3.2
Length	m	436

Item	Unit	Description
Powerhouse		
Type		Semi-underground of reinforced concrete
Dimension	m	Width 17
	m	Length 30
	m	Height 27
Development Plan		
Standard Intake Water Level	m	1,095.7
Standard Tail Water Level	m	929.0
Gross Head	m	166.7
Effective Head	m	154.7
Maximum Discharge	m^3/s	48.0
Unit Capacity	MW	65
Number of Unit	unit	1
Installed Capacity	MW	65
Turbine		
Type		Vertical Shaft Francis
Number of Unit		1
Rated Output	MW	66.5
Revolving Speed	rpm	333

Item	Unit	Description
Generator		
Type		3-phase, AC, synchronous
Number of Unit		1
Capacity	MVA	74
Voltage	kV	11
Power Factor		0.9 lag
Frequency	Hz	50
Revolving Speed	rpm	333
Main Transformer		
Type		Outdoor, 3-phase transformer
Number of Unit		1
Capacity	MVA	74
Voltage	kV	11:154
Switchyard		
Bus Type		Single bus + Transfer bus
Voltage	kV	154
Circuit Breaker Type		Gas insulated
Transmission Line Section		
Number of Circuit		1
Voltage		154
Section		Olur switchyard - Ayvali switchyard

Item	Unit	Description
Annual Energy Production		
Firm Energy	GWh	126.5
Secondary Energy	GWh	115.0
Total Energy	GWh	241.5
Construction Period	years	6
Project Cost	10^6 T.L.	677,364 (US$157.5 x 10^6)
Unit Construction Cost		
per kW	T.L./kW	10,420,969
per kWh	T.L./kWh	2,804
Economic Internal Rate of Return (EIRR)	%	18.72
Financial Internal Rate of Return (FIRR)	%	9.87
Net Present Value (B-C)	10^3 US$	137,774
Benefit Cost Ratio (B/C)		1.33
Exchange Rate		1US$=4,300 T.L. (As of July 1991)

Summary of Ayvalı Hydroelectric Power Development Project

Item	Unit	Description
Location		Oltu River
Catchment Area	km^2	4,517
Annual Inflow	10^6 m^3	813.0
Design Flood	m^3/sec	5,270
Regulating Reservoir		
Normal High Water Level	m	930
Low Water Level	m	908
Available Drawdown	m	22
Sedimentation Level	m	890.1
Gross Storage Capacity	10^6 m^3	354.8
Effective Storage Capacity	10^6 m^3	150.0
Reservoir Area	km^2	8.2
Diversion		
Diameter	m	6.0
Length	m	659
Design Flood Discharge	m^3/sec	376
Number		1
Dam		
Type		Rockfill with center core
Crest Elevation	m	935
Dam Height	m	175
Crest Length	m	444
Dam Volume	$10^3 m^3$	9,268

Item	Unit	Description
Spillway		
Type		Gated Chute
Spillway Capacity	m^3/sec	5,270
Number of Gate		3
Gate Dimension	m	13.5 x 17.5
Intake		
Type		Inclined type made of reinforced concrete
Gate		Roller Gate 1
Penstock		
Type		Embedded steel pipe
Diameter	m	4.1 ~ 3.8
Length	m	288
Number		1
Powerhouse		
Type		Underground
Dimension	m	Width 19
	m	Length 44.5
	m	Height 42
Surge Chamber		
Type		Chamber
Dimension	m	Wide 5.4 m
	m	Length 100 m
	m	Height 11.7 m

Item	Unit	Description
Tailrace Tunnel		
Type		Horseshoe Circular Non-pressure
Diameter	m	5.4
Length	m	9,260.9
Development Plan		
Standard Intake Water Level	m	922.7
Standard Tail Water Level	m	700.0
Gross Head	m	222.7
Effective Head	m	211.8
Maximum Discharge	m^3/s	67.0
Unit Capacity	MW	125
Number of Unit		1
Installed Capacity	MW	125
Turbine		
Type		Vertical Francis
Number of Unit		1
Rated Output	MW	126.5
Revolving Speed	rpm	300

Item	Unit	Description
Generator		
Type		3-phase, AC, synchronous
Number of Unit		1
Capacity	MVA	140.6
Voltage	kV	14.4
Power Factor		0.9 lag
Frequency	Hz	50
Revolving Speed	rpm	300
Main Transformer		
Type		Outdoor, 3-phase
Number of Unit		4 (including 1 spare)
Capacity	MVA	47
Voltage	kV	14.4:154 $\sqrt{3}$
Switchyard		
Bus Type		Double bus
Voltage	kV	154
Circuit Breaker Type		Gas insulated
Transmission Line		
Number of Circuits		2
Voltage	kV	154
Section		Ayvali switchyard-Yusufeli switchyard

Item	Unit	Description
Annual Energy Production		
Firm Energy	GWh	248.0
Secondary Energy	GWh	161.4
Total Energy	GWh	409.4
Construction Period	years	6.5
Project Cost	10^6 T.L.	957,688 (US$222.7)
Unit Construction Cost		
per kW	T.L./kW	7,661,504
per kWh	T.L./kWh	2,339
Economic Internal Rate of Return (EIRR)	%	33.05
Financial Internal Rate of Return (FIRR)	%	11.39
Net Present Value (B-C)	10^6 T.L.	401,170
Benefit Cost Ratio (B/C)	-	1.71
Exchange Rate		1US$=4,300 T.L . (As of July 1991)

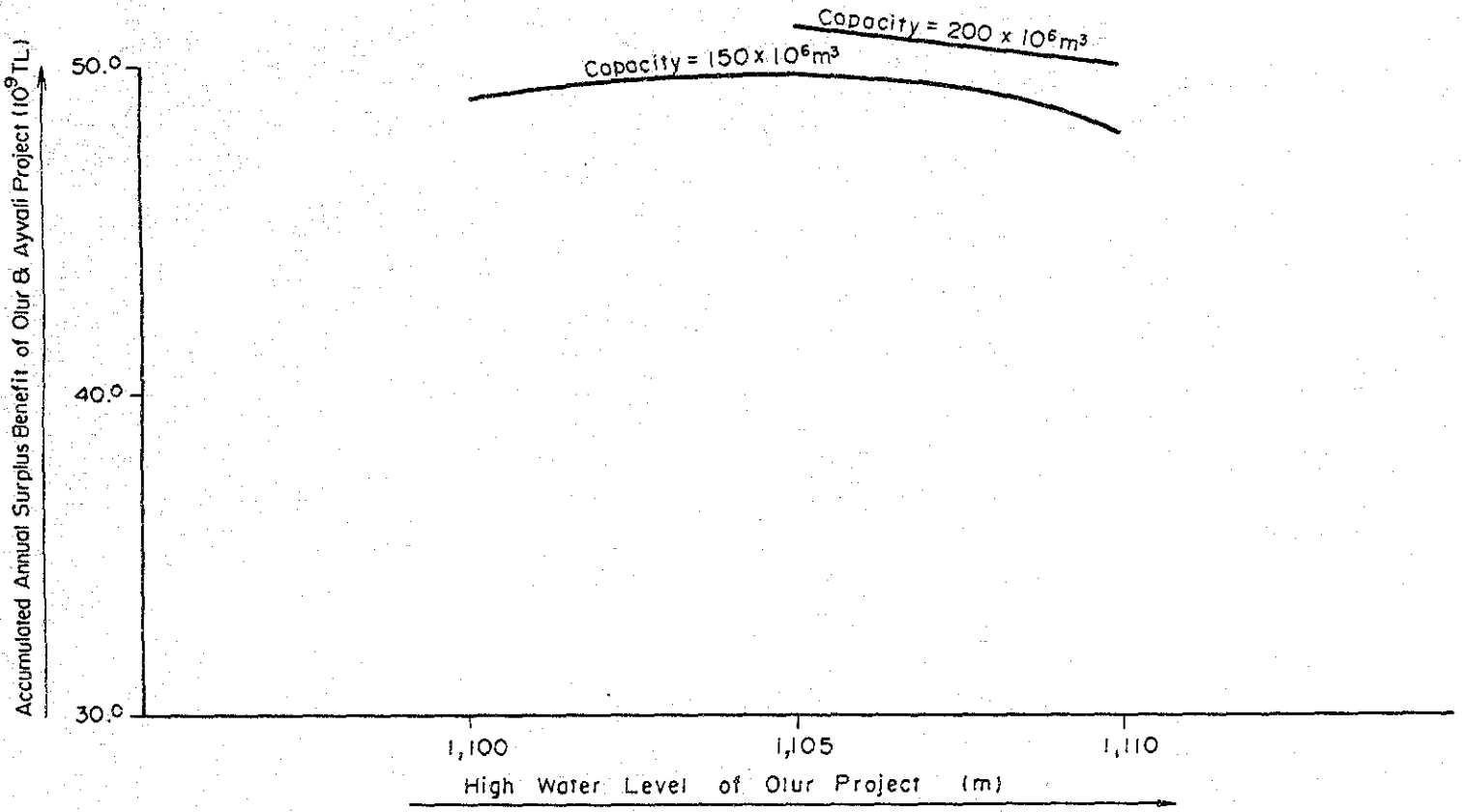


Fig. 4 Optimization Study on Effective Storage Capacity and High Water Level of Olur Project

