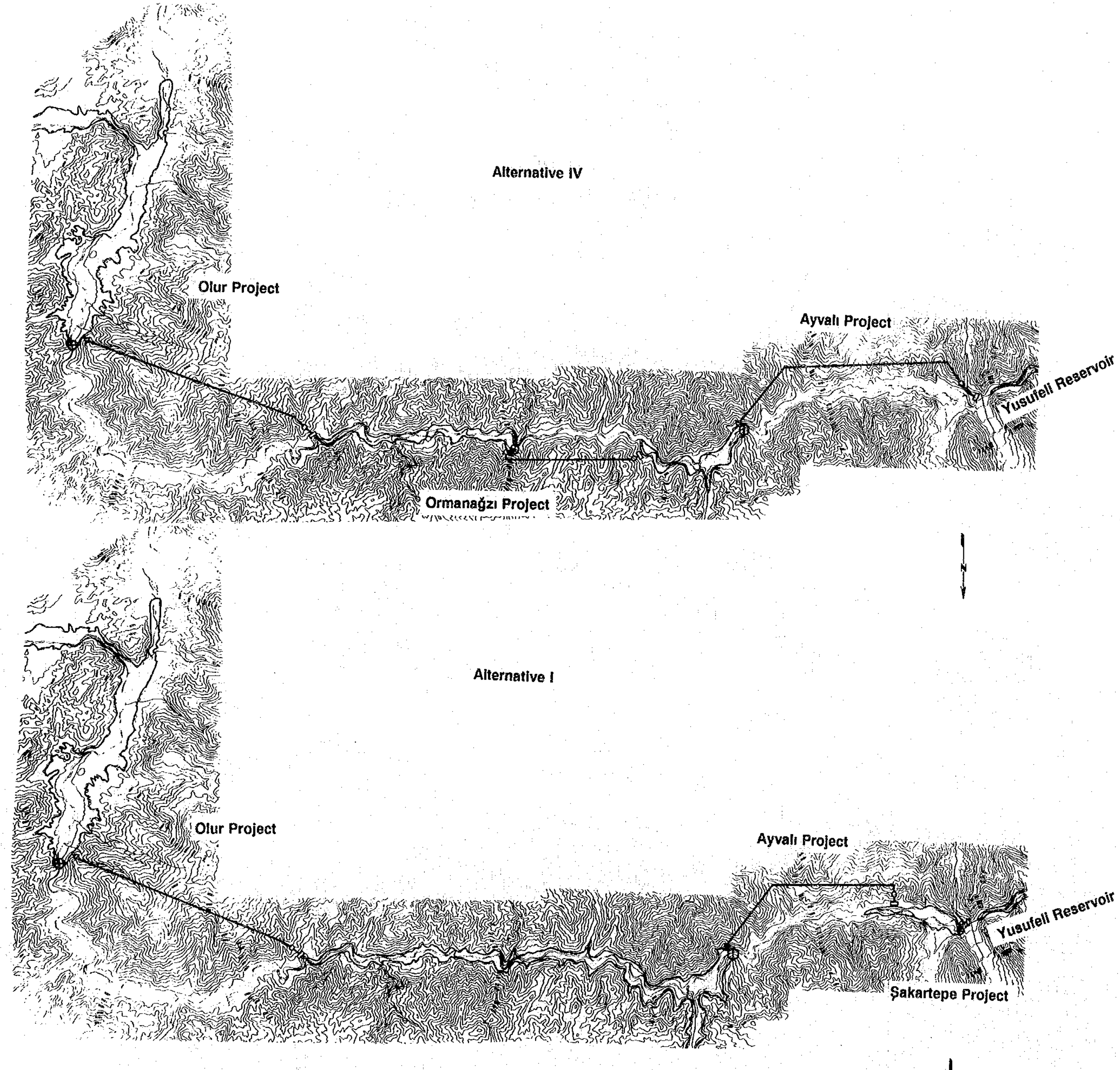



Fig. 9-2 General Plan of Alternative Development Scheme

## 9.2 Comparative Study of Alternative Development Plan

### 9.2.1 Basic Conditions

(1) Fundamental View

The method used for a comparative study of the alternative development plan is that of considering an alternative thermal power plant that would be built without the Oltu project and taking the cost of the thermal power plant as the benefit of the project.

In order to select the optimum development plan an imported coal-fired thermal power plant which is supposed to be the future main thermal power plant is used as the alternative facility to be installed in Hopa with an installed capacity of 300 MW.

Alternative development plans were set up concerning waterway routes, powerhouse locations, and water storage scales for the two-stepped development with the two projects of Olur and Ayvalı, and comparative studies were made on these alternative development plans to select the optimum development plan.

As described in 5.3.3, development of the Olur Project and the Ayvalı project will be implemented simultaneously, and commencement of commercial operation of the Olur Project and the Ayvali Project will be by the end of 2005 and middle of 2006 successively. Therefore reservoir scales of the Olur and the Ayvalı Project were optimized in the manner that the combination of the two projects as a whole would be most optimum.

No consideration has been made to the case that the Olur and Ayvalı Projects would be developed individually.

The annual surplus benefit (B-C) obtained from equalized annual costs (C) for the project life (50 years) of the hydropower facility, and the equalized annual cost (B) of the alternative thermal facilities having a capacity equivalent to the hydropower facilities are used in the study as the indices. Market prices in July 1991 without import taxes are used in the comparisons.

With regard to construction cost and fuel cost of alternative thermal power plant, they are decided from standard international prices taking into account the situation in Turkey.

The costs of the transmission line between the Powerhouse of the Oltu Project and the Yusufeli Project and the transmission line between the alternative thermal power plant and Hopa City are omitted since their influence on the evaluation of the project is small.

Parameters of the alternative thermal plant are as shown in Table 9-3.

(2) Equalized Annual Cost

The equalized annual cost of a hydropower facility consists of depreciation and operation-maintenance cost. This is estimated by multiplying the annual cost factor by the investment cost.

Equalized Annual Cost = Annual Cost Factor x Investment Cost
= Depreciation + Interest + Operation and Maintenance Cost

Depreciation + Interest = Investment Cost x Capital Recovery Factor

- Capital Recovery Factor = $\frac{i(1+i)^n}{(1+i)^n - 1}$

| | | | |
|---|---|---|---|
| n: Service Life | Civil Facility | 50 years |
| | Hydro-mechanical Facility | 35 years |
| | Electro-mechanical Facility | 35 years |
| i: Discount Rate | 9.5% | |

Civil Facility 9.6%
Hydro-mechanical Facility 9.9%
Electro-mechanical Facility 9.9%

- Operation and Maintenance Cost (Rate to Direct Cost)

Civil Facility 0.5%
Hydro-mechanical Facility 1.5%
Electro-mechanical Facility 1.5%

(3) Benefit

The benefits of the project are summarized according to the project cost, maintenance and operation costs, and the fuel cost of an alternative thermal-power plant. The effective power output and effective energy that are used to calculating the advantages of the project, are given according to the below conditions.

1) The effective power output at the receiving end is expressed by the below equation. This equation reduces the station service rate by 0.3%, the forced outage rate by 0.3%, the scheduled outage rate by 2.0%, and the transmission loss rate by 2.1% from the firm peak output. The firm peak output is defined as the average of 12 monthly minimum power outputs for a study period. This is because a 95% output figure

gives too small a firm output under Turkish river discharge conditions where the wet season is different in each area.

Effective power output = (1 - 0.003) x (1 - 0.003 x (1 - 0.02) x (1 - 0.021) x Firm peak output

2) The effective energy at the receiving end is expressed by the below equation that reduces the station service rate by 0.3% and transmission loss rate by 1.4% from the average energy for the 43-year period.

Effective Energy = (1 - 0.003) x (1 - 0.014) x Average annual energy

Table 9-3 Alternative Thermal Power Plant for Optimization Study

| Item | Unit | Description | |
|---|---|---|---|
| Type | | Coal Fired Power Plant | |
| Installed Capacity | MW | 300 | |
| Annual Plant Factor | % | 70 | |
| Thermal Efficiency | % | 38.3 | |
| Annual Energy Production | GWh | 1,839.6 | |
| Investment Cost | $10^6$ TL | 1,806,000 | |
| Service Life | Years | 25 | |
| Construction Period | Years | 4 | |
| Capital Recovery Factor | | 0.10596 | |
| Coal Calorific Value | kcal/kg | 6,500 | |
| Coal Surface Moisture | % | 7 | |
| Oil Calorific Value | kcal/kg | 10,500 | |
| Fuel Consumption Rate (Coal 95%) | kg/kWh | 0.353 | |
| Fuel Consumption Rate (Oil 5%) | kg/kWh | 0.011 | |
| O & M Cost, Administration Cost | % | 3.0 | |
| Unit Fuel Cost (Coal) | TL/kg | 205.1 | |
| Unit Fuel Cost (Oil) | TL/kg | 552.0 | |
| **Annual Cost** | | **Fixed Cost** | **Variable Cost** |
| Capital Recovery | $10^6$ TL | 191,363.0 | - |
| O & M Cost, Administration Cost | $10^6$ TL | 48,762.0 | 5,418.0 |
| Fuel Cost | $10^6$ TL | - | 144,364.1 |
| Total | $10^6$ TL | 240,125.0 | 149,782.1 |
| Annual Cost at Receiving End | | | |
| kW Cost | TL/kW | 1,018,133[1)] | |
| kWh Cost | TL/kWh | | 87.85[2)] |

1) $\dfrac{240{,}125.0 \times 10^6 \text{ TL}}{300{,}000 \text{ kW}} \times 1{,}272^{3)} = 1{,}018{,}133$

2) $\dfrac{149{,}702.1 \times 10^6 \text{ TL}}{1{,}839.6 \times 10^6 \text{ kWh}} \times 1.079^{3)} = 87.85$

3) Adjustment Factor for kW & kWh

| Item | kW | kWh |
|---|---|---|
| Transmission Loss Rate (%) | 1.4 | 1.1 |
| Station Service Rate (%) | 5.6 | 6.3 |
| Forced Outage Rate (%) | 4.0 | - |
| Scheduled Outage Rate (%) | 12.0 | - |

kW Adjustment Factor $= \dfrac{1}{(1-0.014) \times (1-0.056) \times (1 - 0.04) \times (1-0.\ )}$

$= 1.272$

kWh Adjustment Factor $= \dfrac{1}{(1 - 0.011) \times (1 - 0.063)} = 1.079$

### 9.2.2 Alternative Development Plans

(1) Olur Project

1) Olur Dam Site

In the 1982 Master Plan, the site for Olur Dam was selected in the vicinity of EL. 1,100 m downstream of the village of Duracik, but in the 1990 Master Plan, the dam site was changed and selected at a point approximately 600 m further upstream and in the vicinity of 500 m downstream of the same hamlet. Other than these two dam sites, both upstream and downstream parts have valley widths which are extremely large, and there are no sites suitable for dam construction.

During the master plan stage, approximately 1,100 m of drilling investigations were carried out at the downstream dam site. For the upstream dam site, new drilling investigations were started before the time for commencement of the Feasibility Study. According to the results of drilling investigations and subsurface geological investigations up to this time, large differences have not been recognized between the geological conditions of the upstream and downstream dam sites.

To select the optimum dam site, comparison of costs of these two dams by preliminary designs were carried out adopting rockfill type dams with upstream slopes 1:2.4, 1:1.9 respectively as shown in Fig. 9-3. The general plan of the dam was decided based on the topographical condition bypass and spillway both to be on the right-bank side in case of the upstream site. For the design flood discharge of the spillway, 4,950 $m^3/s$ was selected from the Master Plan.

The result of the comparison is shown in Table 9-4. The dam volumes would be 3.7 x $10^{6}$ $m^3$ in the downstream site, and volume in the upstream site would be 30% smaller than that in the downstream site.

Further, since the two dam sites are close to each other, the difference in storage capacities is only 3% and small.

Therefore, it is thought to be reasonable to adopt the upstream site in the Master Plan Report.

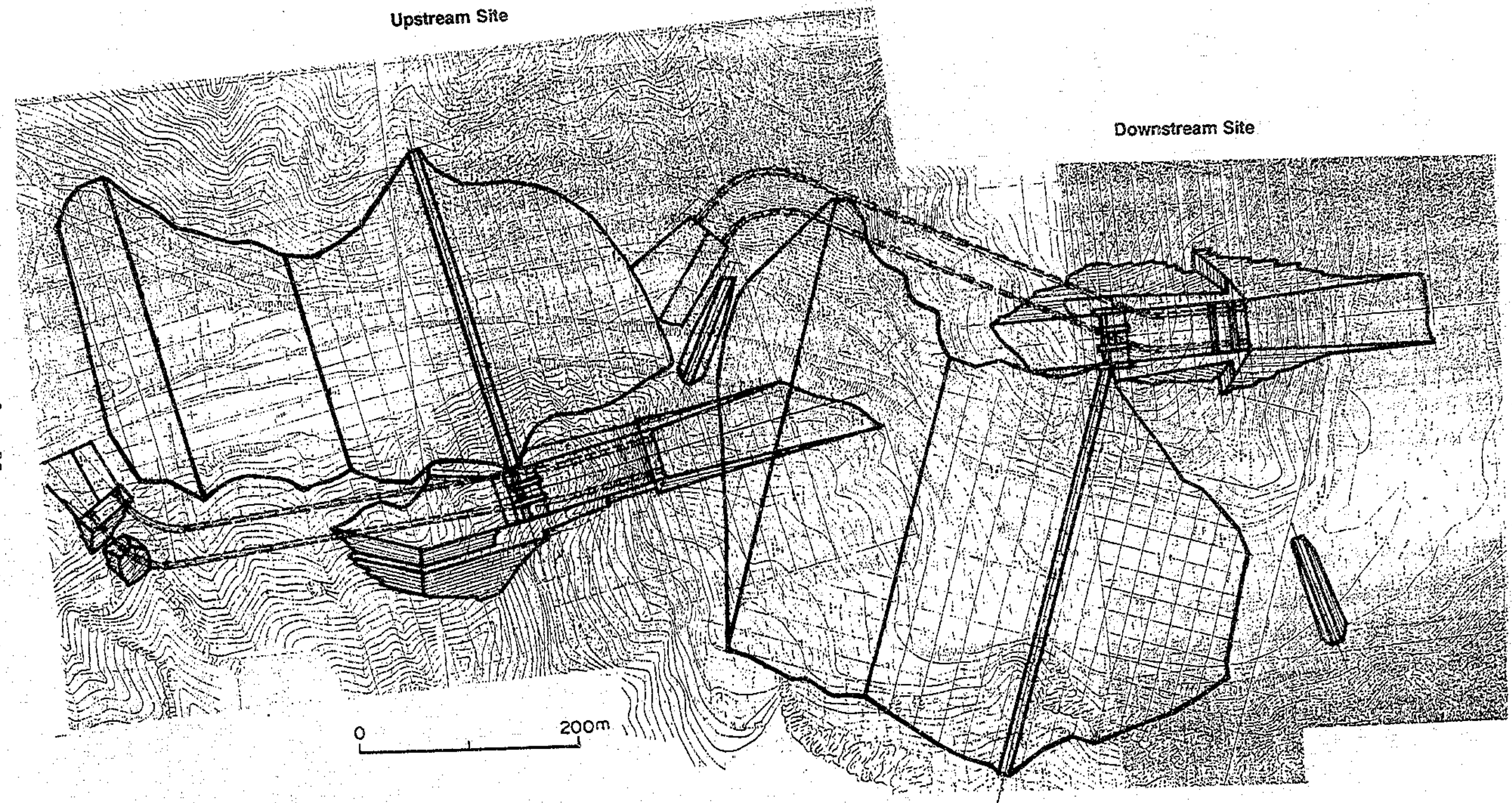



Fig. 9-3 Preliminary Layout of Olur Dam Sites

## Table 9-4 Comparative Study on Olur Dam Sites

| Items | Unit | (1) Upstream Site | (2) Downstream Site | Difference ((1) - (2)) |
|---|---|---|---|---|
| Outline of Main Structure | | | | |
| Effective Storage Capacity | $10^6$ $m^3$ | 145.6 | 150.1 | -4.4 |
| Diversion Tunnel | | | | |
| Number of tunnel | | 1 | 1 | |
| Inner diameter x length | m | 5.4 x 500 | 5.4 x 500 | |
| Dam | | | | |
| Crest elevation | m | 1,104.0 | 1,104.0 | |
| Height of dam | m | 131.0 | 136.0 | |
| Crest length | m | 310.0 | 390.0 | |
| Upstream slope | | 1:2.4 | 1:2.4 | |
| Downstream slope | | 1:1.9 | 1:1.9 | |
| Spillway | | | | |
| Design discharge | $m^3/s$ | 4,950 | 4,950 | |
| Gate type x number | | radial x 3 | radial x 3 | |
| Width x height | m | 13.6 x 16.0 | 13.6 x 16.0 | |
| Headrace Tunnel | m | 8,500 | 8,250 | +250 |
| Quantities of Main Construction Works | | | | |
| Excavation for Dam | $10^3$ $m^3$ | 1,020 | 1,270 | -250 |
| Total Dam Volume | $10^3$ $m^3$ | 3,693 | 5,227 | -1,534 |
| Drilling for Grouting | m | 29,000 | 34,000 | -5,000 |
| Excavation for Spillway | $10^3$ $m^3$ | 790 | 920 | -130 |
| Construction Cost | | | | |
| Dam | $10^9$ TL | 129.6 | 167.7 | -38.1 |
| Spillway | $10^9$ TL | 48.3 | 51.7 | -3.4 |
| Headrace Tunnel | $10^9$ TL | 120.5 | 116.9 | +3.6 |
| Total | $10^6$ TL | 298.4 | 336.3 | -41.5 |
| Annual Cost (C) | $10^9$ TL | 44.8 | 50.5 | -5.7 |
| Annual Benefit (B) | $10^9$ TL | 124.4 | 124.6 | +0.2 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 79.6 | 74.1 | +5.5 |

2) Olur Powerhouse Site

As shown in Fig. 9-4, the powerhouse site in the Master Plan was selected at the left bank of the Oltu River at river-bed elevation of 943 m in the area of the Köprübasi village, but studies including alternative sites have not been made. The Oltu River downstream of the Olur dam site is of a gentle gradient of about 1/200 at the stretch of 13.5 km to the river-bed elevation of 955 m downstream of the Savgurun village upstream of the powerhouse site (hereafter referred to as "OPM Site") selected in the Master Plan, but in the 3.5 km stretch from this vicinity to the neighborhood of EL. 928 m at the downstream end of the downstream Pokans village, the river gradient is about 1/130. However, the direction of flow of the Oltu River from Olur Dam to the vicinity of the Pokans village bends largely to the left side and when the short-cutting effect of the waterway is considered, the real river gradient corresponds to about 1/100. Especially, between downstream of the Savgurun village and the Pokans village, the direction of flow of the meandering Oltu River intersects diagonally on the inside with the power station waterway, and in real terms, it is a steep gradient of around 1/80.

The river-bed gradient of the 15 km section from the downstream end of the village of Pokans to the Ayvalı dam site is about 1/150. The direction of flow is a straight line as a whole, and in addition, downstream of the lower end of Pokans there is a mountain stream of gentle river gradient flowing in at the left-bank side, and if the headrace is to be extended further downstream than this mountain stream, it would be necessary for a large detour to be made around the upstream part of this stream, and the actual river gradient to the Ayvalı dam site will be about 1/150.

Consequently, in case of selecting the powerhouse location for the Olur Project upstream of the OPM Site, idle head would be produced unless the scale of Ayvalı Reservoir is increased. In the stretch from the OPM Site to the downstream end of the downstream Pokans village, the real river gradient will become steeper the more that the powerhouse site is selected downstream, and improvement in the economics of the plan can be looked forward to.

Because of this, as alternative sites for the powerhouse, the three sites of OPJ, OPT, and OPK were selected besides the OPM Site as shown in Fig. 9-5 and Table 9-5 and comparison studies were made. In carrying out the studies, the high water level in the Olur Project was made the same EL. 1,100 m as in the Master Plan. In the Master Plan, the headrace is to cross the gully immediately upstream of the OPM powerhouse site by an aqueduct, but since this gully has basement rock exposed at the river bed above EL. 1,070 m, the headrace crossing point was moved about 200 m upstream from the location in the Master Plan for crossing to be achieved going through the foundation rock by tunnel. And tail water level was set at EL. 944 m considering elevation of river bed and sedimentation in the future.

The result of the study is as given in Table 9-6, and since the OPK alternation provided highest annual surplus benefit, the unit energy cost at a minimum, it is considered as the optimum development plan.

But the difference with the OPT site is small, consequently, the optimality of the OPK site is to be confirmed at the stage of feasibility design.

Table 9-5 Outline of Alternative Development Plan of Olur Project

| Item | Unit | Name of Alternative | | | |
|---|---|---|---|---|---|
| | | OPM | OPJ | OPT | OPK |
| Catchment Area | $km^2$ | 3,509 | | | |
| Annual Inflow | $10^6$ $m^3$ | 655.65 | | | |
| Reservoir | | | | | |
| High Water Level | m | 1,100.00 | | | |
| Low Water Level | m | 1,078.00 | | | |
| Available Drawdown | m | 22.00 | | | |
| Gross Storage Capacity | $10^6$ $m^3$ | 244.10 | | | |
| Effective Storage Capacity | $10^6$ $m^3$ | 145.60 | | | |
| Water Surface Area | $10^6$ $m^3$ | 9.03 | | | |
| Dam | | | | | |
| Type | | Rockfill | | | |
| Height | m | 136.0 | | | |
| Volume | $10^6$ $m^3$ | 3.5 | | | |
| Headrace Tunnel | | | | | |
| Type | | Pressure | Pressure | Pressure | Pressure |
| Length | km | 8.10 | 9.67 | 9.30 | 9.66 |
| Penstock | | | | | |
| Length | m | 393 | 325 | 428 | 436 |
| Development Plan | | | | | |
| Normal Water Level | m | 1,092.70 | 1,092.70 | 1,092.70 | 1,029.70 |
| Tail Water Level | m | 944.00 | 934.00 | 930.00 | 929.00 |
| Gross Head | m | 148.7 | 158.7 | 162.7 | 163.7 |
| Effective Head | m | 139.7 | 148.5 | 152.4 | 153.2 |
| Firm Discharge | $m^3/s$ | 11.1 | 11.1 | 11.1 | 11.1 |
| Maximum Discharge | $m^3/s$ | 44.4 | 44.4 | 44.4 | 44.4 |
| Installed Capacity | MW | 54.0 | 57.4 | 58.9 | 59.2 |
| Construction Cost | | | | | |
| Relocation Road | $10^9$ TL | 12.7 | | | |
| Comp Facilities | $10^9$ TL | 5.0 | | | |
| Land Acquisition | $10^9$ TL | 50.9 | | | |
| Civil Work | $10^9$ TL | 255.8 | 272.9 | 278.1 | 275.9 |
| Hydraulic Equipment | $10^9$ TL | 28.0 | 27.7 | 29.4 | 28.8 |
| Electrical Equipment | $10^9$ TL | 64.5 | 67.5 | 69.3 | 69.6 |
| Contingency | $10^9$ TL | 32.0 | 33.8 | 35.5 | 34.3 |
| Engineering and Admini. | $10^9$ TL | 36.6 | 38.6 | 39.4 | 39.2 |
| Interest during Construction | $10^9$ TL | 106.5 | 111.9 | 113.9 | 113.3 |
| Total | $10^9$ TL | 592.1 | 620.9 | 633.2 | 629.7 |