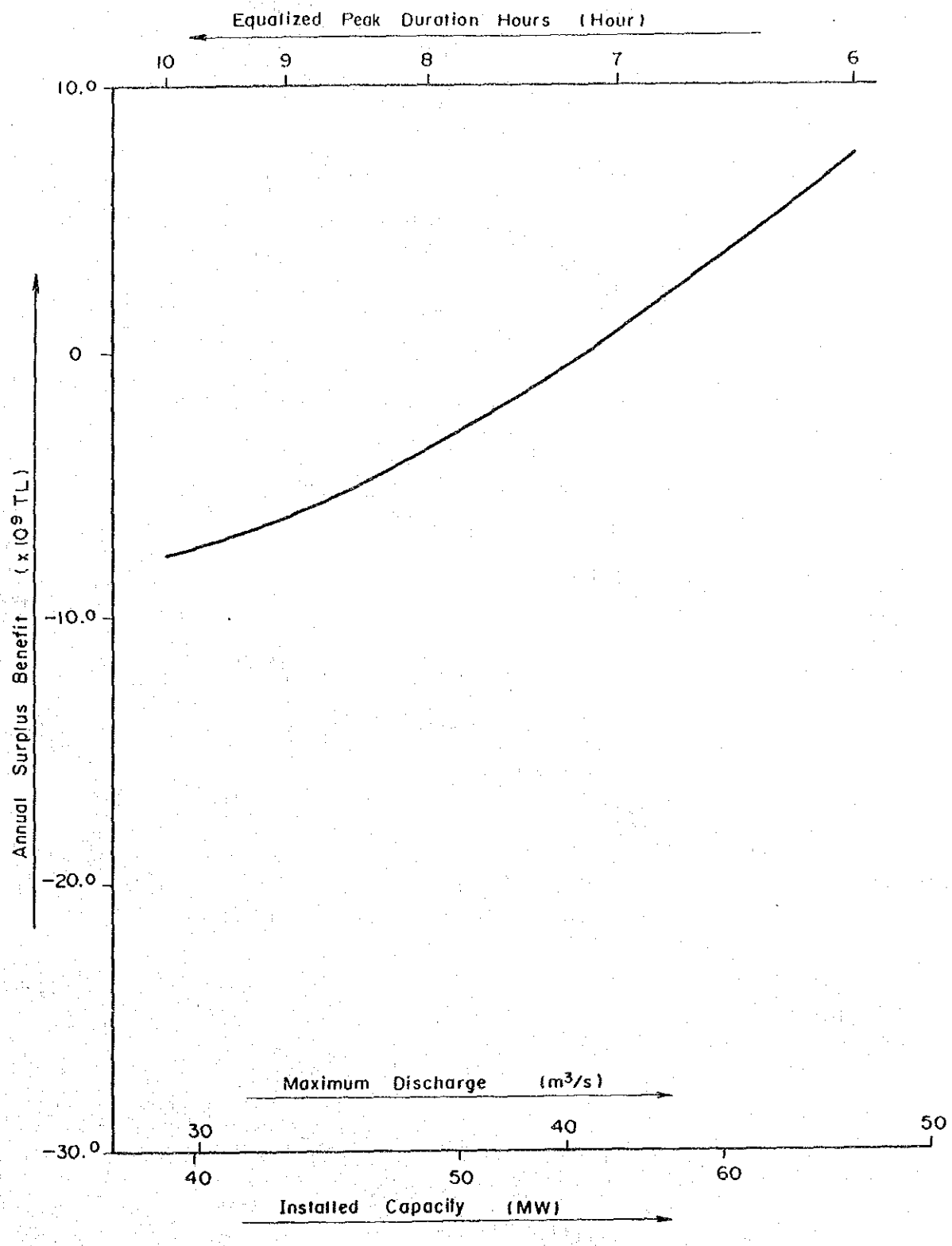


Fig. 5 Optimization Study on Installed Capacity of Olur Project

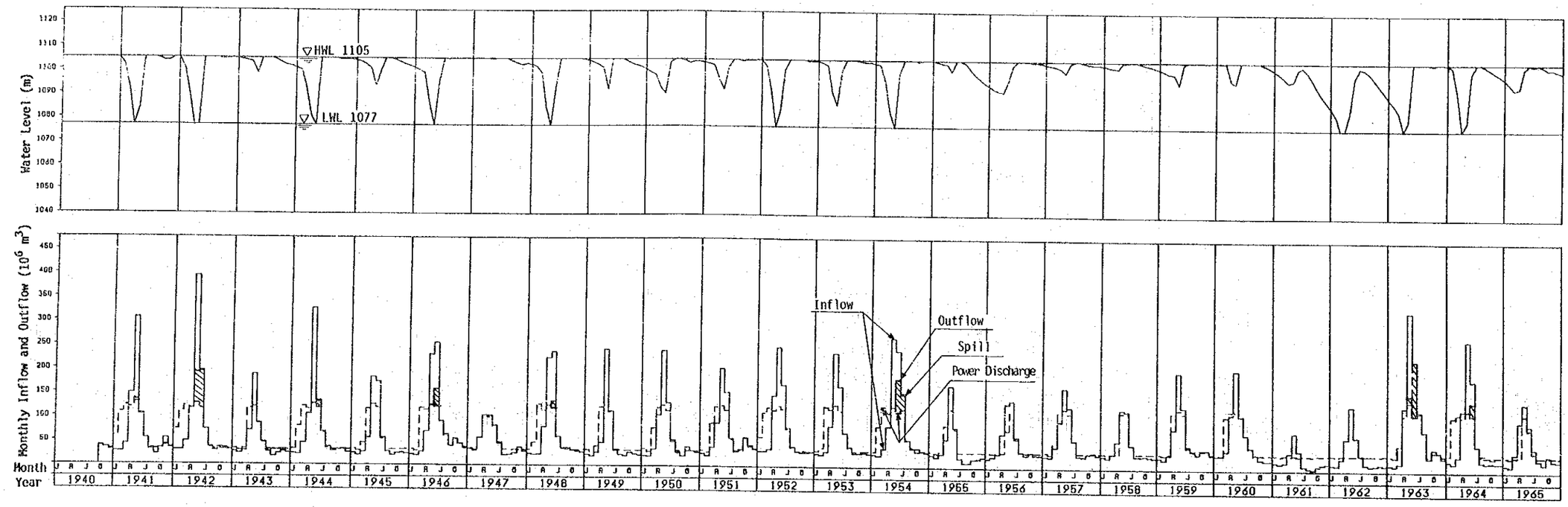
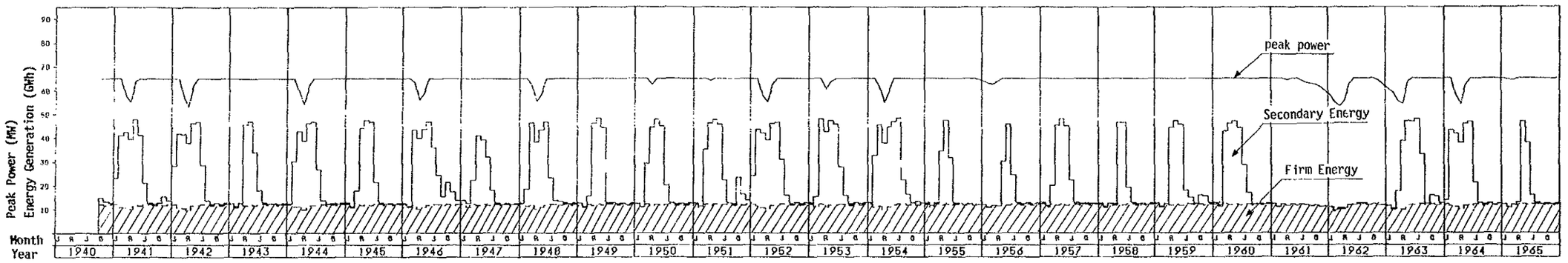


Fig. 6 Olur Reservoir Operation



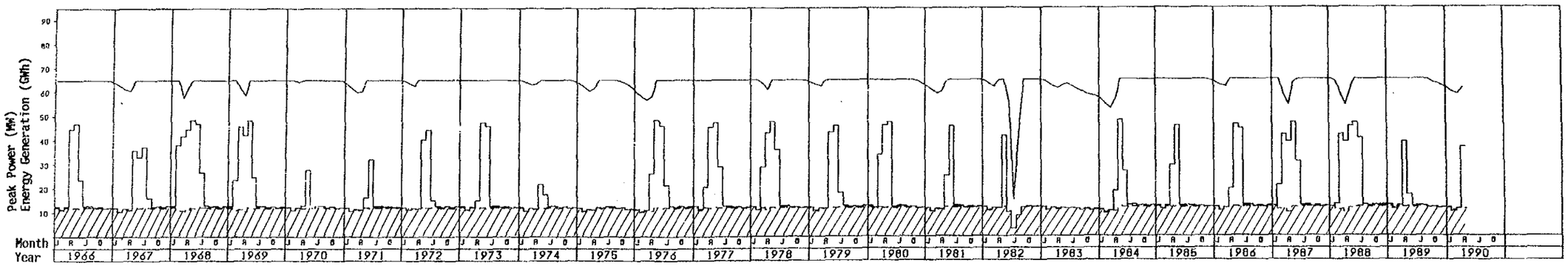


Fig. 7 Energy Generation of Olur Project

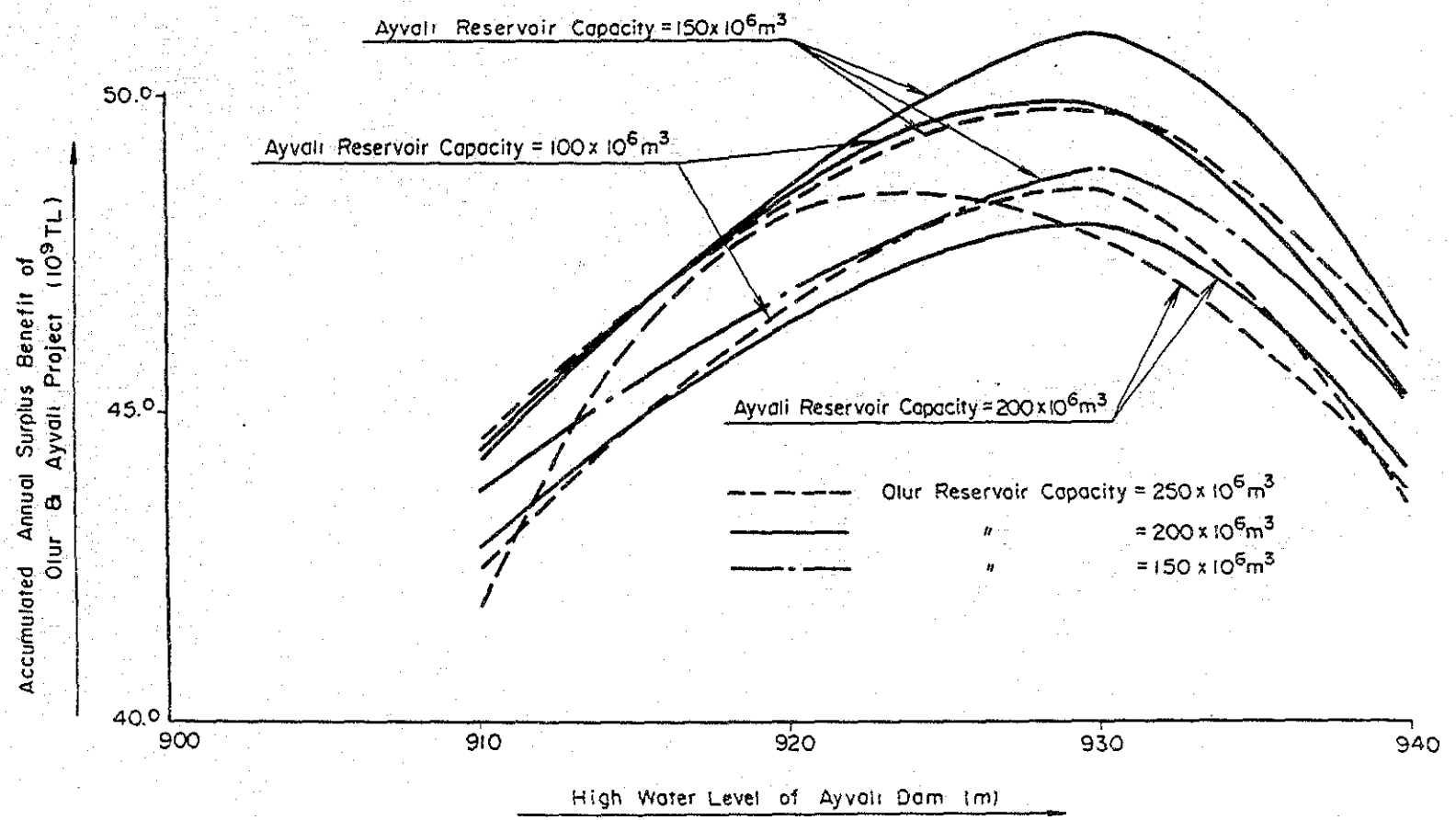


Fig. 8 Optimization Study on Effective Storage Capacity and High Water Level of Ayvali Project