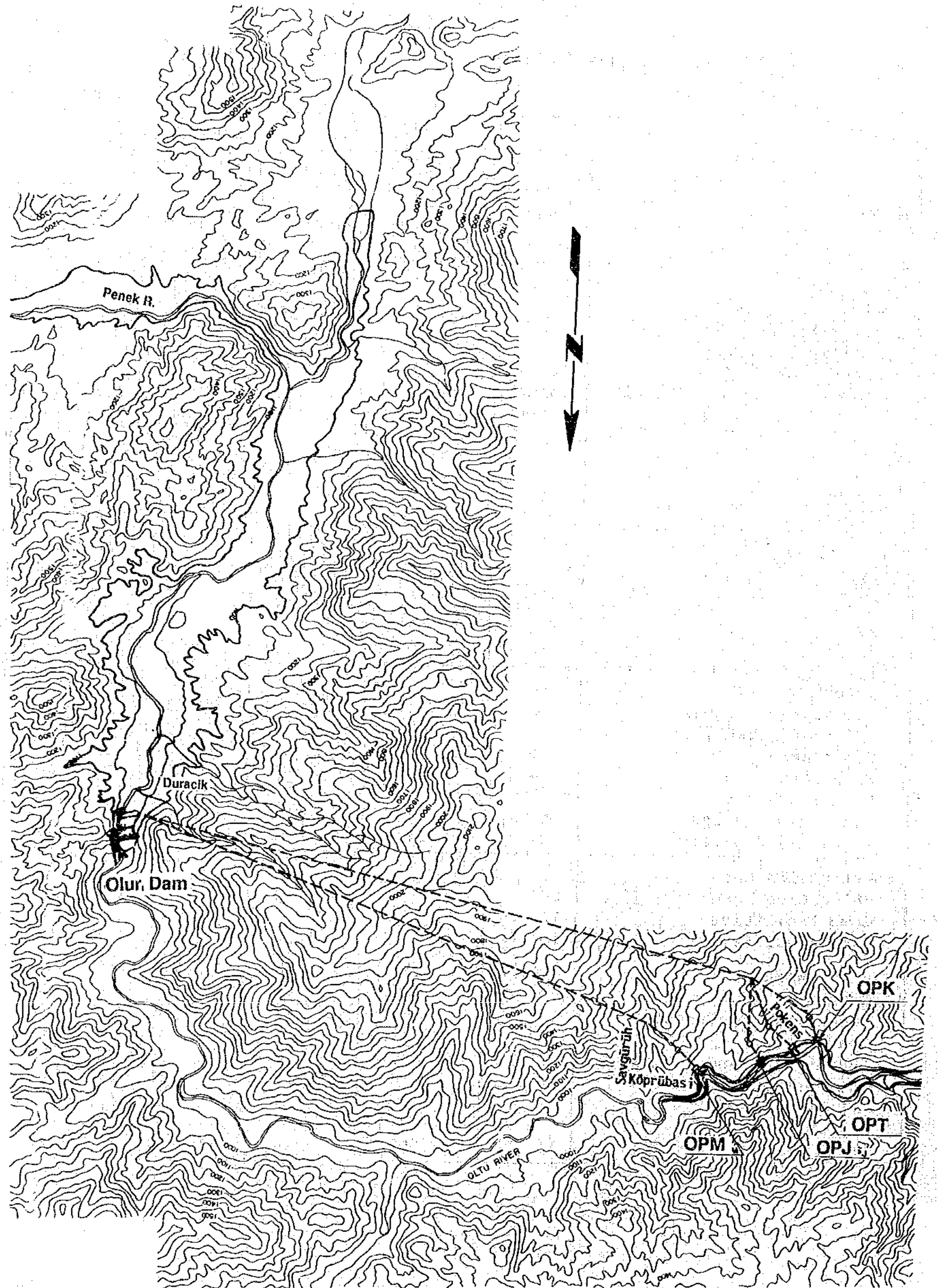



Fig. 9-4 Alternative Development Plan of Olur Project

Table 9-6 Comparative Study on Alternative Development Plan of Olur Project

| Description | Unit | Name of Alternative | | | |
|---|---|---|---|---|---|
| | | OPM | OPJ | OPT | OPK |
| High Water Level | m | 1,100.00 | 1,100.00 | 1,100.00 | 1,100.00 |
| Low Water Level | m | 1,078.00 | 1,078.00 | 1,078.00 | 1,078.00 |
| Available Drawdown | m | 22.00 | 22.00 | 22.00 | 22.00 |
| Effective Storage Capacity | $m^3$ $10^6$ | 145.60 | 145.00 | 145.60 | 145.60 |
| Tailwater Level | m | 944.00 | 934.00 | 930.00 | 929.00 |
| Effective Head | m | 139.70 | 148.50 | 152.40 | 153.20 |
| Maximum Discharge | $m^3/s$ | 44.4 | 44.4 | 44.4 | 44.4 |
| Installed Capacity | MW | 54.0 | 57.4 | 58.9 | 59.2 |
| Firm Peak Power | MW | 45.2 | 48.2 | 49.6 | 50.1 |
| Energy Production | | | | | |
| Average Energy | GWh | 202.5 | 212.8 | 216.7 | 217.6 |
| Firm Energy | GWh | 112.3 | 118.0 | 120.1 | 120.6 |
| Unit Benefit Value | | | | | |
| Firm Peak Power | TL/kW | 1,018,133 | 1,018,133 | 1,018,133 | 1,018,133 |
| Average Energy | TL/kWh | 87.85 | 87.85 | 87.85 | 87.85 |
| Benefit (B) | | | | | |
| Firm Peak Power | TL $10^9$ | 43.9 | 46.8 | 48.2 | 48.6 |
| Average Energy | TL $10^9$ | 17.5 | 18.4 | 18.7 | 18.8 |
| Total | TL $10^9$ | 61.4 | 6.51 | 66.9 | 67.4 |
| Investment Cost | | | | | |
| Civil Facilities | TL $10^9$ | 469.8 | 494.2 | 500.4 | 497.6 |
| Hydro and Ele.-Mech. Eq. | TL $10^9$ | 122.3 | 126.5 | 130.3 | 130.1 |
| Total | TL $10^9$ | 592.1 | 620.7 | 630.7 | 627.6 |
| Annual Cost (C) | | | | | |
| Civil Facilities | TL $10^9$ | 47.4 | 49.9 | 50.5 | 50.3 |
| Hydro and Ele.-Mech. Eq. | TL $10^9$ | 13.9 | 14.4 | 14.9 | 14.9 |
| Total | TL $10^9$ | 61.4 | 64.3 | 65.4 | 65.1 |
| Annual Surplus Benefit (B-C) | TL $10^9$ | 0 | 0.8 | 1.5 | 2.3 |
| Benefit Cost Ratio (B/C) | | 1.00 | 1.01 | 1.02 | 1.03 |
| Unit Annual Cost | TL/kWh | 303 | 302 | 302 | 299 |

(2) Ayvalı Project

As shown in Fig. 9-5, the site for Ayvalı Dam has been selected at a point of river-bed elevation 808 m downstream 1,700 m from the confluence with the Tavusker River, a major tributary. During the master plan stage, approximately 1,000 m of drilling investigation were carried out at the site.

For the effective utilization of the remaining catchment area of the Olur Project, the dam site should be selected downstream of the Tavusker River confluence, while downstream of the dam site presently selected, there is no site suited for a dam, and upstream, there is no suitable site between this and the confluence of the Tavusker River. Therefore, the dam site presently selected is the optimum site.

The Oltu River downstream of the Ayvalı dam site has a river bed gradient of about 1/100 in the stretch of 3.4 km to the Kenonpos village river bed elevation of 775 m, while in the 5.4 km stretch from Kenonpos village to immediately upstream of the powerhouse site selected in the Master Plan, river bed elevation 735 m in the Sakartepe District, the gradient is about 1/140. At the 1.5 km from the Sakartepe District to river bed elevation of 700 m inside Yusufeli Reservoir, the stream is torrential with a river bed gradient of 1/40.

The Oltu River from Ayvalı Dam to the end of the backwater of Yusufeli Reservoir meanders delicately, but as a whole, it flows in a straight east-west line, and when the shortcutting effect of the power station waterway is considered, the real gradient is about 1/90.

In the Master Plan, the headrace route has been selected at the left bank side, with a surface type powerhouse planned at the Sakartepe site, but as stated in 9.1.2, there will remain an idle head of more than 15 m to the high water level of Yusufeli Reservoir, and when the water level variation of Yusufeli Reservoir is considered, this value would become even larger.

If Ayvalı Power Station is made an underground type, it would become possible for the Anzav Valley to be crossed deep underground with a tailrace, and the tailrace outlet can be selected inside Yusufeli Reservoir. Consequently, the head between Ayvalı Dam and Yusufeli Reservoir would be effectively utilized completely. Therefore, as alternative development plans for the project, in addition to the powerhouse site (hereinafter referred to as "APM") selected in the Master Plan, two other cases were selected. The case of providing an underground powerhouse at the left bank, immediately downstream of Ayvalı Dam (hereinafter referred to as "APU") and discharging into Yusufeli Reservoir by a tailrace, and a case of providing also an underground powerhouse at the left bank at the Sakartepe District (hereinafter referred to as "APL") and discharging into Yusufeli Reservoir by a tailrace. A total of three cases were selected and comparative studies were made.

Regarding a right-bank side waterway route, because of the geology of the dam-site right bank, the topography and geology of the Anbarkaya Valley at the right bank immediately downstream of the dam, and further, the existence of the Bulanik River and Ohur Bahcesi Valley in the area at the end of the waterway, it was found to be more disadvantageous than left bank side routes. So it was not considered as an alternative development plan for the project.

Comparative studies of the alternative development plans were made considering high water level of Ayvalı Dam as EL. 940 m. The results of studies are as given in Table 9-7, and since the APU alternative provided the highest power generation capability, while construction cost was a minimum, it was considered as the optimum alternative development plan. As for the APL alternative, comparative study with APU is also to be made at the feasibility design stage.