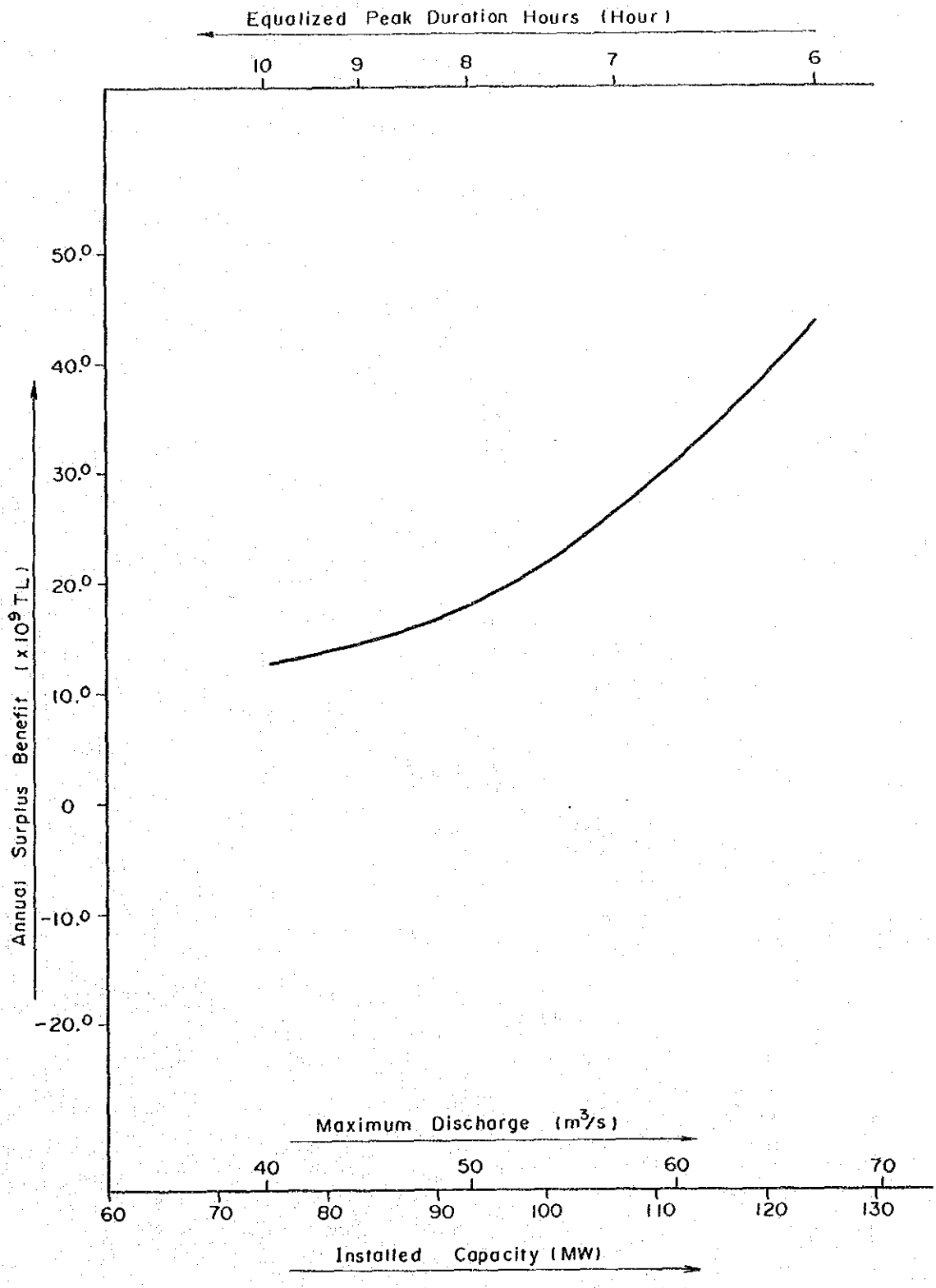


Fig. 9 Optimization Study on Installed Capacity of Ayvalı Project

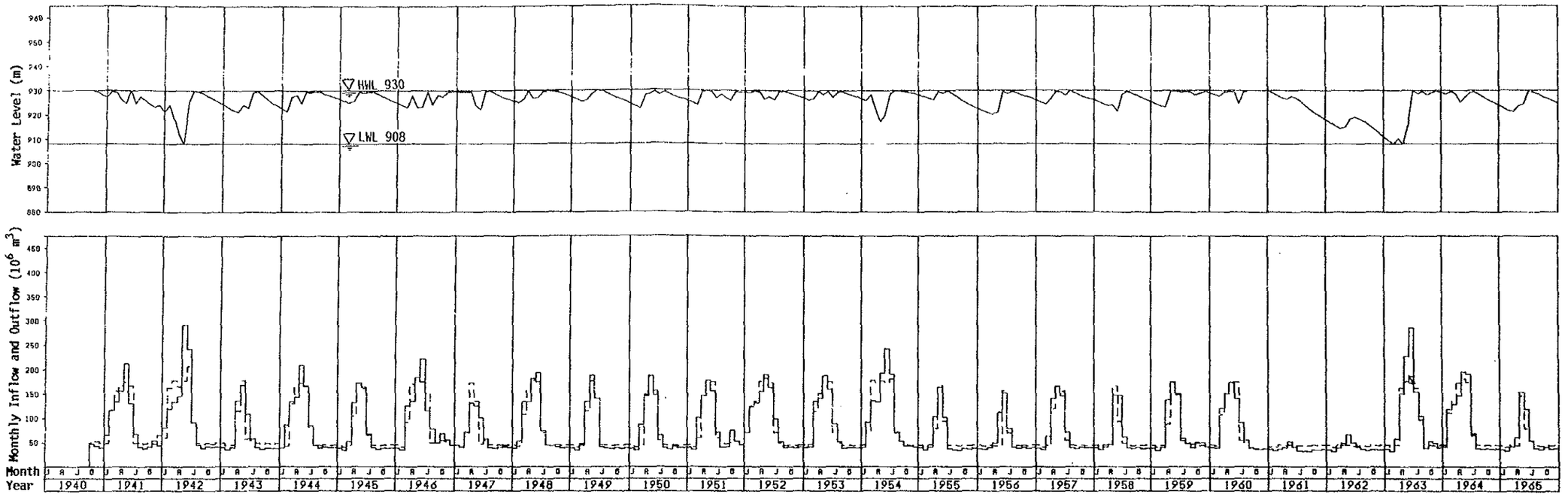
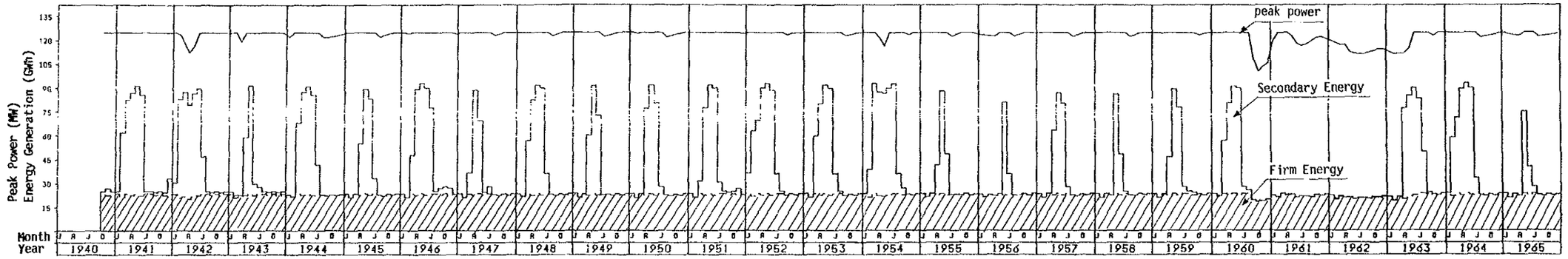


Fig. 10 Ayvalı Reservoir Operation



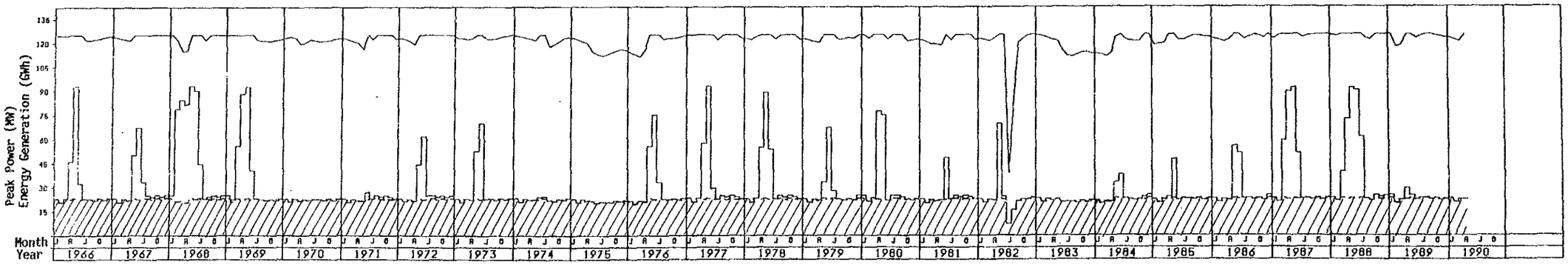
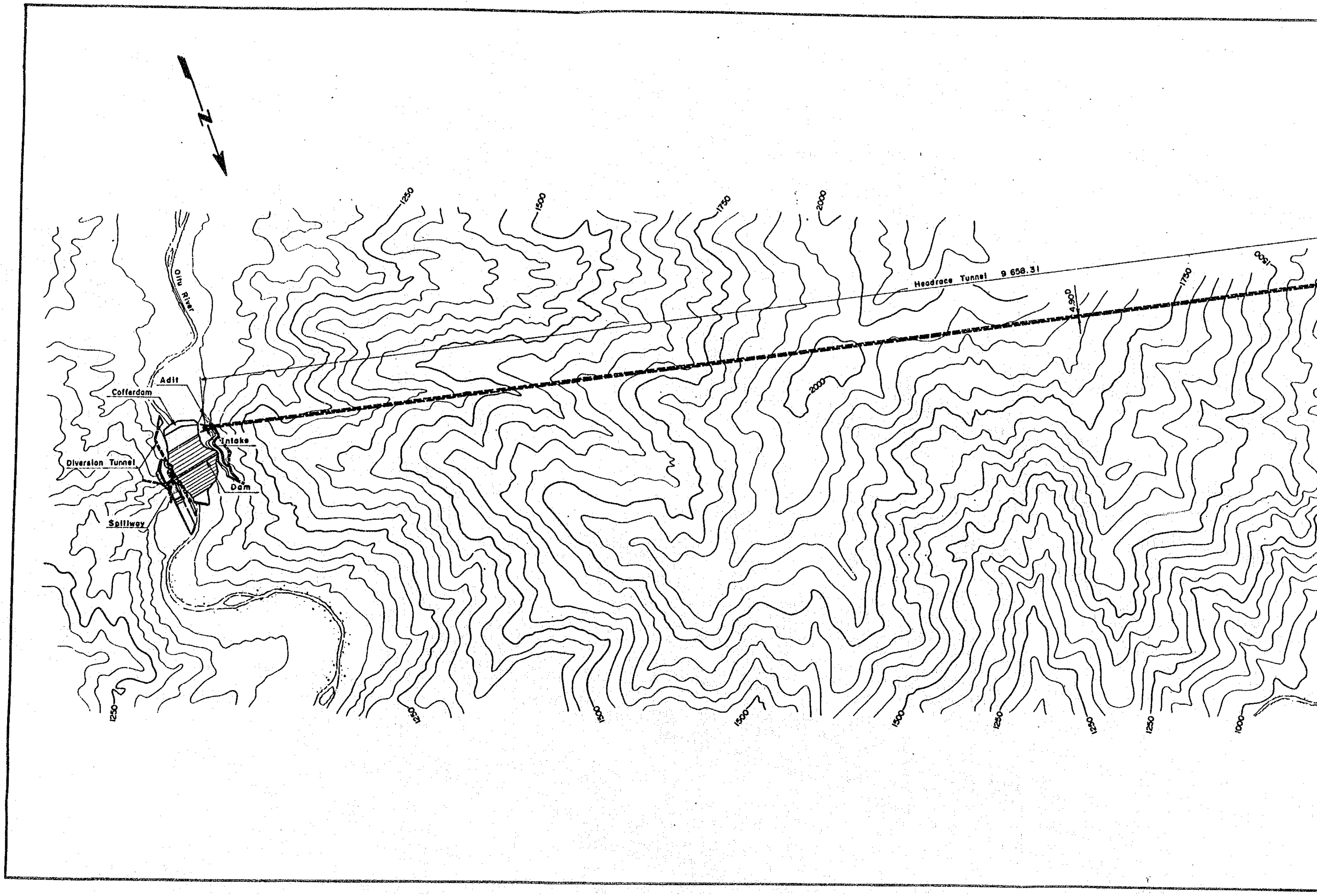
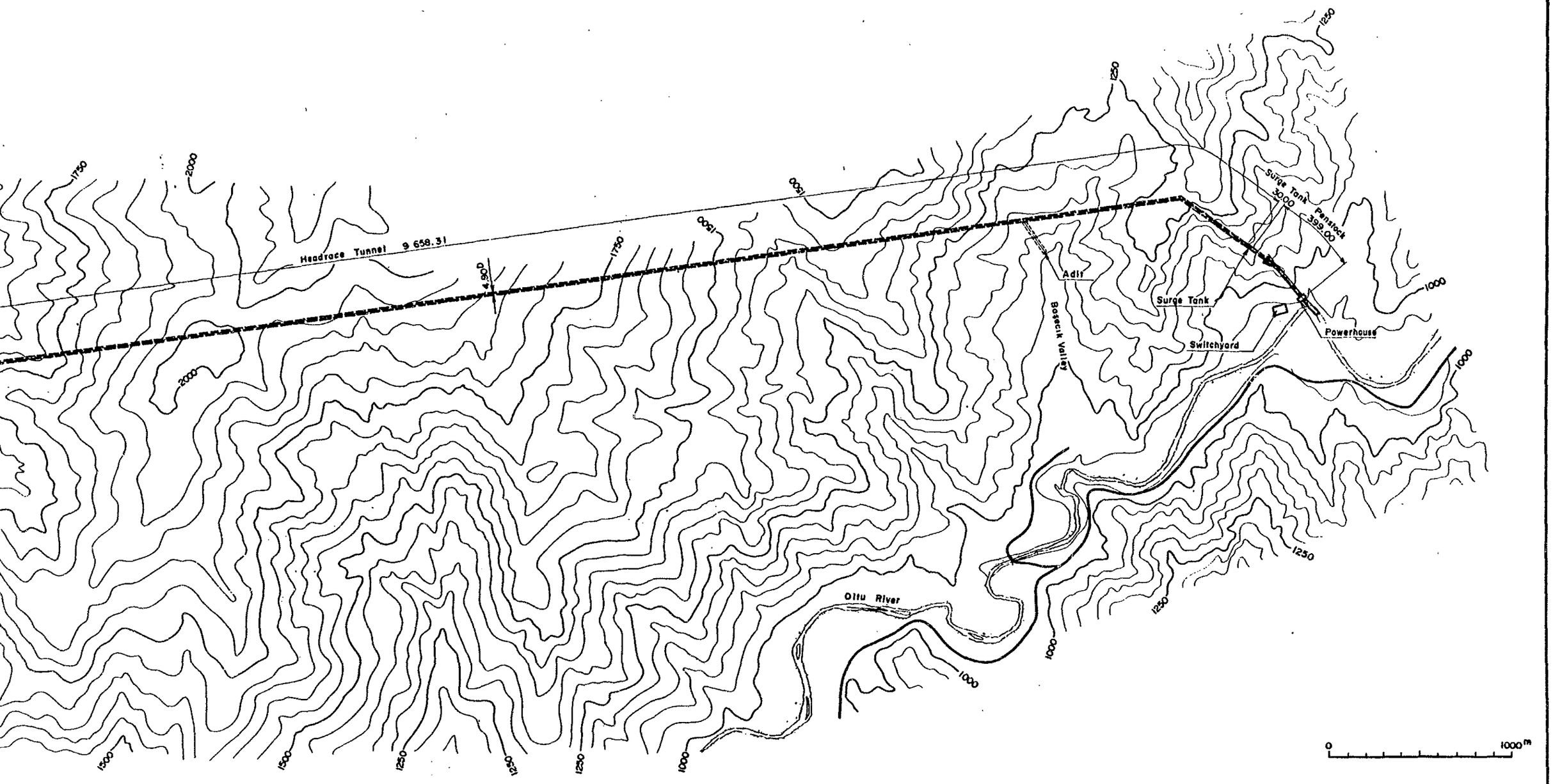


Fig. 11 Energy Generation of Ayvali Project


N
Olta River
Adit
Cofferdam
Intake
Diversion Tunnel
Dam
Spillway
Headrace Tunnel 9 658.31
4,900
1250
1500
1750
2000
1000

業
(5-9)



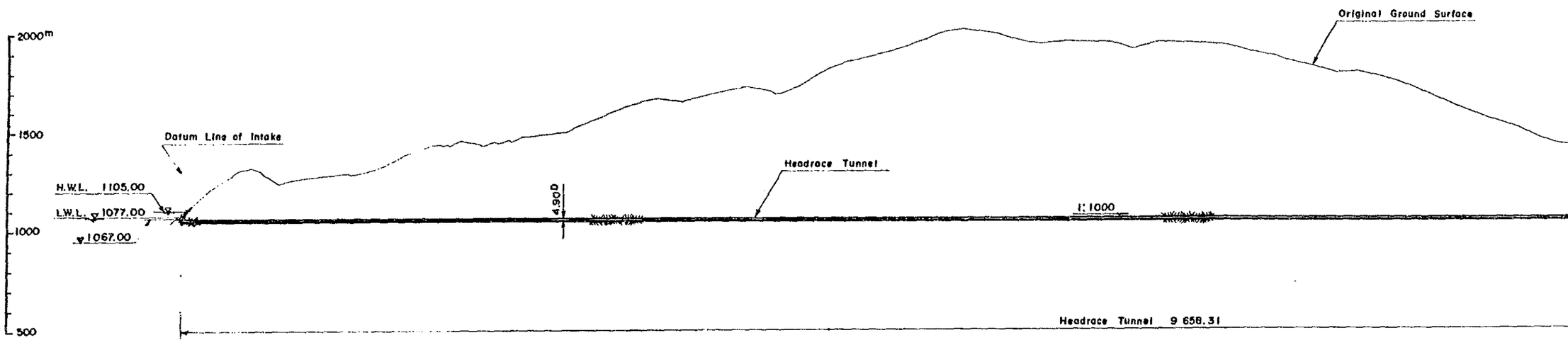
OLTU RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

OLUR PROJECT

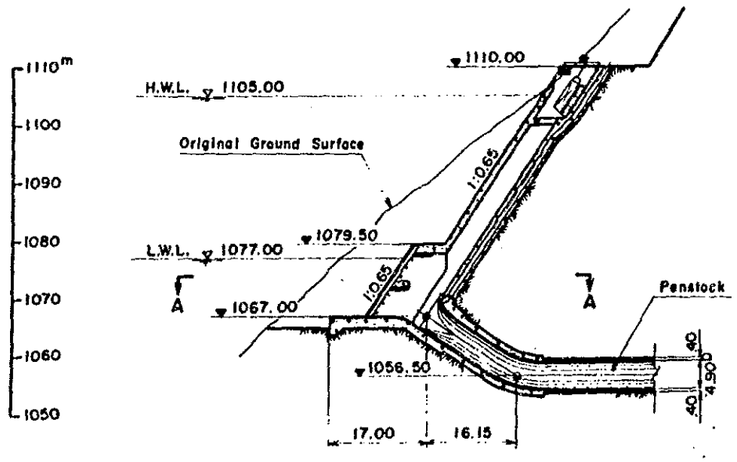
GENERAL PLAN

Fig. 12

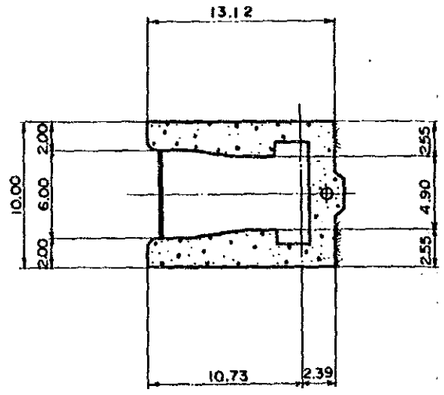
PROFILE



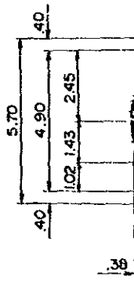
TYPICAL SECTION OF INTAKE



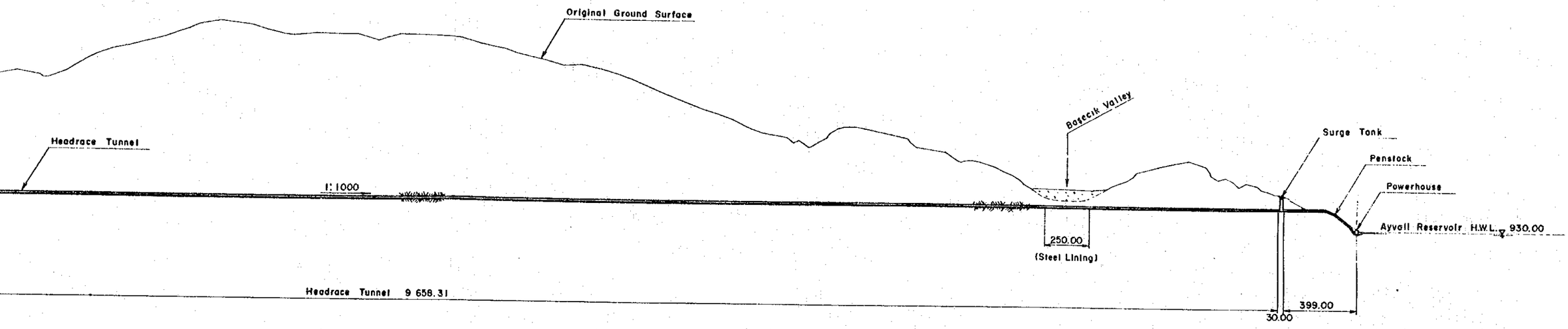
SECTION A-A



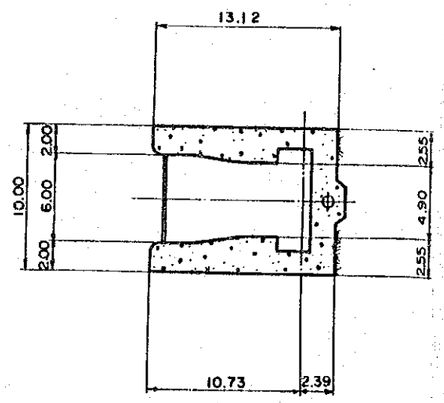
TYPICAL SEC



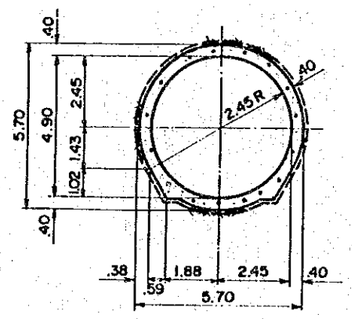
PROFILE



SECTION A – A



TYPICAL SECTION OF HEADRACE TUNNEL



0 1000m (PROFILE)

0 50m (TYPICAL SECTION OF INTAKE)

0 20m (SECTION A – A)

0 10m (TYPICAL SECTION OF HEADRACE TUNNEL)