Table 9-7 Outline of Alternative Development Plan of Ayvalı Project

| Item | Unit | Name of Alternative | | |
|---|---|---|---|---|
| | | APM | APU | APL |
| Catchment Area | $km^2$ | 4,517 | | |
| Annual Inflow | $10^6\ m^3$ | 813.0 | | |
| Reservoir | | | | |
| High Water Level | m | 940.00 | | |
| Low Water Level | m | 900.00 | | |
| Available Drawdown | m | 40.00 | | |
| Gross Storage Capacity | $10^6\ m^3$ | 447.10 | | |
| Effective Storage Capacity | $10^6\ m^3$ | 283.60 | | |
| Water Surface Area | $10^6\ m^3$ | 10.17 | | |
| Dam | | | | |
| Type | | Rockfill | | |
| Height | m | 185.0 | | |
| Volume | $10^6\ m^3$ | 10.9 | | |
| Headrace Tunnel | | | | |
| Type | | Pressure | - | Pressure |
| Length | km | 8.5 | - | 7.6 |
| Penstock | | | | |
| Length | m | 940 | 290 | 320 |
| Tailrace Tunnel | | | | |
| Type | | - | Non Pressure | Non Pressure |
| Length | km | - | 9.3 | 2.1 |
| Development Plan | | | | |
| Normal Water Level | m | 926.70 | 926.70 | 926.70 |
| Tail Water Level | m | 725.00 | 700.00 | 700.00 |
| Gross Head | m | 201.70 | 226.70 | 226.70 |
| Effective Head | m | 187.70 | 214.20 | 213.70 |
| Firm Discharge | $m^3/s$ | 17.6 | 17.6 | 17.6 |
| Maximum Discharge | $m^3/s$ | 70.4 | 70.4 | 70.4 |
| Installed Capacity | MW | 117.4 | 133.4 | 133.1 |
| Construction Cost | | | | |
| Relocation Road | $10^9$ TL | 34.0 | | |
| Comp Facilities | $10^9$ TL | 5.0 | | |
| Land Acquisition | $10^9$ TL | 42.7 | | |
| Civil Work | $10^9$ TL | 531.4 | 536.1 | 550.9 |
| Hydraulic Equipment | $10^9$ TL | 33.2 | 25.2 | 27.9 |
| Electrical Equipment | $10^9$ TL | 95.4 | 108.4 | 108.2 |
| Contingency | $10^9$ TL | 63.5 | 65.5 | 67.2 |
| Engineering and Admini. | $10^9$ TL | 69.9 | 70.9 | 72.6 |
| Interest during Construction | $10^9$ TL | 209.5 | 212.1 | 217.1 |
| Total | $10^9$ TL | 1,084.6 | 1,099.9 | 1,125.6 |

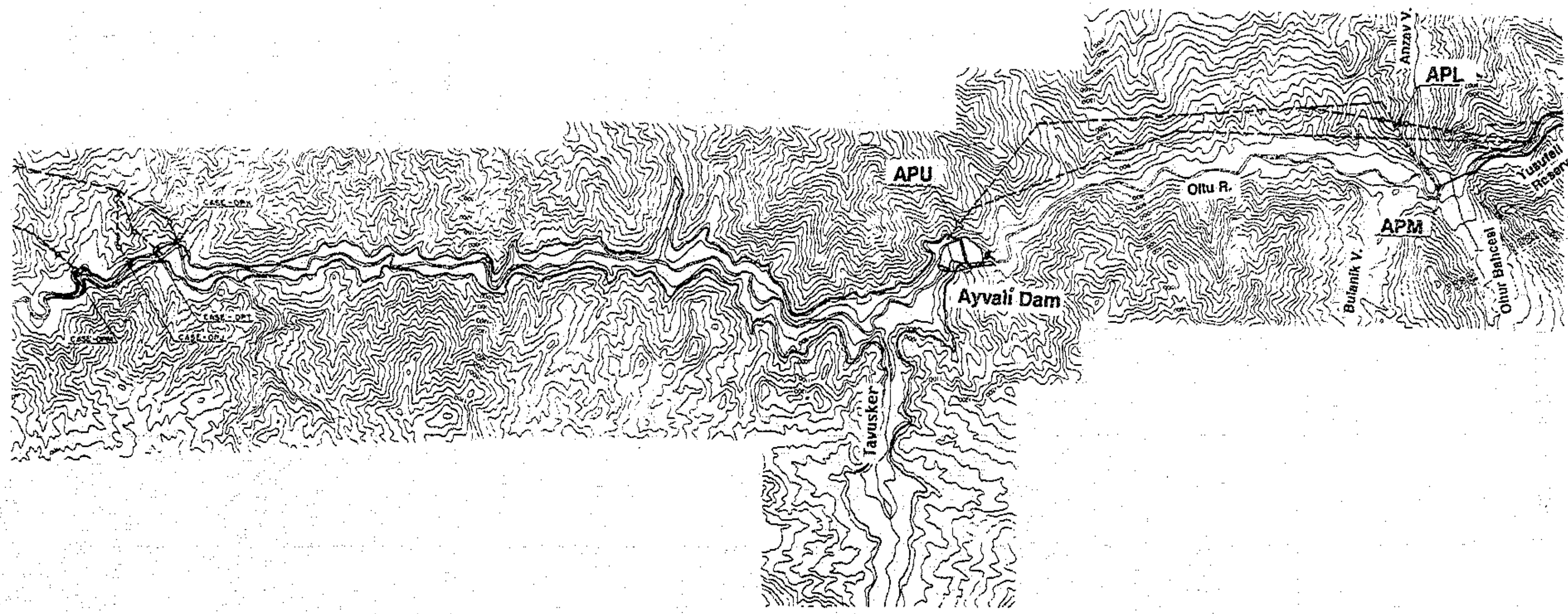



Fig. 9-5 Alternative Development Plan of Ayvalı Project

Table 9-8 Comparative Study on Alternative Development Plan of Ayvalı Project

| Item | Unit | Name of Alternative | | |
|---|---|---|---|---|
| | | APM | APU | APL |
| High Water Level | m | 940.00 | 940.00 | 940.00 |
| Low Water Level | m | 900.00 | 900.00 | 900.00 |
| Available Drawdown | m | 40.00 | 40.00 | 40.00 |
| Effective Storage Capacity | $m^3$ $10^6$ | 283.60 | 283.60 | 283.60 |
| Tailwater Level | m | 725.00 | 700.00 | 700.00 |
| Effective Head | m | 191.8 | 217.9 | 217.3 |
| Maximum Discharge | $m^3/s$ | 70 | 70 | 70 |
| Installed Capacity | MW | 117 | 133 | 133 |
| Firm Peak Power | MW | 95.7 | 110.8 | 110.4 |
| Energy Production | | | | |
| Average Energy | GWh | 364.2 | 409.1 | 407.9 |
| Firm Energy | GWh | 246.1 | 276.5 | 275.3 |
| Unit Benefit Value | | | | |
| Firm Peak Power | TL/kW | 1,018,133.00 | 1,018,133.00 | 1,018,133.00 |
| Average Energy | TL/kWh | 87.85 | 87.85 | 87.85 |
| Benefit (B) | | | | |
| Firm Peak Power | TL $10^9$ | 93.0 | 107.6 | 107.2 |
| Average Energy | TL $10^9$ | 31.5 | 35.3 | 35.2 |
| Total | TL $10^9$ | 124.4 | 142.9 | 142.4 |
| Investment Cost | | | | |
| Civil Facilities | TL $10^9$ | 911.6 | 918.7 | 940.9 |
| Hydro and Ele.-Mech. Eq. | TL $10^9$ | 172.9 | 181.2 | 184.7 |
| Total | TL $10^9$ | 1,084.6 | 1,099.9 | 1,125.6 |
| Annual Cost (C) | | | | |
| Civil Facilities | TL $10^9$ | 92.1 | 92.8 | 95.0 |
| Hydro and Ele.-Mech. Eq. | TL $10^9$ | 19.7 | 20.7 | 21.1 |
| Total | TL $10^9$ | 111.8 | 113.4 | 116.1 |
| Annual Surplus Benefit (B-C) | TL $10^9$ | 12.6 | 29.4 | 26.3 |
| Benefit Cost Ratio (B/C) | | 1.11 | 1.26 | 1.23 |
| Unit Annual Cost | TL/kWh | 307 | 277 | 285 |

### 9.2.3 Reservoir Scale

(1) Reservoir Operation Study

The annual average inflow at the Olur dam site is 21 $m^3/s$, with the snowmelt period of April to June corresponding to the high water season, 63% of the annual inflow occurring during this period. The inflow during December to February corresponding to the low water season has 9% of the annual inflow, and the seasonal variation range of inflow is not narrow. The minimum value of annual inflow is 39% of the average inflow, and the maximum value 180%. The maximum value of annual inflow is 4.6 times the minimum value. Although the annual average inflow at the Ayvalı dam site is 26 $m^3/s$, the trends of seasonal variations and year to year variations in inflow are exactly the same as at the Olur dam site.

In this way, regarding the storage capacity in the Olur Project, because of topographical constraints at the dam site, a high water level elevation of 1,100 m and effective storage capacity of 250 x $10^6$ $m^3$ are the limits, but with a regulating capacity of this degree it would not be possible for inflow to be completely averaged. In the remaining catchment area between Olur Dam and Ayvali Dam, there is an inflow of an annual average 5 $m^3/s$ corresponding to 20% of the inflow at Olur Dam. Therefore, it is necessary for effective utilization of inflow for power generation to have some degree of storage capacity in the Ayvali Project also.

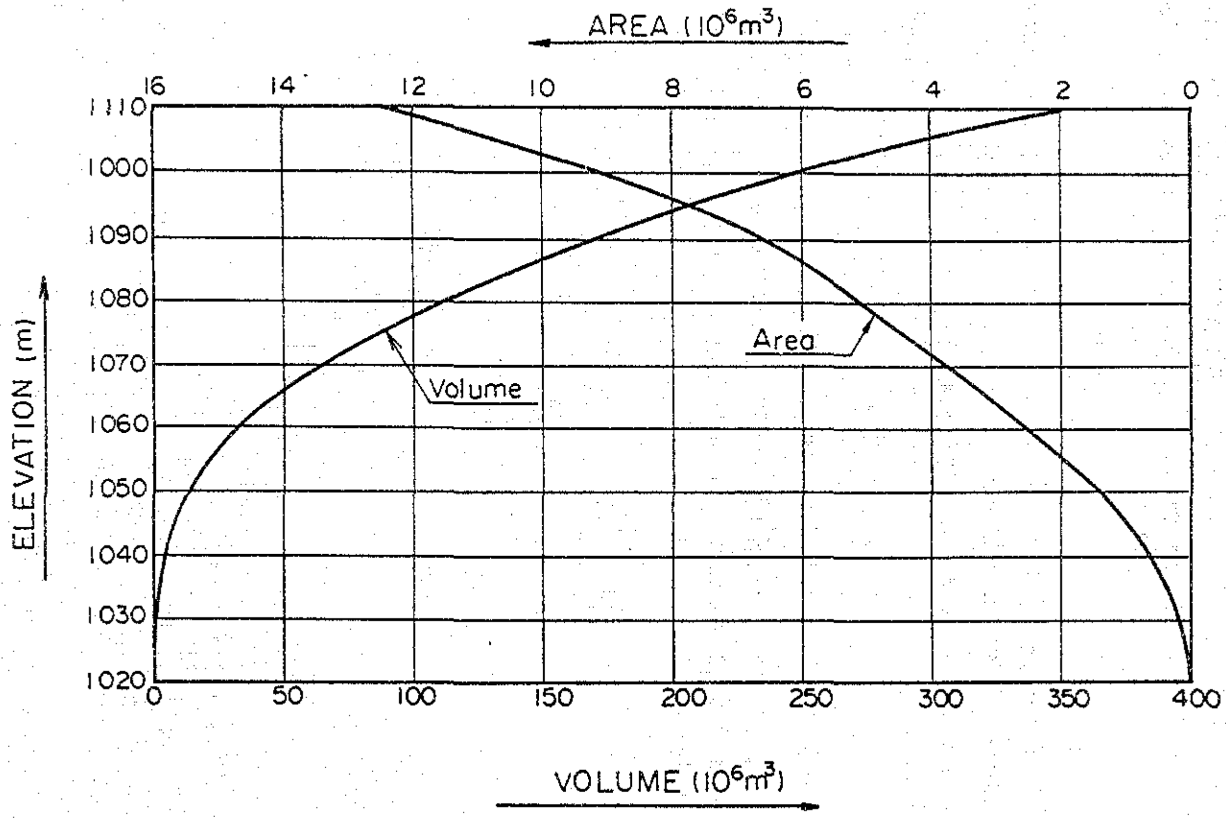
The calculations of energy generation for the study were carried out by electronic computer using the monthly inflows for the 50-year period from October 1940 to September 1989.