OLTU RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

OLUR PROJECT

WATERWAY

PROFILE AND SECTIONS

Fig. 13

Intake

1067.00

12.00

Axis of Dam

1110.00

1: 2.2

Cofferdam

1045.00

1028.00

1: 2.2

328.00

1: 1.9

Inlet of Outlet Works

Cofferdam

1: 2.2

1027.00

Diversion Tunnel

1022.00

Outlet Works

1084.00

46.50

1: 10

1: 1.0

Oltu River

1022.00

Spillway

Grout Tunnel

Access of Outlet Works

0 100m

OLTU RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

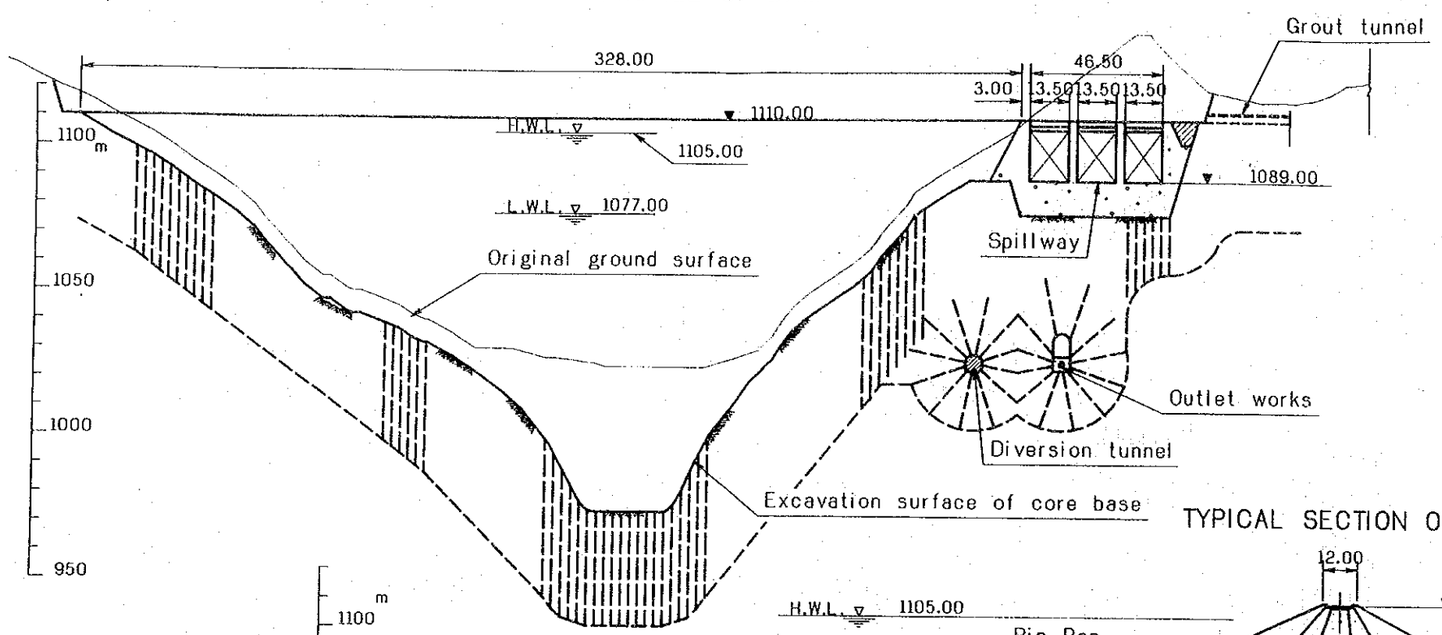
OLUR PROJECT

DAM

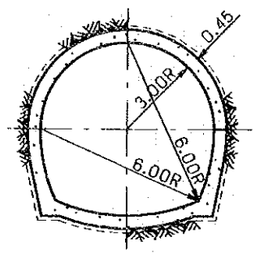
GENERAL PLAN

Fig. 14

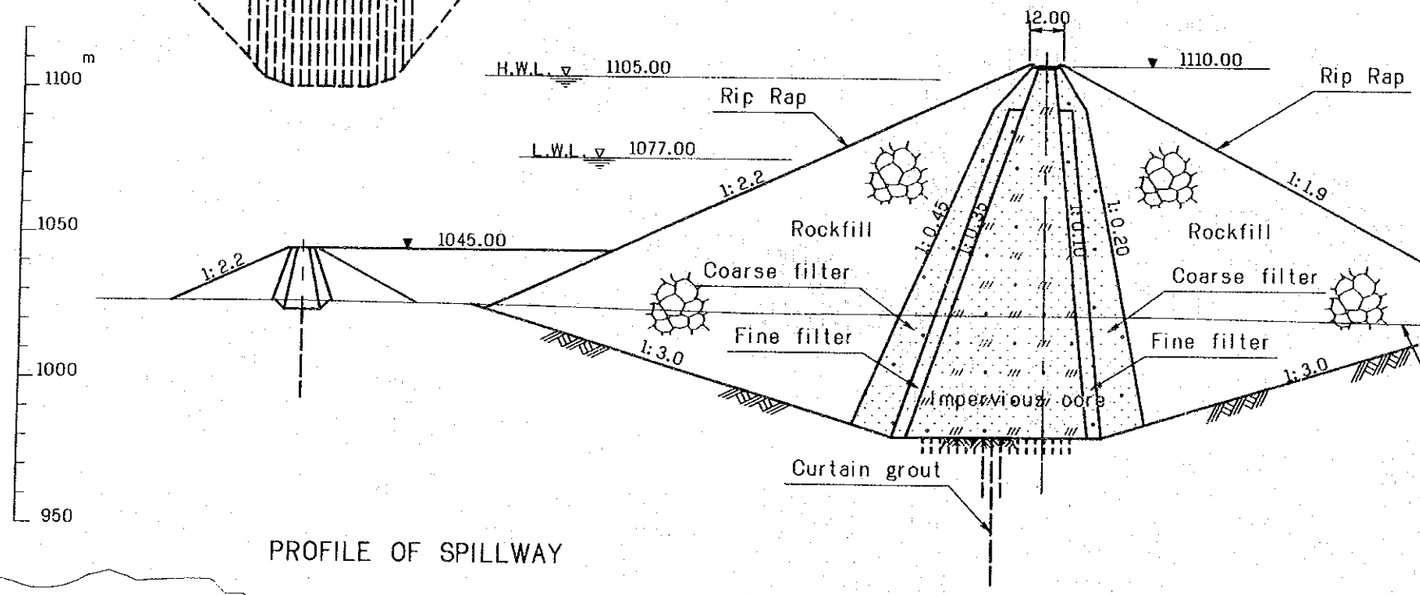
PROFILE OF DAM



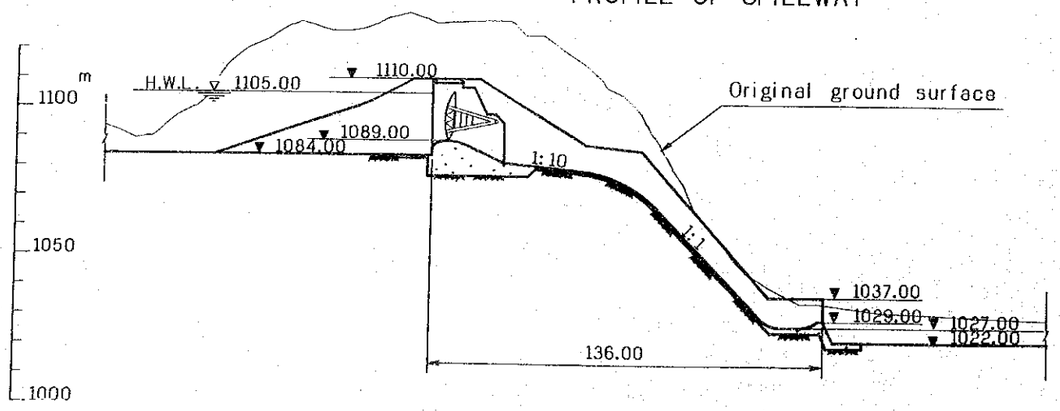
TYPICAL SECTION OF DIVERSION TUNNEL



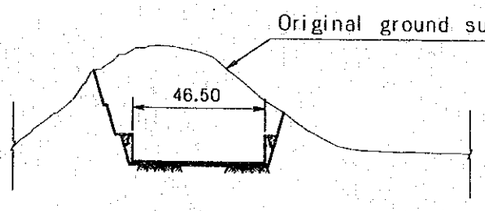
TYPICAL SECTION OF DAM

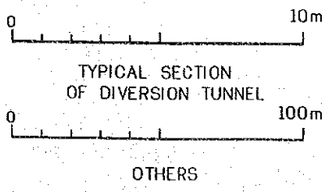


PROFILE OF SPILLWAY



TYPICAL SECTION OF SPILLWAY

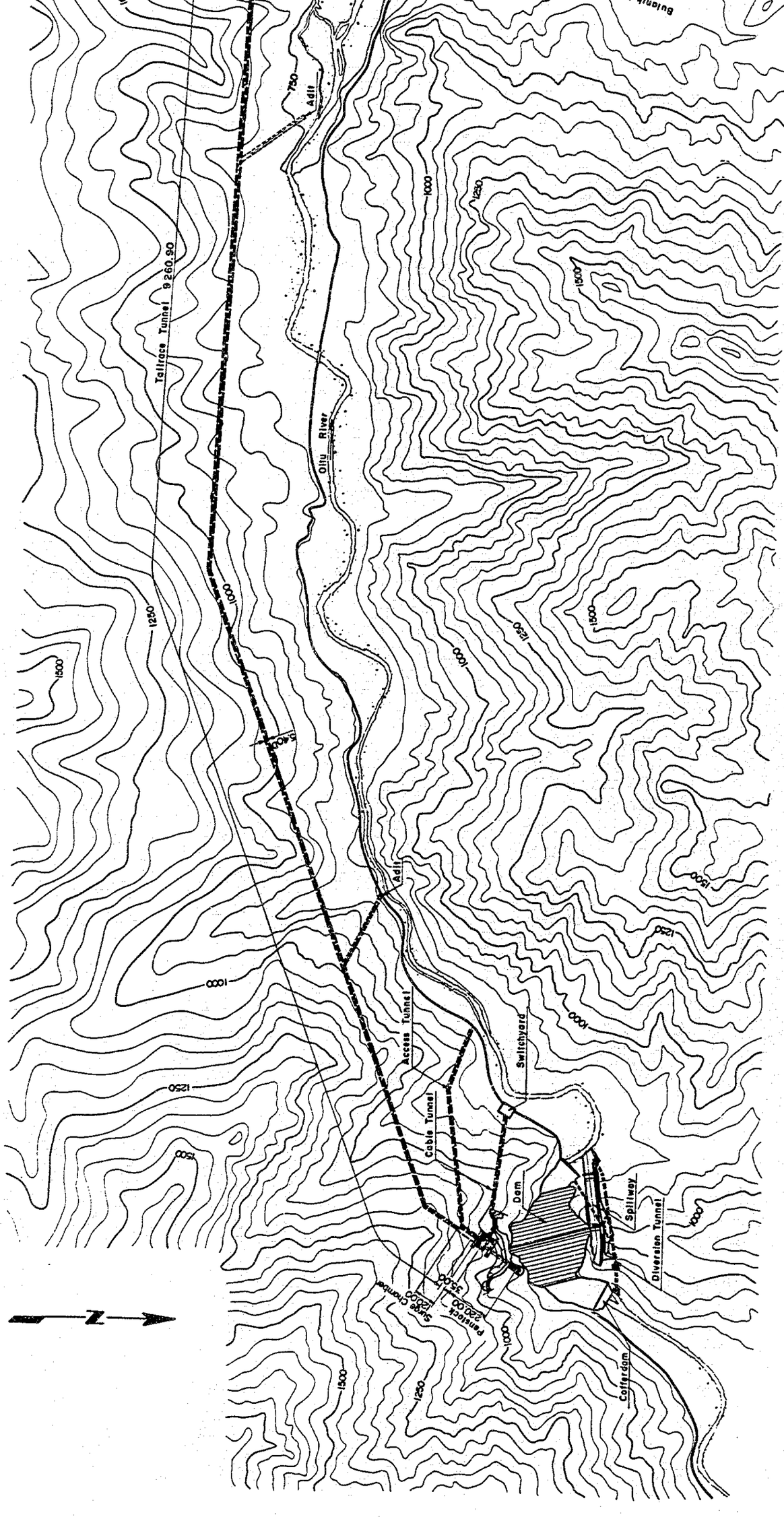


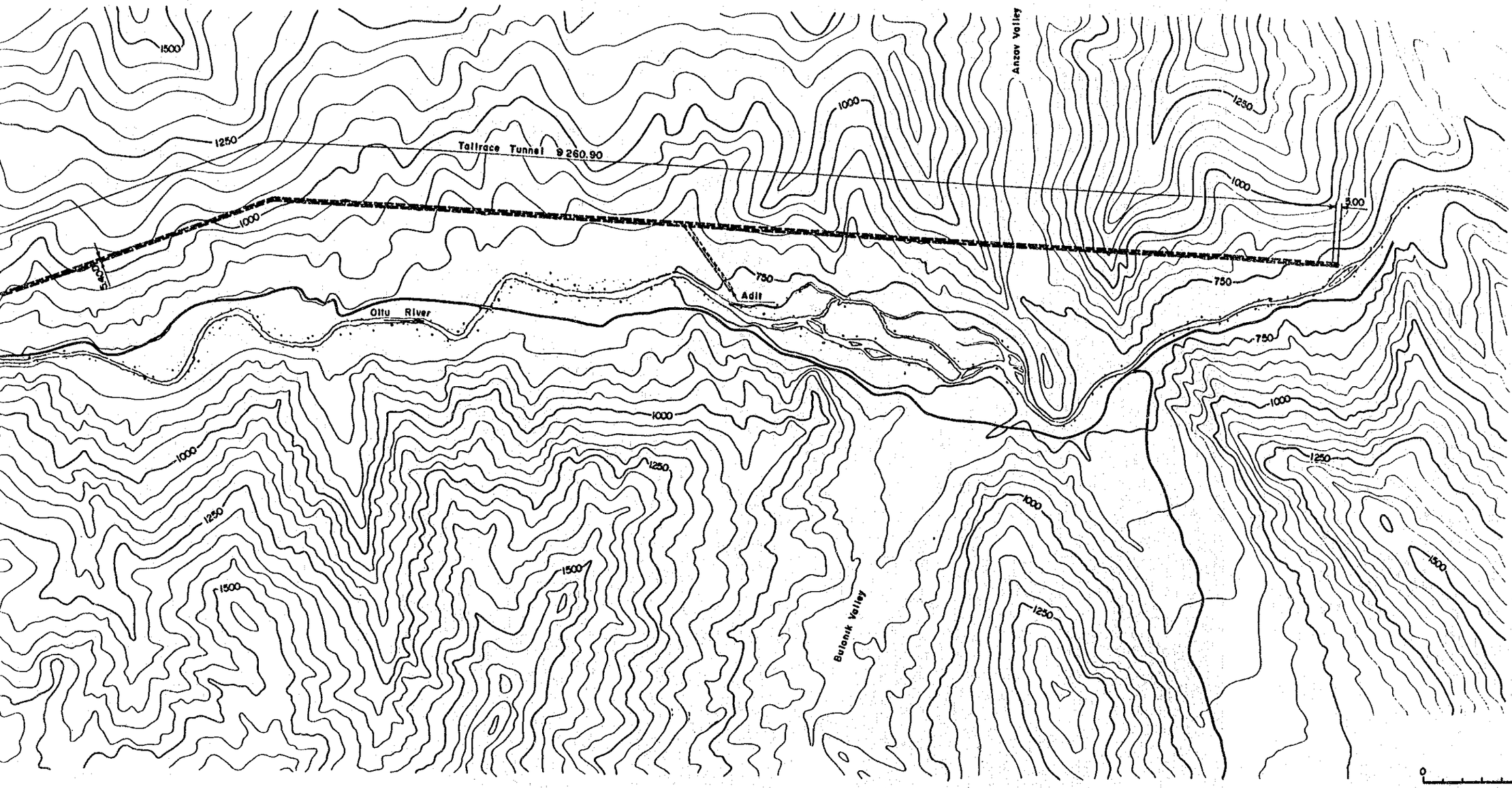


OLTU RIVER HYDROELECTRIC
POWER DEVELOPMENT PROJECT

OLUR PROJECT
DAM
PROFILE AND SECTIONS

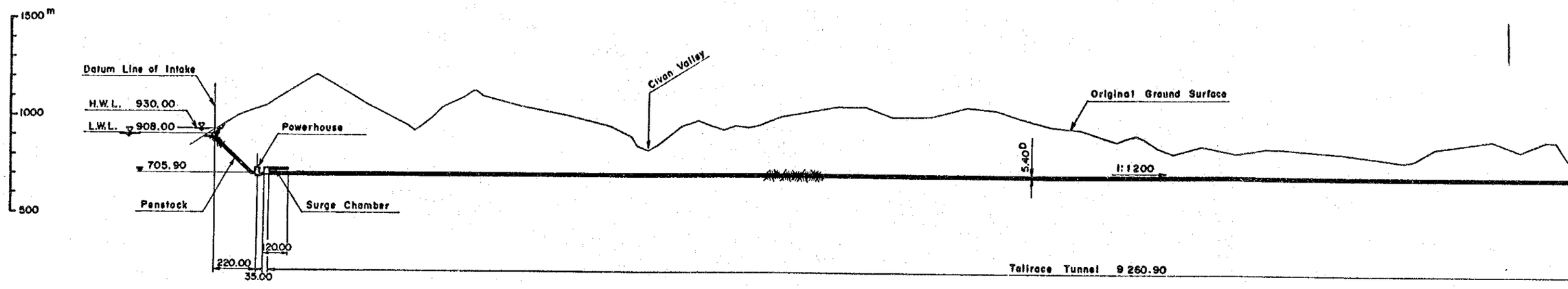
Fig. 15


Tailrace Tunnel
9 260.90
Adit
750
Olitu River
1000
1250
1500
Adit
Access Tunnel
Cable Tunnel
Switchyard
Dam
Spillway
Diversion Tunnel
Cofferdam
Surge Chamber
Penstock
2200.00
3500
N

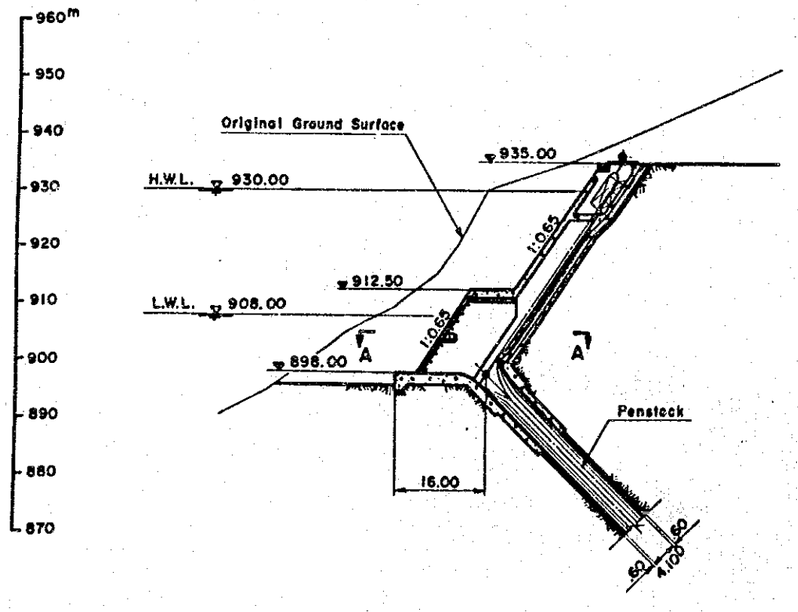


OLTU RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT	
AYVALI PROJECT	
GENERAL PLAN	
Fig. 16	

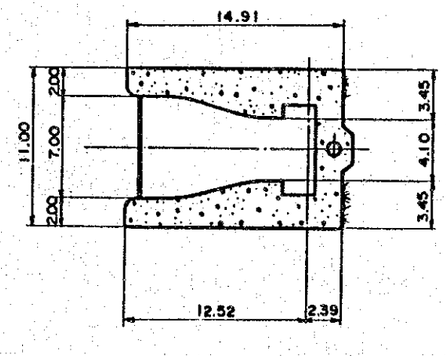
PROFILE



TYPICAL SECTION OF INTAKE

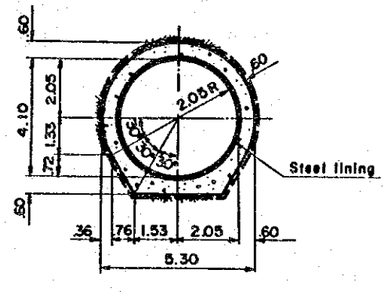


SECTION A – A

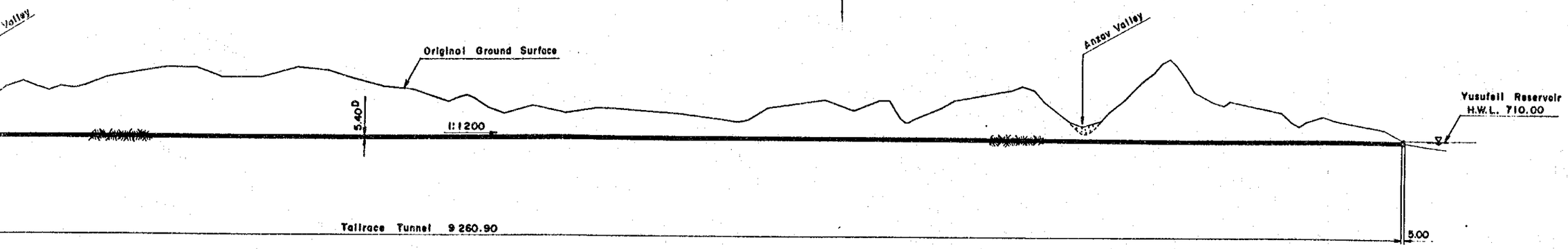


TYPICAL

PENSTOCK



PROFILE



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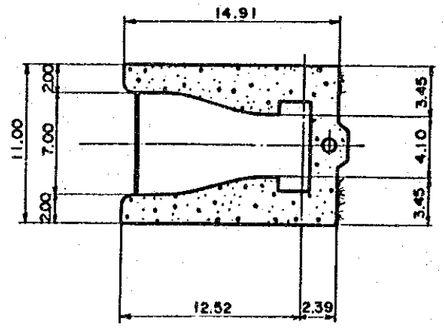
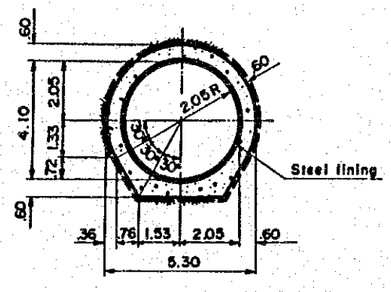
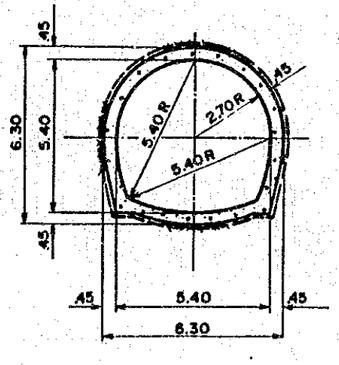


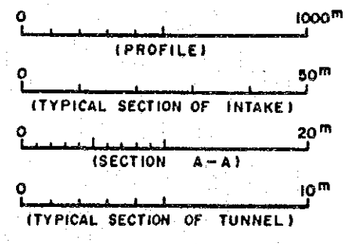
TYPICAL SECTION OF TUNNEL

PENSTOCK



TAILRACE TUNNEL





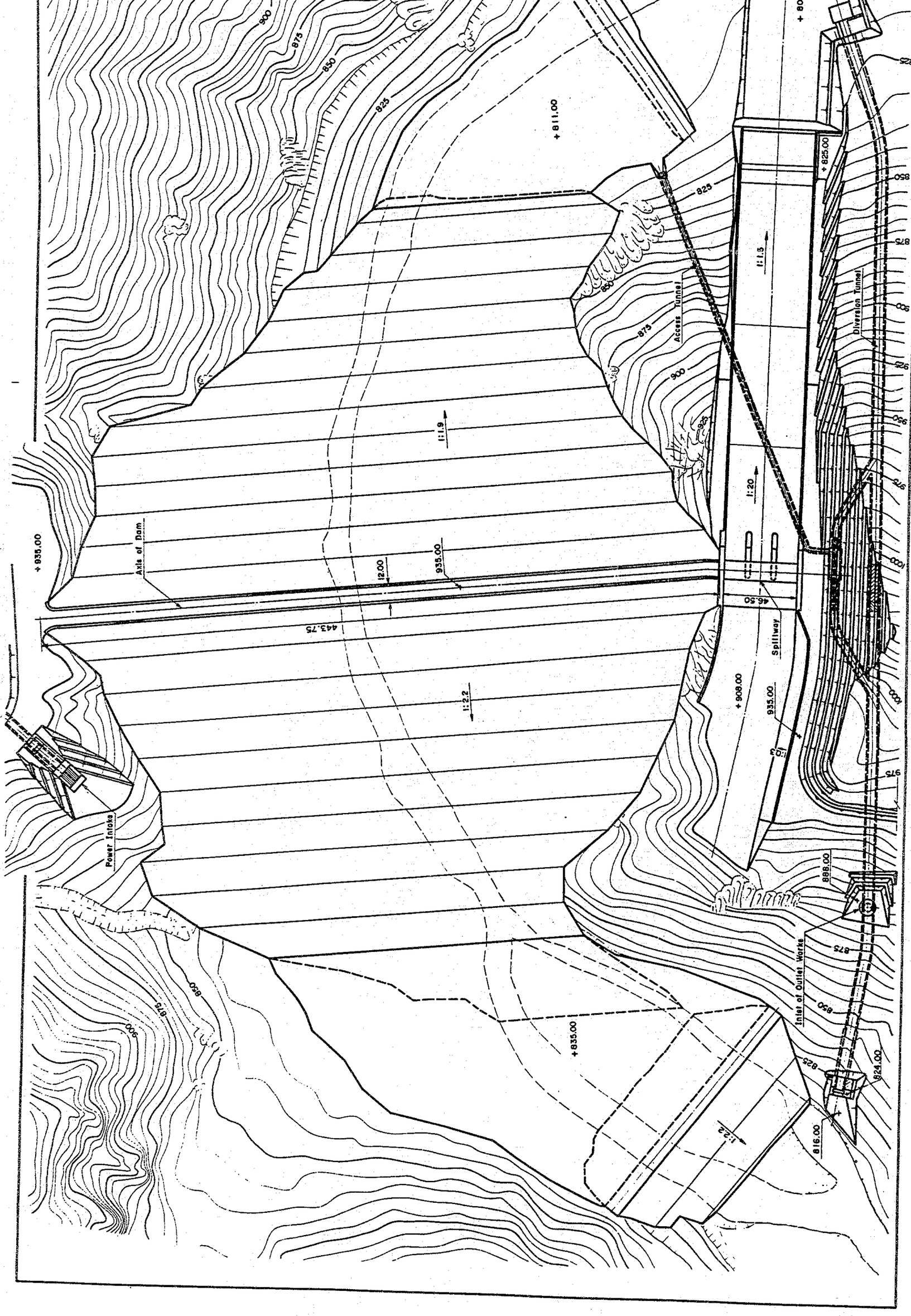
OLTU RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

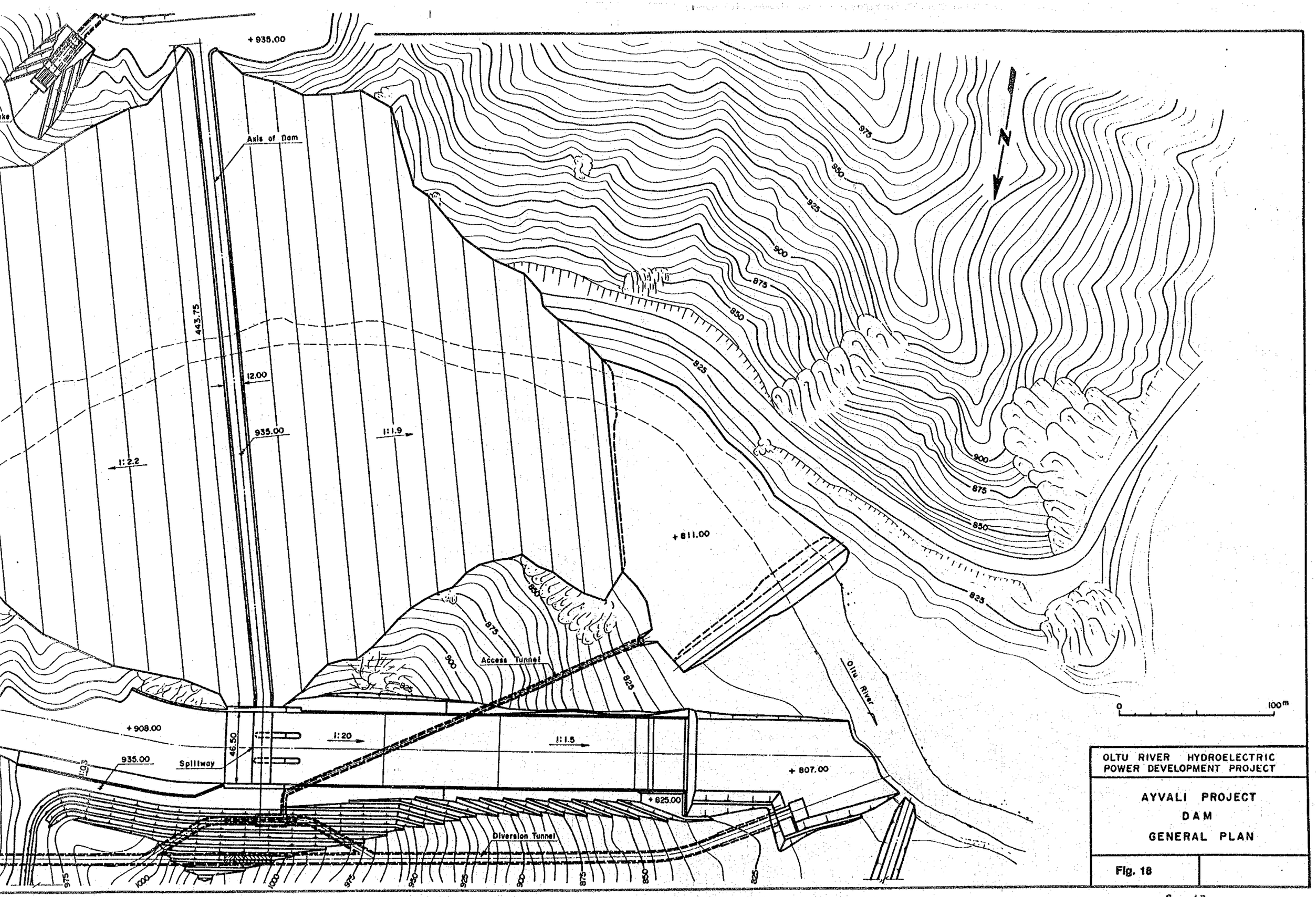
AYVALI PROJECT

WATERWAY

PROFILE AND SECTIONS

Fig. 17


+ 935.00
Axis of Dam
12.00
935.00
443.75
1:1.9
1:2.2
+ 811.00
825
850
875
900
1:1.5
Access Tunnel
Diversion Tunnel
+ 825.00
1:20
46.50
Spillway
+ 908.00
935.00
1:0.3
975
888.00
Power Intake
Inlet of Outlet Works
+ 835.00
824.00
816.00