Defining firm discharge as the discharge which can be utilized for power generation at all times during 95% of the 50-year period, it was determined using the mass curve of inflow so that firm discharge would be a maximum.

For Ayvalı Reservoir, the inflow at the Ayvalı dam site was taken to be the discharge after operation of Olur Reservoir by mass curve to which the runoff of the remaining catchment area between Olur Reservoir and Ayvali Reservoir was added. Figs. 9-6, 9-7, and 9-8, and Figs. 9-9, 9-10, and 9-11 respectively show the area capacity curves, mass curves, and the relationship between effective storage capacity and firm discharge of Olur Reservoir and Ayvalı Reservoir.

As for energy calculation, the mass curve rule was used for the ideal operation so that overflow would be small. The irrigation discharge from the reservoir to the downstream area was ignored.

The normal operating water level (high water level - 1/3 x drawdown) was given as the standard intake water level to be the basis for turbine generation design.




| ELEVATION (m) | AREA ($10^3m^2$) | VOLUME ($10^3m^3$) |
|---|---|---|
| 1 025 | 2 | 0 |
| 1 030 | 85 | 220 |
| 1 040 | 599 | 3 640 |
| 1 050 | 1 371 | 13 490 |
| 1 060 | 2 536 | 33 030 |
| 1 070 | 3 683 | 64 130 |
| 1 080 | 5 105 | 108 070 |
| 1 090 | 6 536 | 166 280 |
| 1 100 | 9 025 | 244 090 |
| 1 110 | 12 436 | 351 400 |

**Fig. 9-6 Area-Capacity Curve of Olur Reservoir**

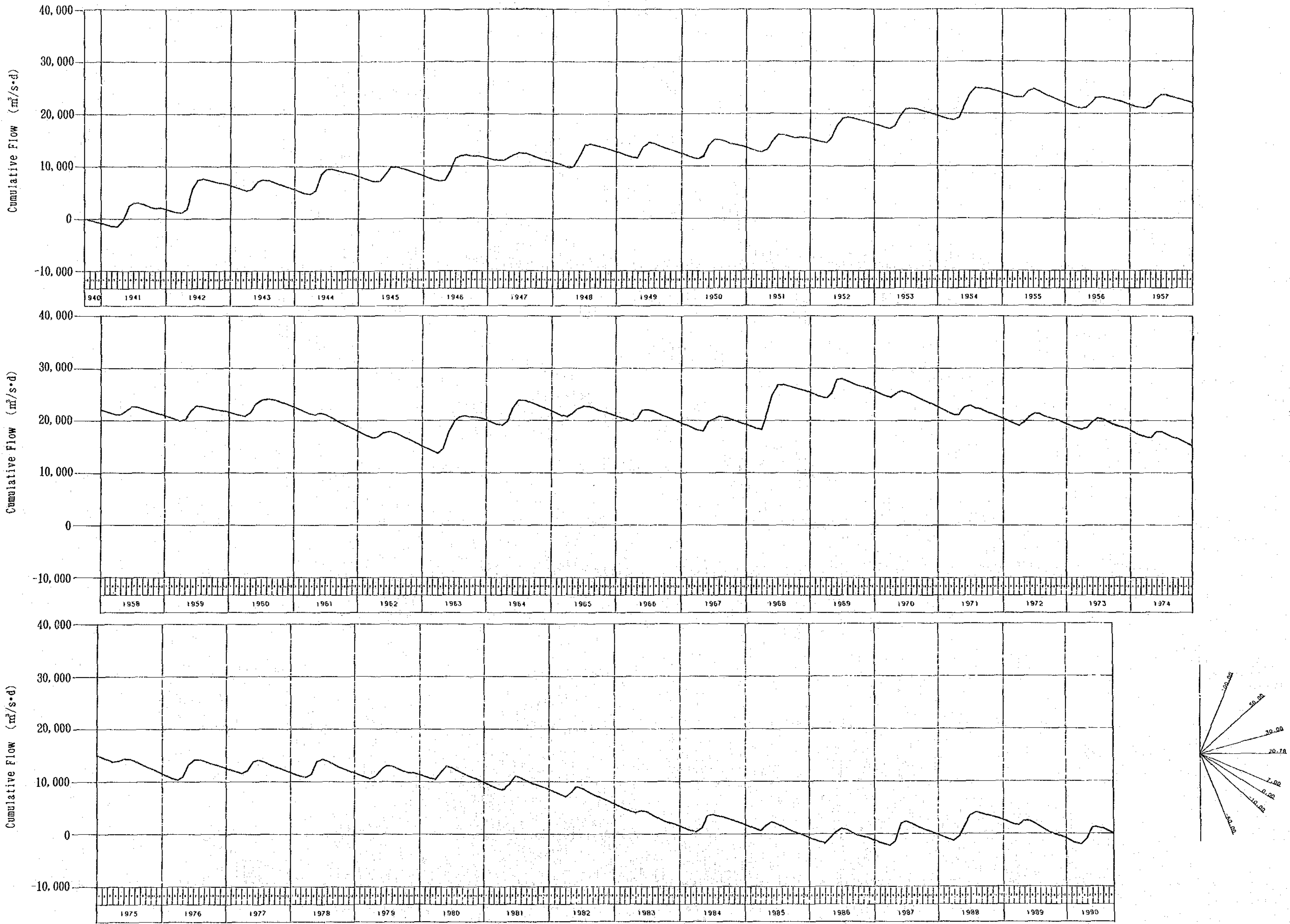



**Fig. 9-7 Mass Curve at Olur Dam Site**

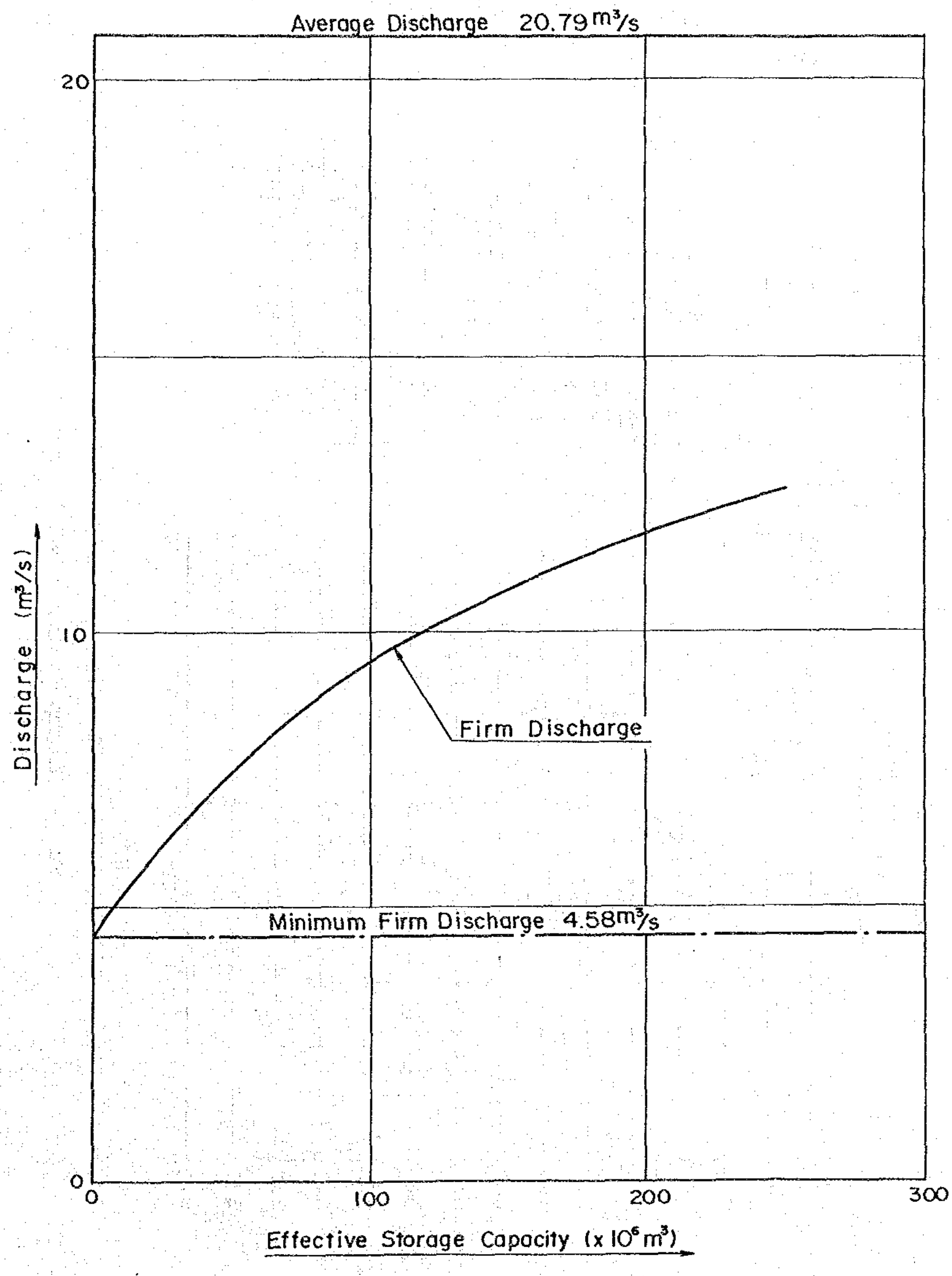
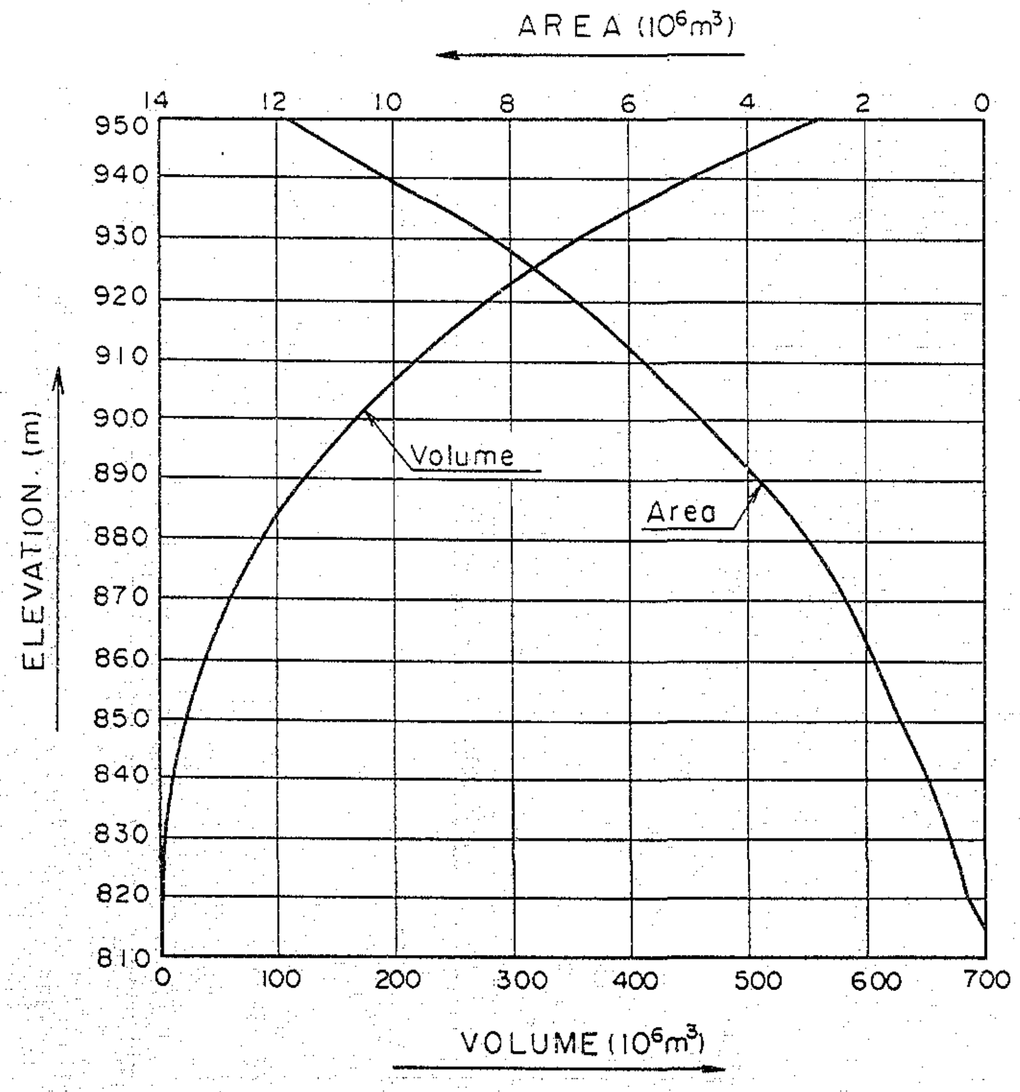



**Fig. 9-8 Effective Storage Capacity and Firm Discharge at Olur Dam Site**




| ELEVATION (m) | AREA ($10^3 m^2$) | VOLUME ($10^3 m^3$) |
|---|---|---|
| 815 | 28 | 0 |
| 820 | 208 | 590 |
| 830 | 544 | 4 350 |
| 840 | 917 | 11 660 |
| 850 | 1 410 | 23 300 |
| 860 | 1 857 | 39 640 |
| 870 | 2 338 | 60 620 |
| 880 | 2 917 | 86 900 |
| 890 | 3 844 | 120 710 |
| 900 | 4 715 | 163 510 |
| 910 | 5 763 | 215 900 |
| 920 | 6 872 | 279 080 |
| 930 | 8 227 | 354 830 |
| 940 | 10 170 | 447 070 |
| 950 | 11 804 | 556 940 |

**Fig. 9-9 Area-Capacity Curve of Ayvalı Reservoir**

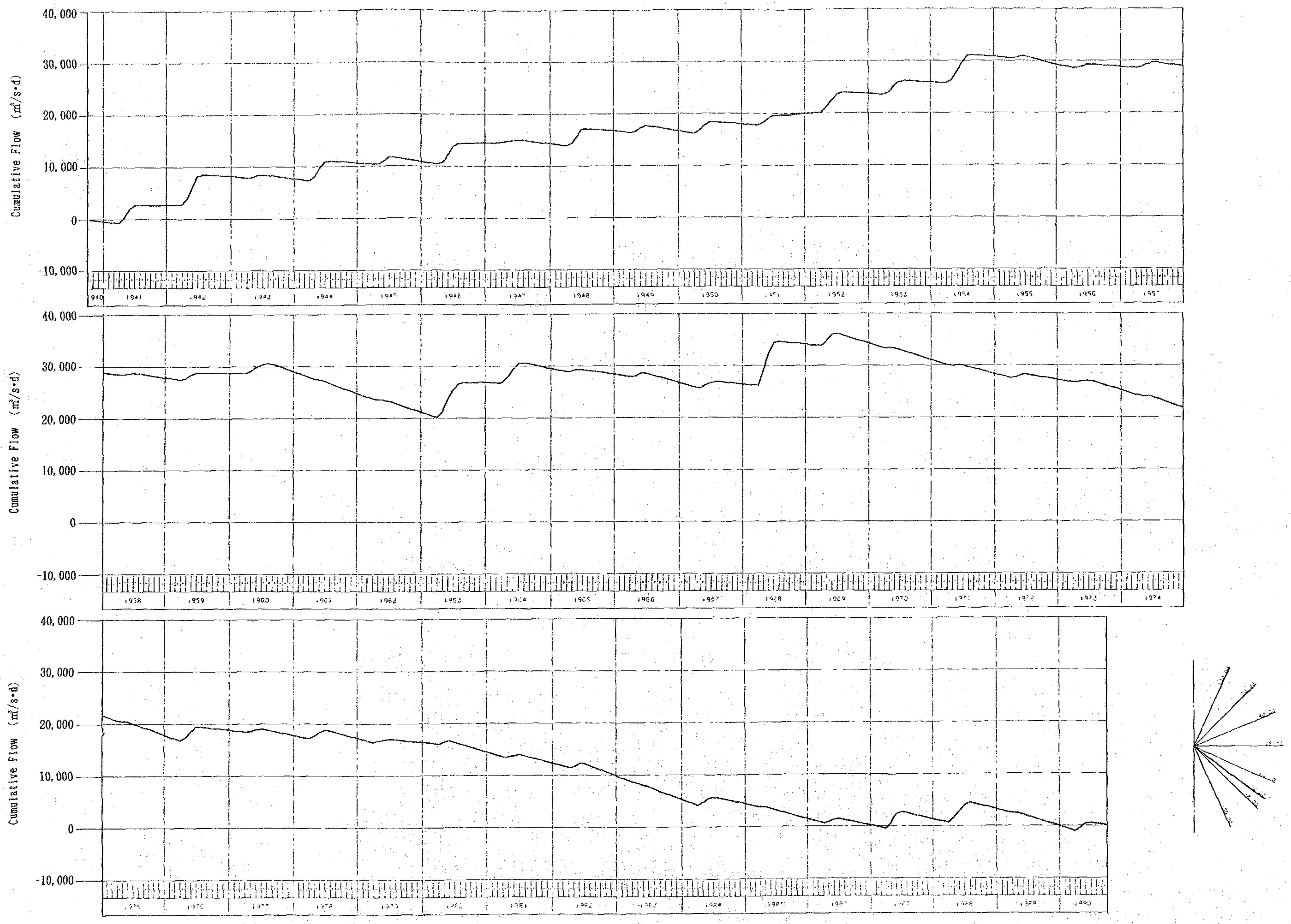



**Fig. 9-10 Mass Curve at Ayvalı Dam Site**

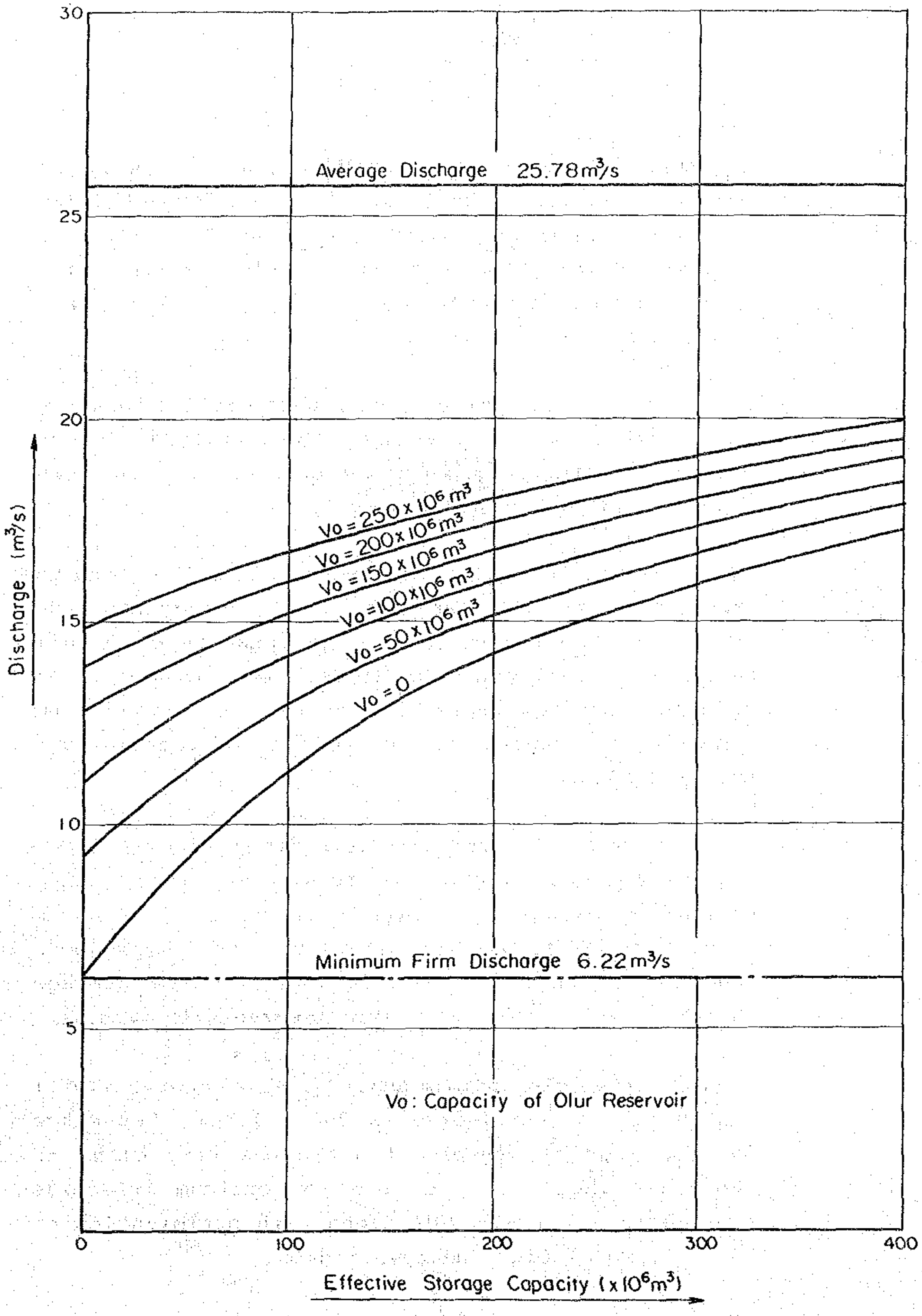



**Fig. 9-11 Effective Storage Capacity and Firm Discharge at Ayvalı Dam Site**

(2) Study of Reservoir Scale

1) Olur Project

The annual sedimentation at the Olur dam site is 940,000 $m^3$ as mentioned in 6.2.4. Therefore, the low water level of Olur Reservoir was made EL. 1,077 m to secure sedimentation capacity of 100 years, with effective storage capacities set above this level, and comparison studies were made.