OLTU RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

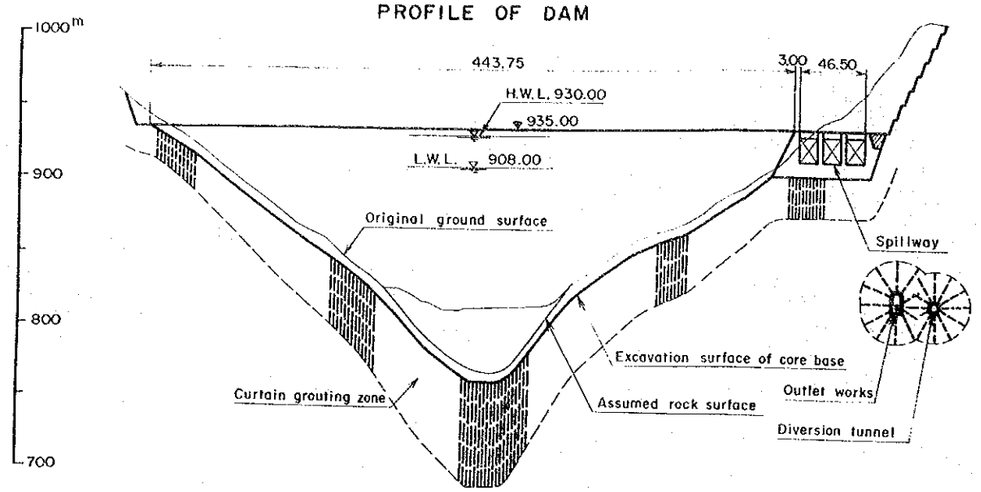
AYVALI PROJECT

DAM

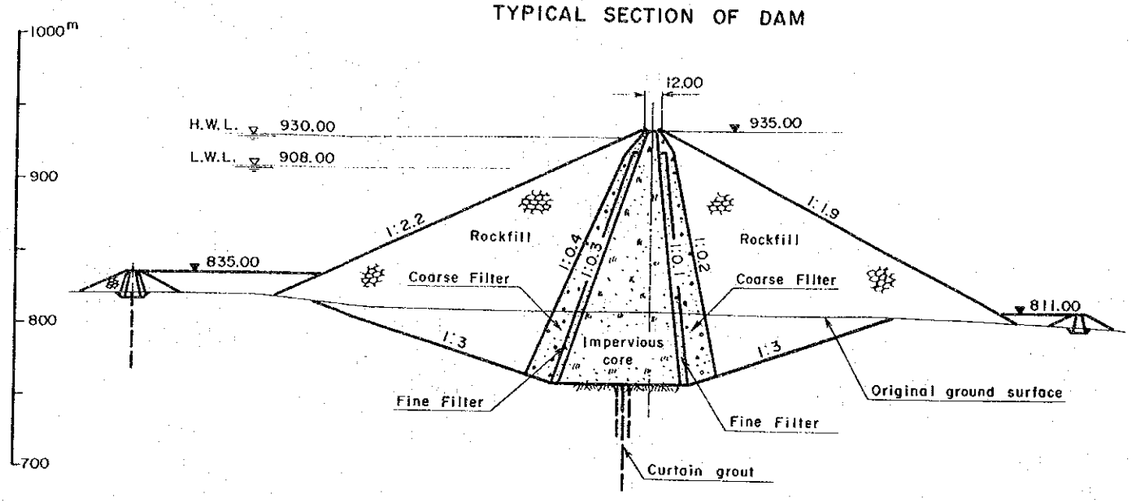
GENERAL PLAN

Fig. 18

PROFILE OF DAM



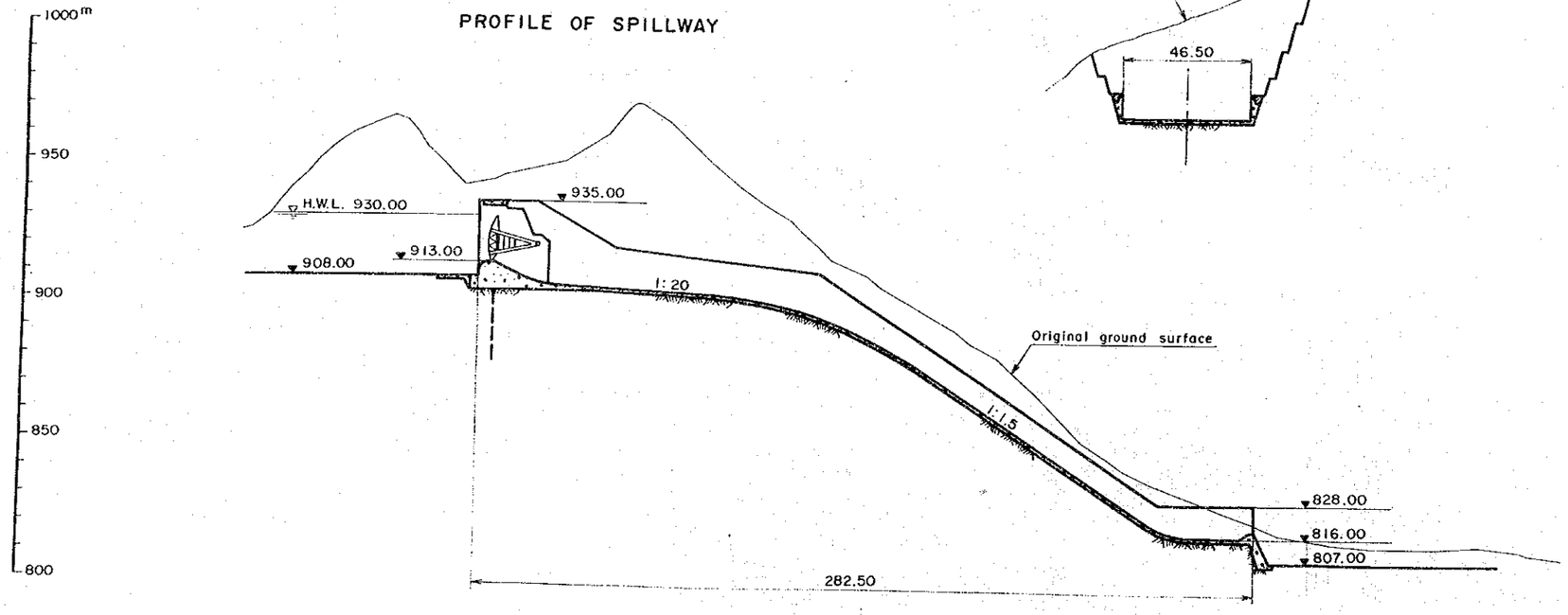
TYPICAL SECTION OF DAM



TYPICAL SECTION OF SPILLWAY

TYPICAL SECTION OF DIVERSION TUNNEL

PROFILE OF SPILLWAY



0 200m
PROFILE OF DAM
TYPICAL SECTION OF DAM

0 100m
PROFIL OF SPILLWAY
TYPICAL SECTION OF SPILLWAY

0 10m
TYPICAL SECTION
OF DIVERSION TUNNEL

OLTU RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

AYVALI PROJECT
DAM
PROFILE AND SECTIONS

Fig. 19

4. CONSTRUCTION SCHEDULE AND CONSTRUCTION COST

4.1 Construction Schedule

Commissioning year of the Oltu Project is appropriate at around 2006 considering necessary periods of additional field investigation works, detailed design, financial formulation and construction of the project as shown below.

Nov. 1990 - Oct. 1992	Feasibility Study
Nov. 1993 - Oct. 1994	Provision and Award of Final Design (1 year)
Nov. 1994 - Oct. 1995	Final Design (2 years)
Nov. 1996 - Oct. 1997	Financial Formulation (1.5 years)
Nov. 1997 - Oct. 1999	Bidding and Award of Contract for Construction (1.5 years)
Nov. 2000 -	Start of Construction of the Olur and Ayvalı Projects
Dec. 2005 -	End of Construction of the Olur Project
Jun. 2006 -	End of Construction of the Ayvali Project

The construction works of the Oltu Project will require periods of approximately 6 years for Olur Project and approximately 6.5 years for Ayvalı Project as a result of studying the scale of construction, layout of structures, preparatory works, etc. Work Schedules at the Projects are given in Fig. 20 and 21.

4.2 Construction Cost

The construction cost of the Project was estimated, considering 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 July 1991. The exchange rate used was US$1.00 = 4,300 TL.

(1) Olur Project

With the total construction cost as 677,364 x 10^6 TC (US$ 157.5 x 10^6) the breakdown of local and foreign currency requirements is 413,190 x 10^6 TL (US$ 96.1 x 10^6), 264,174 x 10^6 TL (US$ 61.4 x 10^6) respectively.

(2) Ayvalı Project

With the total construction cost as 957,688 x 10^6 TL (US$ 222.7 x 10^6) the breakdown of local and foreign currency requirements is 534,046 x 10^6 TL (US$ 124.2 x 10^6), 423,642 x 10^6 TL (US$ 98.5 x 10^6) respectively.

(3) Total Project

With the total construction cost as 1,635,052 x 10^6 TL (US$ 380.3 x 10^6) the breakdown of local and foreign currency requirements is 947,236 x 10^6 TL (US$ 220.3 x 10^6), 687,816 x 10^6 TL (US$ 160.0 x 10^6) respectively.

Detailed construction cost is as shown in Table 2.

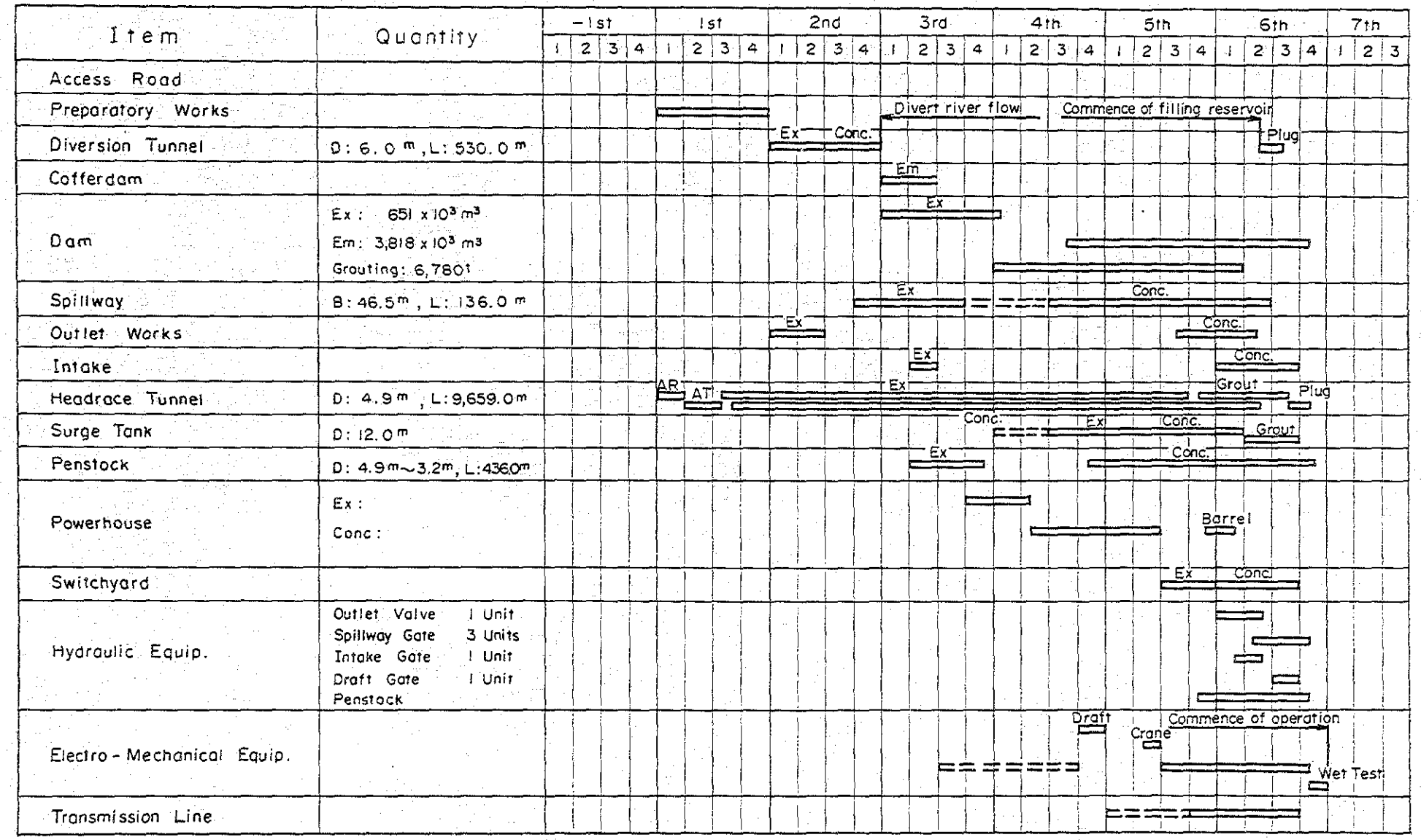


Fig. 20 Construction Schedule of the Olur Project

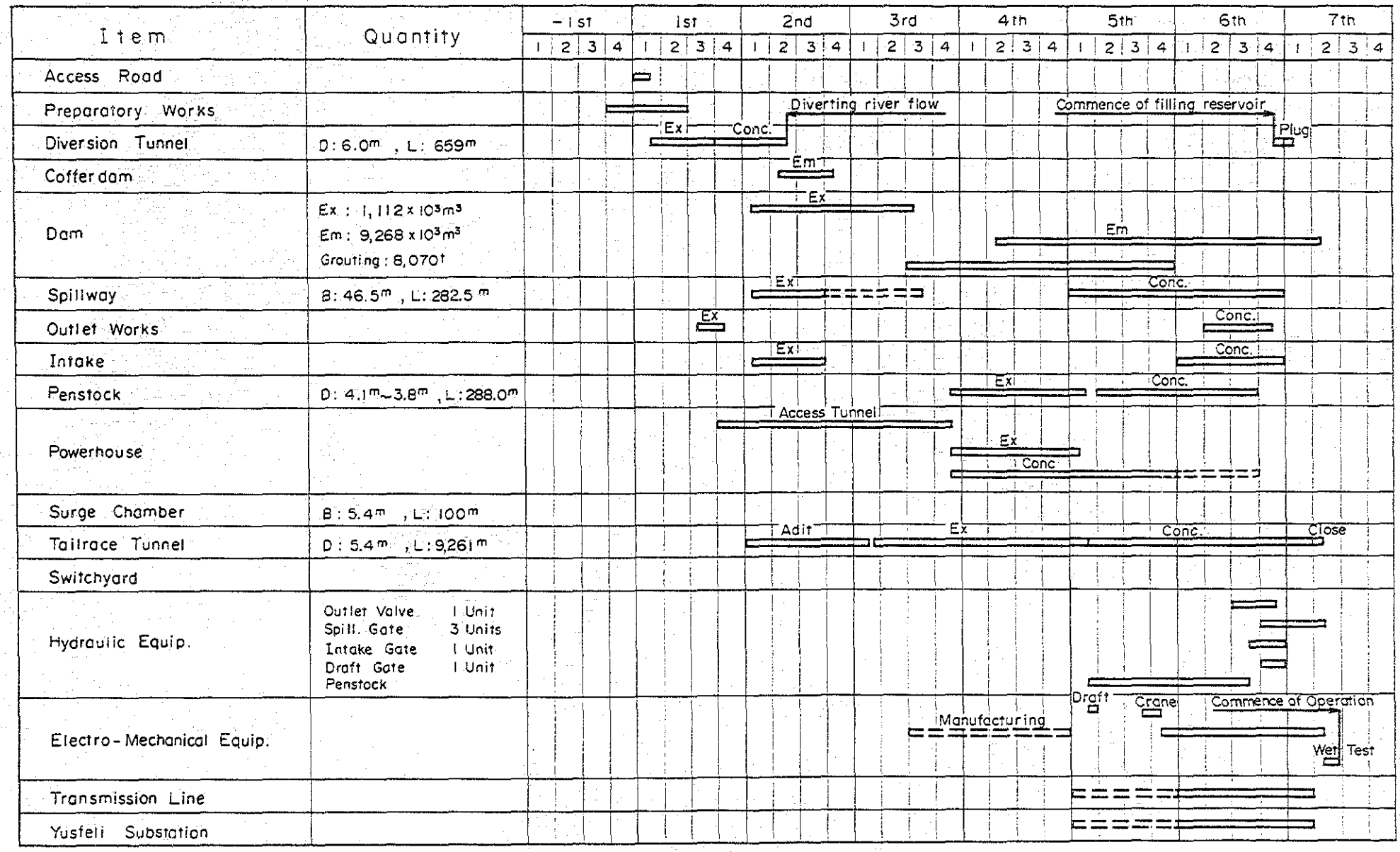


Fig. 21 Construction Schedule of the Ayvalı Project

Table 2 Construction Cost of Oltu Project

Item	Olur Project			Ayvalı Project			Oltu Project Total		
	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency	Total
Relocation Road	0	14,000	24,000	0	28,000	28,000	0	42,000	42,000
Camp Facilities	0	5,000	5,000	0	5,000	5,000	0	10,000	10,000
Land Acquisition	0	51,752	51,752	0	34,106	34,106	0	85,858	85,858
Civil Work							0	0	0
Diversion	3,008	6,007	9,015	3,128	6,914	10,042	6,136	12,921	19,057
Care of River	6,592	4,863	11,455	7,389	5,043	12,432	13,981	9,906	23,887
Dam	62,234	51,003	113,237	138,720	108,390	247,110	200,954	159,393	360,347
Spillway	12,105	17,123	29,228	24,058	32,850	56,908	36,163	49,973	86,136
Outlet Works	2,243	4,675	6,918	1,604	3,373	4,977	3,847	8,048	11,895
Intake	731	2,136	2,867	954	2,887	3,841	1,685	5,023	6,708
Headrace Tunnel	35,737	79,264	115,001	0	0	0	35,737	79,264	115,001
Surge Tank	1,500	3,777	5,277	0	0	0	1,500	3,777	5,277
Penstock	786	1,782	2,568	653	1,680	2,333	1,439	3,462	4,901
Powerhouse	3,016	4,015	7,031	6,286	14,198	20,484	9,302	18,213	27,515
Tailrace	0	0	0	38,698	82,562	121,260	38,698	82,562	121,260
Switchyard	328	442	770	2,005	1,000	3,005	2,333	1,442	3,775
Subtotal	128,280	175,087	303,367	223,495	258,897	482,392	351,775	433,984	785,759
Hydraulic Equipment	0	30,965	30,965	0	25,507	25,507	0	56,472	56,472
Electro-Mechanical Equipment	62,738	12,826	75,564	78,283	18,233	96,516	141,021	31,059	172,080
Transmission Line	0	4,454	4,454	0	9,790	9,790	0	14,244	14,244
Total Cost	191,018	294,084	485,102	301,778	379,533	681,311	492,796	673,617	1,166,413
Contingency	15,965	21,821	37,786	26,264	31,866	58,130	42,229	53,687	95,916
Engineering and Administration Cost	19,102	24,233	43,335	30,178	34,543	64,721	49,280	58,776	108,055
Interest During Construction	38,089	73,052	111,142	65,423	88,104	153,527	103,512	161,156	264,668
Grand Total	264,174	413,190	677,364	423,642	534,046	957,688	687,816	947,236	1,635,052

5. ECONOMIC EVALUATION AND FINANCIAL ANALYSIS

Development of the Olur Project and Ayvalı Project will be implemented simultaneously. Optimization of the project was carried out in the manner that the combination of the two projects as a whole would be most optimum. No consideration has been made in the case that the Olur and Ayvalı Projects would be developed individually.