The outputs of the power station were decided based on firm discharges with peak operation duration time as 6 hours, and rough construction cost of each case was estimated at the price of July 1991.

The regulating effect of Olur Reservoir will extend to the downstream Ayvalı Project, and the study was made by varying the effective storage capacity of Ayvalı Reservoir in numerous cases in relation to the various effective storage capacities of Olur Reservoir, and comparing the annual surplus benefits of the Olur and Ayvalı projects.

The results of the study are as shown in Table 9-9 and Fig. 9-12, and regardless of the size of the effective storage capacity of Ayvalı Reservoir, the annual surplus benefit of the Olur and Ayvalı projects together in the vicinity of the effective storage capacity, 200 x $10^6$ $m^3$, of Olur Reservoir is maximum.

Consequently, the optimum scale of Olur Reservoir will tentatively be considered as 200 x $10^6$ $m^3$, but since the value of the surplus benefit was very close to those of other cases, a study of optimum effective storage capacity was made along with optimization of the heights of Olur and Ayvalı dams.

2) Ayvalı Project

The annual sedimentation at the Ayvalı dam site, as stated in 6.2.4, is 1,200,000 $m^3$ for the entire catchment area, and considered for only the remaining catchment area between Olur Dam and Ayvali Dam, it is 270,000 $m^3$. As described in 5.3.3, completion of the Olur Project is planned six month before the planned completion of the Ayvalı Project, but even if there were to be an interval of 10 years from the time of completion of the Ayvalı Project until completion of the Olur Project, the 100 year sedimentation in Ayvalı Reservoir would be 39,000,000 $m^3$.

In this case, the low water level would be EL. 860 m, and giving consideration to the fact that the discharge water level of the Olur Project will be 928 m, the reservoir scale was studied with low water level at EL. 900 m.

The method of determining output of the power station was the same as the case of (1), Olur Project.

The results of studies are as shown in Table 9-9 and Fig. 9-13, and surplus benefit would be maximum in case of the effective storage capacity of Ayvalı Reservoir about 150 x $10^6$ $m^3$ at effective storage capacity of Olur Reservoir of 200 x $10^6$ $m^3$.

However, the differences with the cases above and below are small and it is not possible to judge the optimum point with certainty. Therefore, optimization of the plan is to be aimed for carrying out further comparison studies in detail through combinations of high water level and effective storage capacity.

# Table 9-9(1) Comparative Study on Reservoir Scale

| Description | Unit | 1-A (OP250 - AP400) | | | 1-B (OP250 - AP400) | | | 1-C (OP250 - AP300) | | | 1-D (OP250 - AP284) | | | 1-E (OP250 - AP250) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ m$^3$ | 300 | 563 | | 300 | 513 | | 300 | 463 | | 300 | 447 | | 300 | 413 | |
| Effective Storage Capacity | $10^6$ m$^3$ | 250 | 400 | | 250 | 350 | | 250 | 300 | | 250 | 284 | | 250 | 250 | |
| High Water Level | m | 1,109.8 | 950.6 | | 1,109.8 | 946.2 | | 1,109.8 | 941.6 | | 1,109.8 | 940.0 | | 1,109.8 | 936.6 | |
| Low Water Level | m | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | |
| Available Drawdown | m | 31.8 | 50.6 | | 31.8 | 46.2 | | 31.8 | 41.6 | | 31.8 | 40.0 | | 31.8 | 36.6 | |
| Tail Water Level | m | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | |
| Effective Head | m | 161.1 | 224.9 | | 161.1 | 222.2 | | 161.1 | 218.9 | | 161.1 | 217.8 | | 161.1 | 215.6 | |
| Maximum Discharge | m$^3$/s | 52 | 86 | | 52 | 82 | | 52 | 79 | | 52 | 77 | | 52 | 75 | |
| Installed Capacity | MW | 72 | 168 | 240 | 72 | 158 | 231 | 72 | 149 | 222 | 72 | 146 | 219 | 72 | 140 | 212 |
| Firm Peak Power | MW | 57.2 | 136.1 | 193.3 | 57.2 | 129.5 | 186.7 | 57.2 | 123.3 | 180.5 | 57.2 | 121.1 | 178.2 | 57.2 | 117.6 | 174.8 |
| Energy Production | | | | | | | | | | | | | | | | |
| Average Energy | GWh | 231.7 | 424.3 | 655.9 | 235.3 | 418.7 | 654.1 | 238.5 | 412.7 | 651.2 | 239.2 | 410.1 | 649.3 | 239.9 | 405.0 | 644.9 |
| Firm Energy | GWh | 143.1 | 348.3 | 491.3 | 145.3 | 328.8 | 474.0 | 147.0 | 309.7 | 456.7 | 147.5 | 303.0 | 450.5 | 147.9 | 290.6 | 438.5 |
| Benefit (B) | $10^9$ TL | 75.5 | 168.7 | 244.2 | 75.8 | 161.9 | 237.7 | 76.0 | 155.3 | 231.4 | 76.1 | 152.9 | 229.1 | 76.2 | 149.2 | 225.4 |
| Investment Cost | $10^9$ TL | 757.7 | 1,248.9 | 2,006.7 | 757.7 | 1,197.0 | 1,954.8 | 757.7 | 1,140.2 | 1,898.0 | 757.7 | 1,118.7 | 1,876.4 | 757.7 | 1,078.2 | 1,835.9 |
| Annual Cost (C) | $10^9$ TL | 78.5 | 128.6 | 207.1 | 78.5 | 123.3 | 201.8 | 78.5 | 117.5 | 196.0 | 78.5 | 115.3 | 193.8 | 78.5 | 111.1 | 189.7 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | -3.0 | 40.1 | 37.1 | -2.6 | 38.5 | 35.8 | -2.4 | 37.8 | 35.4 | -2.3 | 37.6 | 35.2 | -2.2 | 38.0 | 35.7 |
| Benefit Cost Ratio (B/C) | | 0.96 | 1.31 | 1.18 | 0.97 | 1.31 | 1.18 | 0.97 | 1.32 | 1.18 | 0.97 | 1.33 | 1.18 | 0.97 | 1.34 | 1.19 |
| Unit Annual Cost | TL/kWh | 338 | 303 | 315 | 333 | 294 | 308 | 329 | 284 | 301 | 328 | 281 | 298 | 327 | 274 | 294 |

| Description | Unit | 1-F (OP250 - AP200) | | | 1-G (OP250 - AP150) | | | 1-H (OP250 - AP100) | | | 1-I (OP250 - AP050) | | | 1-J (OP250 - AP000) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ m$^3$ | 300 | 363 | | 300 | 313 | | 300 | 263 | | 300 | 213 | | 300 | 0 | |
| Effective Storage Capacity | $10^6$ m$^3$ | 250 | 200 | | 250 | 150 | | 250 | 100 | | 250 | 50 | | 250 | 0 | |
| High Water Level | m | 1,109.8 | 931.0 | | 1,109.8 | 924.7 | | 1,109.8 | 917.6 | | 1,109.8 | 909.5 | | 1,109.8 | 928.0 | |
| Low Water Level | m | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 928.0 | |
| Available Drawdown | m | 31.8 | 31.0 | | 31.8 | 24.7 | | 31.8 | 17.6 | | 31.8 | 9.5 | | 31.8 | 0.0 | |
| Tail Water Level | m | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | |
| Effective Head | m | 161.1 | 211.9 | | 161.1 | 207.7 | | 161.1 | 202.9 | | 161.1 | 197.5 | | 161.1 | 205.0 | |
| Maximum Discharge | m$^3$/s | 52 | 72 | | 52 | 69 | | 52 | 67 | | 52 | 63 | | 52 | 52 | |
| Installed Capacity | MW | 72 | 129 | 202 | 72 | 124 | 197 | 72 | 117 | 189 | 72 | 107 | 179 | 72 | 91 | 164 |
| Firm Peak Power | MW | 57.2 | 111.0 | 168.2 | 57.2 | 109.7 | 166.8 | 57.2 | 104.3 | 161.5 | 57.2 | 98.0 | 155.1 | 57.2 | 85.9 | 143.1 |
| Energy Production | | | | | | | | | | | | | | | | |
| Average Energy | GWh | 242.3 | 391.5 | 633.8 | 243.8 | 390.8 | 634.7 | 243.8 | 377.3 | 621.1 | 243.8 | 358.5 | 602.4 | 243.8 | 294.3 | 538.2 |
| Firm Energy | GWh | 149.1 | 269.6 | 418.7 | 149.9 | 260.9 | 410.8 | 149.9 | 242.9 | 392.8 | 149.9 | 220.8 | 370.7 | 149.9 | 182.0 | 331.9 |
| Benefit (B) | $10^9$ TL | 76.4 | 141.5 | 218.0 | 76.5 | 140.2 | 216.7 | 76.5 | 133.8 | 210.4 | 76.5 | 126.0 | 202.6 | 76.5 | 108.9 | 185.4 |
| Investment Cost | $10^9$ TL | 757.7 | 1,015.8 | 1,773.6 | 757.7 | 955.1 | 1,712.9 | 757.7 | 901.4 | 1,659.2 | 757.7 | 828.2 | 1,585.9 | 757.7 | 671.8 | 1,429.6 |
| Annual Cost (C) | $10^9$ TL | 78.5 | 104.7 | 183.3 | 78.5 | 98.5 | 177.0 | 78.5 | 93.0 | 171.5 | 78.5 | 85.5 | 164.1 | 78.5 | 69.5 | 148.0 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | -2.0 | 36.7 | 34.7 | -1.9 | 41.6 | 39.6 | -1.9 | 40.8 | 38.8 | -1.9 | 40.4 | 38.5 | -1.9 | 39.4 | 37.4 |
| Benefit Cost Ratio (B/C) | | 0.97 | 1.35 | 1.19 | 0.98 | 1.42 | 1.22 | 0.98 | 1.44 | 1.23 | 0.98 | 1.47 | 1.23 | 0.98 | 1.57 | 1.25 |
| Unit Annual Cost | TL/kWh | 324 | 267 | 289 | 321.9 | 252 | 279 | 321 | 246 | 276 | 321 | 238 | 272 | 321 | 236 | 275 |