Therefore, the result of economic and financial analyses should be evaluated about the Oltu Project as a whole.

5.1 Economic Evaluation

As the method of the economic evaluation of this project, an alternative plant approach is employed to measure and evaluate economic costs of the proposed project and the alternative project.

The results of evaluation of EIRR, B-C and B/C of the Olur and Ayvalı projects and the combined project are as follows:

	EIRR	B - C	B/C
Olur Project	18.72%	137,774 x 10^6 TL (US$ 32.0 x 10^6)	1.33
Ayvalı Project	33.05%	401,170 x 10^6 TL (US$ 93.3 x 10^6)	1.71
Combined Total Project	26.82%	538,944 x 10^6 TL (US$ 125.3 x 10^6)	1.54

As indicated by indices B-C and B/C of the combined project, the costs of construction and operation of the project are much smaller than those of an alternative thermal power plant which can provide equivalent service, and it can be also concluded that

the project can continue to maintain its superiority as long as the discount rate which reflects the capital opportunity cost does not exceed 26.82%.

5.2 Financial Analysis

For the financial analysis of the project, "Financial Evaluation from Viewpoint of Total Investment-Calculation of the Financial Internal Rate of Return" is analyzed and judgement is made for evaluation.

FIRRs of the Olur Project and the Ayvalı Project are 9.87% and 11.25% respectively and that of the combined project is 10.68%.

Judging from the FIRR of the combined total project, the project is sound from the financial point of view.

6. CONCLUSIONS

This project site is on the midstream stretch of the Oltu River, a tributary of the Çoruh River which is located in the northeastern part of the Republic of Turkey and empties into the Black Sea, the project consisting of construction of two power development schemes.

As a result of studies made based on the data investigated up to the present, the conclusion was drawn that both the Olur Project and the Ayvalı project are feasible, technically and economically. The Contents of the conclusions are described below.

(1) This Project is to be developed with the purpose of supplying plentiful and stable electric power which effectively utilizes water resources existing abundantly in Turkey, as purely indigenous resources which are practically nonpollutant. It is considered that going ahead with development of this Project will contribute to regional development.

(2) The growth of power demand in the Republic of Turkey up to 1983 was blunted because of sluggished economics; however, annual growth at the 7.8 - 12.5% level was indicated from 1984 to 1990, and annual average growth rates from 1991 to 1995 and 1996 to 2010 are expected to be 10% and 8% respectively. Therefore, it is calculated that the peak demand at 2010 will be 50,600 MW.

(3) As principal energy resources produced in the Republic of Turkey, there are the 5.7×10^6 ton of petroleum reserves, 12.9×10^6 ton of lignite reserves and 30,800 MW of hydroelectric power potential. Of this hydroelectric 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, 20,100 MW is planned to be developed by 2010.

(4) Review of the development scheme recommended by the Oltu River Master plan Report carried out and appropriate selection of development layout, development scale and development time was implemented. Development of the Olur Project and Ayvalı Project should be implemented simultaneously and both projects should be commissioned by the middle of 2006.

(5) The Oltu project is planned as the most efficient power generation scheme to effectively utilize the head existing between the vicinity of EL. 1,100 m and the water level of Yusufeli Reservoir, EL. 710 m, based on the Master Plan for the Oltu River Basin. River gradients are steep in this area, and hard rock is exposed at both banks with the topography very rugged so that the area has site characteristics favourable for formulating dam-and-waterway type plans combining reservoirs and tunnels. Comparisons were made of two-stage, three-stage, and four-stage proposals and with power station locations varied, and the present two-stage development Basic Project Plan of the Olur project, OPK Alternative, and the Ayvalı Project, APU Alternative, was selected as being most advantageous.

(6) Regarding the Olur Project, two dam sites and four powerhouse sites were selected for the Olur Project and comparison studies were made. The upstream site was chosen for the dam, and the downstream most OPK site for the powerhouse location. The headrace length would be approximately 9 km is length.

Regarding the Ayvilı Project with the dam site as a single location, comparison studies were made of four sites for the powerhouse, including both underground and above-ground types, and the most economically advantageous dam-

underground powerhouse (APU site) - tailrace (approximately 10 Km is length) alternative was selected. This alternative was adopted due to the necessity of passing through the bedrock under the river bed of the Anzav Valley.

(7) Various comparison studies were made regarding high water level and scale of reservoirs taking into consideration sedimentation and effective storage capacities of reservoirs. As a result as shown in Fig. 4 and 8 high water level of EL. 1,105 m and effective storage capacity of 200 x $10^6 m^3$ was selected for the Olur project and high water level of EL. 930 m and effective storage capacity of 150 x $10^6 m^3$ was selected for the Ayvalı project.

(8) Regarding the optimum scale of the Oltu Project, comparison studies were made by varying maximum discharges in case of equivalent peak duration hours of 6 hours, 8 hours and 10 hours.

As the results as show in Fig. 5 and 9, the case of equivalent peak duration hours of 6 hours is optimum for both the Olur and the Ayvalı Project. Therefore Optimum Scale of the Olur and Ayvalı Projects are 65 MW and 125 MW respectively.

(9) The geology of Olur Reservoir consists of gabbro, spilite, and green schist of the Yusufeli Formation, lava and tuff of Ayvalı volcanic rocks, mudstone, marl, sandstone, and conglomerate of the Cenzoic Tertiary Period Oltu Formation, and Quaternary deposits.

There will be no problem regarding the water-tightness of the reservoir, while large-scale landslides at slopes in the reservoir area do not exist.

The geology at the site of Olur Dam consists of granite porphyry, rhyolite, diabase, and river deposits, and there is ample bearing power as the foundation for a rockfill dam of height 136 m. It is considered that the impermeability of the foundation rock can be easily secured with ordinary cement grout.

(10) Regarding the type of Olur Dam, a central impervious core rockfill dam was selected as being economically advantageous upon comparison studies considering topography, geology, meteorology, materials, etc. The height of the dam is to be 136 m and the dam volume 3.8 x 10^6 m^3.

Of embankment materials, soil materials are to be collected from Kaledibi Borrow Area approximately 3 km upstream of the dam and Yolboyu Borrow Area 8 km upstream and used upon gradation adjustments. Riverbed sand-gravel excavated from the dam site is to be used as fine-grained filter, and excavated rock of higher content of fines is to be used as coarse-grained filter.

Rock materials are to be collected from a quarry at the right bank 1.0 km downstream from the dam and used for embankment.

The spillway is to be a chute type with flip bucket at the right bank having 3 gates, and the flood discharge capacity is to be the PMF of 4,750 m^3/s.

(11) The intake is to be approximately 170 m upstream of the dam and is to be an inclined type. The power discharge of the power station is to be 48 m^3/s. The headrace route was selected to be as short as possible between the dam and powerhouse while taking into consideration topography, geology, work execution properties, and safety. The inside diameter and length of the headrace are 4.9 m and 9,659 m,

respectively. A restricted orifice type was adopted for the surge tank. The penstock is to be a surface type. The diameters are from 4.9 to 3.2 m, while the length is 436 m.

(12) The powerhouse of Olur Power Station was selected to be an above-ground type giving consideration to topography, geology, work execution properties, access road, and the economics. The number of main equipment units was made one unit considering the scale of the electric power system of Turkey at the time of development, and the turbine and the generator are to be a vertical-shaft Francis turbine (65 MW) and a 3-phase, alternating-current synchronous generator (74,000 kVA).

The switchyard of the Olur Project is to be an outdoor type and provided adjacent to the powerhouse.

The electric power generated at Olur Power Station is to be sent to Yusufeli Switchyard via Ayvalı Switchyard by a 154 kV transmission line, and upon step-up to 380 kV, it is to be sent to load areas by 380 kV transmission line.

(13) The geology of Ayvalı Reservoir consists of Ayvalı volcanic rocks of lava, rhyolite, tuff, and volcanic breccia, the Pügey Formation of alternations of mudstone, marl, and limestone, and Quaternary deposits.

There is practically no possibility of leakage in the geology of the reservoir surroundings. The scales of landslides at the slopes around the reservoir are small and are not of a degree to impair the safety of the reservoir.

The geology at the site of Ayvalı Dam consists of volcanic breccia, tuff breccia, tuff, rhyolite, and river-bed deposits, and there is sufficient bearing power as the foundation for a rockfill dam of height about 175 m. It is

considered that securing impermeability of the foundation rock is amply possible with ordinary cement grout.

(14) Regarding the type of Ayvalı Dam, a central impervious core rockfill dam was selected as being economically advantageous upon considering topography, geology, meteorology, materials, etc. The height of the dam selected is to be 175 m, and the dam volume 9.3 x 10^6 m^3.

Of embankment materials, soil materials are planned to be obtained from borrow areas at the Bulanik Valley 8 km downstream from the dam and the Tavusker Valley 8 km upstream, and the materials collected from these borrow areas are to be used for embankment upon adjustment of grain sizes. For fine-grained filter, sand-gravel excavated from the dam site, and for coarse-grained filter, excavated rock of higher content of fines is to be used.

Rock materials are to be collected at a quarry site on the left bank upstream of the dam, transported, and banked. The spillway is to be a chute type with flip bucket at the right bank and having 3 gates. The flood discharge capacity is to be sufficient for PMF of 5,270 m^3/s.

(15) The intake of the Ayvalı Project is to be an inclined type equipped with gate provided at the left bank approximately 100 m upstream from the dam. The power discharge of the power station is to be 67 m^3/s. The penstock continuing from the intake is to be a buried type. The diameters are to be from 4.1 to 3.8 m, and the length 288 m. The powerhouse of Ayvalı Power Station was selected to be an underground type from the standpoint of the layout of the waterway system. The bedrock at the left bank in the vicinity of the dam is considered to be capable of amply withstanding excavation of a large cavern for an underground powerhouse. The underground powerhouse and Yusufeli Reservoir are to be connected by a standard

horseshoe-shaped tailrace tunnel of diameter 5.4 m and length 9,261 m.

(16) The number of main equipment units of Ayvalı Project is to be one unit according to the same thinking as for Olur Power Station with a turbine of vertical-shaft Francis turbine (125 MW) and a generator of 3-phase, alternating current synchronous generator (140,600 kVA). A main transformer is installed in the powerhouse. The switchyard of the Ayvalı Project is to be an outdoor type with the powerhouse and the switchyard connected by a 154 kV x 1 cct XLPE cable transmission line. The electric power generated at Ayvalı Power station is to be sent to Yusufeli Switchyard by 154-kV transmission line, and upon step-up, sent to load areas by 380 kV transmission line.

(17) Total construction cost including foreign and local currencies of the Oltu Project is 1,635,052 x 10^6 TL (US$ 380.3 x 10^6). Total construction cost including foreign and local currencies of the Olur project and Ayvalı Project is 677,364 x 10^6 TL (US$ 157.5 x 10^6) and 957,688 x 10^6 TL (US$ 222.7 x 10^6) respectively.

(18) The environmental impact assessment was made based on field investigations and data collection during a short period of time, and there is hardly anything to be found in the results of studies against development of this Project. Further, from the points of view of electric power supply and regional development the Project should be aggressively developed. However, thorough consideration should be given to the people living in the area with regard to agricultural land to be submerged in the reservoirs and to other related matters.

(19) 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) of the Oltu Project are 538,944 x 10^6 TL (US$125.3 x 10^6) and 1.54 respectively.

And the net present values (B-C) and the benefit cost ratios (B/C) of Olur and Ayvalı Projects are 137,774 x 10^6 TL (US$32.0 x 10^6), 1.33 and 401,170 x 10^6 TL (US$93.3 x 10^6) 1.71 respectively.

(20) The economic internal rate of return (EIRR) was calculated by the modification market price (conversion to border price), which was obtained by modifying the market price used in the FIRR. The discount rate at which the present values of the investments on the Project and on the alternative thermal power plant becomes equal in the first year of the projects, is 26.82%. Thus it can be concluded that the Project is superior unless the discount rate does not exceed 26.82%.

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 Oltu Project. The financial internal rate of return of the Project is 10.68%, exceeding the expected borrowing interest rate of 9.5%.

Thus it can be concluded that the Project is feasible from economic and financial points of view.

The economic internal rate of return (EIRR) and financial rate of return (FIRR) of the Olur and Ayvalı projects are 18.72%, 9.87% and 33.05%, 11.25% respectively.

7. RECOMMENDATIONS

The Olur and Ayvalı Projects are technically and economically feasible, and it is recommended that they be developed.

For realization of the Project it is necessary for the following to be implemented:

(1) It is necessary for the various preparations needed for construction such as definite designs and production of tender documents to be made.

(2) For carrying out definite designing, additional investigations and testing are needed regarding the items listed in Chapter 16, "Further Investigations," and the results must be amply reflected in the detailed designs.

(3) It is necessary for concrete relocation plans to be formulated regarding the national highway to be affected by implementation of this Project.

(4) It is necessary to set up concrete plans regarding relocation of approximately 4,200 people to be affected by submersion due to implementation of this Project.

(5) To satisfy energy demand, the Oltu Project should be developed as soon as possible. Therefore the start of construction work for the Oltu Project will be beginning of 2000. The start of operation of the Olur Power Station will be at the end of 2005 and that of Ayvalı Power Station in the middle of 2006.