# Table 9-9(2) Comparative Study on Reservoir Scale

| Description | Unit | 2-A (OP200 - AP400) | | | 2-B (OP200 - AP350) | | | 2-C (OP200 - AP300) | | | 2-D (OP200 - AP284) | | | 2-E (OP200 - AP250) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 300 | 563 | | 300 | 513 | | 300 | 463 | | 300 | 447 | | 300 | 413 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 200 | 400 | | 200 | 350 | | 200 | 300 | | 200 | 284 | | 200 | 250 | |
| High Water Level | m | 1,105.6 | 950.6 | | 1,105.6 | 946.2 | | 1,105.6 | 941.6 | | 1,105.6 | 940.0 | | 1,105.6 | 936.6 | |
| Low Water Level | m | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | |
| Available Drawdown | m | 27.6 | 50.6 | | 27.6 | 46.2 | | 27.6 | 41.6 | | 27.6 | 40.0 | | 27.6 | 36.6 | |
| Tail Water Level | m | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | |
| Effective Head | m | 157.9 | 224.9 | | 157.9 | 222.2 | | 157.9 | 218.9 | | 157.9 | 217.8 | | 157.9 | 215.6 | |
| Maximum Discharge | $m^3/s$ | 48 | 83 | | 48 | 79 | | 48 | 75 | | 48 | 77 | | 48 | 71 | |
| Installed Capacity | MW | 65 | 161 | 226 | 65 | 152 | 217 | 65 | 142 | 208 | 65 | 146 | 205 | 65 | 134 | 199 |
| Firm Peak Power | MW | 53.6 | 130.5 | 184.1 | 53.6 | 124.5 | 178.2 | 53.6 | 117.9 | 171.5 | 53.6 | 121.1 | 169.6 | 53.6 | 112.3 | 166.0 |
| Energy Production | | | | | | | | | | | | | | | | |
| Average Energy | GWh | 223.7 | 424.2 | 647.8 | 228.1 | 418.8 | 646.9 | 233.6 | 412.8 | 646.4 | 231.2 | 409.2 | 640.4 | 232.0 | 405.6 | 637.5 |
| Firm Energy | GWh | 129.4 | 334.0 | 463.3 | 131.8 | 316.0 | 447.8 | 134.9 | 296.0 | 430.9 | 133.6 | 289.6 | 423.2 | 134.0 | 278.3 | 412.3 |
| Benefit (B) | $10^9$ TL | 71.4 | 163.3 | 234.7 | 71.8 | 157.1 | 228.9 | 71.7 | 150.1 | 222.3 | 72.1 | 147.9 | 219.9 | 72.1 | 144.1 | 216.2 |
| Investment Cost | $10^9$ TL | 676.4 | 1,237.3 | 1,913.6 | 676.4 | 1,183.5 | 1,859.9 | 672.3 | 1,122.3 | 1,798.7 | 676.3 | 1,104.0 | 1,780.5 | 676.4 | 1,063.1 | 1,739.5 |
| Annual Cost (C) | $10^9$ TL | 70.2 | 127.4 | 197.6 | 70.2 | 122.0 | 192.1 | 70.2 | 115.7 | 135.8 | 70.2 | 113.7 | 183.9 | 70.2 | 109.6 | 179.7 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 1.2 | 35.9 | 37.1 | 1.6 | 35.1 | 36.8 | 2.1 | 34.4 | 36.5 | 1.9 | 34.1 | 36.0 | 1.9 | 34.5 | 36.5 |
| Benefit Cost Ratio (B/C) | | 1.02 | 1.28 | 1.19 | 1.02 | 1.29 | 1.19 | 1.03 | 1.30 | 1.20 | 1.03 | 1.30 | 1.20 | 1.03 | 1.32 | 1.20 |
| Unit Annual Cost | TL/KWh | 313 | 300 | 305 | 307 | 291 | 297 | 300 | 280 | 287 | 303 | 278 | 287 | 302 | 270 | 282 |

| Description | Unit | 2-F (OP200 - AP200) | | | 2-G (OP200 - AP150) | | | 2-H (OP200 - AP100) | | | 2-I (OP200 - AP050) | | | 2-J (OP200 - AP000) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 300 | 363 | | 300 | 313 | | 300 | 263 | | 300 | 213 | | 300 | 0 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 200 | 200 | | 200 | 150 | | 200 | 100 | | 200 | 50 | | 200 | 0 | |
| High Water Level | m | 1,105.6 | 931.0 | | 1,105.6 | 924.7 | | 1,105.6 | 917.6 | | 1,105.6 | 909.5 | | 1,105.6 | 928.0 | |
| Low Water Level | m | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 928.0 | |
| Available Drawdown | m | 27.6 | 31.0 | | 27.6 | 24.7 | | 27.6 | 17.6 | | 27.6 | 9.5 | | 27.6 | 0.0 | |
| Tail Water Level | m | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | |
| Effective Head | m | 157.9 | 211.9 | | 157.9 | 207.7 | | 157.9 | 202.9 | | 157.9 | 197.5 | | 157.9 | 205.0 | |
| Maximum Discharge | $m^3/s$ | 48 | 69 | | 48 | 67 | | 48 | 64 | | 48 | 60 | | 48 | 48 | |
| Installed Capacity | MW | 65 | 127 | 192 | 65 | 120 | 185 | 65 | 112 | 178 | 65 | 102 | 167 | 65 | 84 | 150 |
| Firm Peak Power | MW | 53.6 | 109.3 | 163.0 | 53.6 | 105.7 | 159.4 | 53.6 | 100.2 | 153.9 | 53.6 | 93.2 | 146.8 | 53.6 | 80.6 | 134.2 |
| Energy Production | | | | | | | | | | | | | | | | |
| Average Energy | GWh | 234.9 | 398.4 | 633.3 | 235.8 | 390.5 | 626.4 | 235.8 | 375.1 | 611.0 | 235.8 | 358.3 | 594.2 | 235.8 | 294.3 | 530.2 |
| Firm Energy | GWh | 135.2 | 265.2 | 400.4 | 136.1 | 251.8 | 387.9 | 136.1 | 233.6 | 369.7 | 136.1 | 210.2 | 346.2 | 136.1 | 168.3 | 304.4 |
| Benefit (B) | $10^9$ TL | 72.4 | 140.6 | 212.9 | 72.4 | 136.4 | 208.8 | 72.4 | 129.7 | 202.2 | 72.4 | 121.4 | 193.9 | 72.4 | 103.7 | 176.1 |
| Investment Cost | $10^9$ TL | 676.4 | 1,002.8 | 1,679.2 | 676.3 | 941.8 | 1,618.2 | 676.4 | 889.7 | 1,566.1 | 676.3 | 814.2 | 1,490.5 | 676.3 | 631.5 | 1,307.8 |
| Annual Cost (C) | $10^9$ TL | 70.2 | 103.4 | 173.6 | 70.2 | 97.2 | 167.3 | 70.2 | 91.8 | 162.0 | 70.2 | 84.1 | 154.2 | 70.2 | 65.3 | 135.5 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 2.2 | 37.2 | 39.4 | 2.3 | 39.2 | 41.5 | 2.3 | 37.9 | 40.2 | 2.3 | 37.3 | 39.6 | 2.3 | 38.3 | 40.6 |
| Benefit Cost Ratio (B/C) | | 1.03 | 1.36 | 1.23 | 1.03 | 1.40 | 1.25 | 1.03 | 1.41 | 1.25 | 1.03 | 1.44 | 1.26 | 1.03 | 1.59 | 1.30 |
| Unit Annual Cost | TL/KWh | 298 | 260 | 274 | 297 | 249 | 267 | 297 | 245 | 265 | 297 | 235 | 259 | 297 | 222 | 255 |

## Table 9-9(3) Comparative Study on Reservoir Scale

| Description | Unit | 3-A (OP146 - AP400) | | | 3-B (OP146 - AP350) | | | 3-C (OP146 - AP300) | | | 3-D (OP146 - AP284) | | | 3-E (OP146 - AP250) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 300 | 563 | | 300 | 513 | | 300 | 464 | | 300 | 447 | | 300 | 414 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 146 | 400 | | 146 | 350 | | 146 | 300 | | 146 | 284 | | 146 | 250 | |
| High Water Level | m | 1,100.0 | 950.6 | | 1,100.0 | 946.2 | | 1,100.0 | 941.6 | | 1,100.0 | 940.0 | | 1,100.0 | 936.6 | |
| Low Water Level | m | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | |
| Available Drawdown | m | 22.0 | 50.6 | | 22.0 | 46.2 | | 22.0 | 41.6 | | 22.0 | 40.0 | | 22.0 | 36.6 | |
| Tail Water Level | m | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | |
| Effective Head | m | 154.2 | 224.9 | | 154.2 | 222.2 | | 154.2 | 218.9 | | 154.2 | 217.9 | | 154.2 | 215.6 | |
| Maximum Discharge | $m^3/s$ | 44 | 78 | | 44 | 74 | | 44 | 70 | | 44 | 71 | | 44 | 69 | |
| Installed Capacity | MW | 59 | 153 | 212 | 59 | 145 | 204 | 59 | 135 | 195 | 59 | 133 | 192 | 59 | 128 | 188 |
| Firm Peak Power | MW | 50.1 | 123.8 | 173.9 | 50.1 | 118.8 | 168.9 | 50.1 | 112.0 | 162.0 | 50.1 | 110.8 | 160.9 | 50.1 | 108.6 | 158.7 |
| Energy Production | | | | | | | | | | | | | | | | |
| Average Energy | GWh | 210.2 | 424.2 | 634.4 | 213.9 | 418.5 | 632.3 | 217.0 | 411.5 | 628.5 | 217.7 | 409.3 | 627.0 | 218.5 | 404.5 | 622.9 |
| Firm Energy | GWh | 116.5 | 316.8 | 433.3 | 118.5 | 301.7 | 420.1 | 120.3 | 281.2 | 401.5 | 120.7 | 276.6 | 397.2 | 121.1 | 267.4 | 388.5 |
| Benefit (B) | $10^9$ TL | 66.7 | 156.8 | 223.6 | 67.1 | 151.5 | 218.5 | 67.3 | 144.2 | 211.6 | 67.4 | 142.9 | 210.3 | 67.5 | 140.3 | 207.8 |
| Investment Cost | $10^9$ TL | 627.6 | 1,218.2 | 1,845.8 | 627.6 | 1,163.1 | 1,790.7 | 627.6 | 1,107.7 | 1,735.3 | 627.6 | 1,088.7 | 1,716.3 | 627.6 | 1,049.2 | 1,676.8 |
| Annual Cost (C) | $10^9$ TL | 65.0 | 125.4 | 190.4 | 65.0 | 119.8 | 184.8 | 65.0 | 114.1 | 179.1 | 65.0 | 112.1 | 177.2 | 65.0 | 108.1 | 173.1 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 1.7 | 31.4 | 33.1 | 2.0 | 31.7 | 33.7 | 2.2 | 30.1 | 32.4 | 2.3 | 30.7 | 33.1 | 2.4 | 32.2 | 34.6 |
| Benefit Cost Ratio (B/C) | | 1.03 | 1.25 | 1.17 | 1.03 | 1.26 | 1.18 | 1.04 | 1.26 | 1.18 | 1.04 | 1.27 | 1.19 | 1.04 | 1.30 | 1.20 |
| Unit Annual Cost | TL/kWh | 309 | 295 | 300 | 304 | 286 | 292 | 299 | 277 | 285 | 298 | 274 | 282 | 297 | 267 | 278 |

| Description | Unit | 3-F (OP146 - AP250) | | | 3-G (OP146 - AP200) | | | 3-H (OP146 - AP100) | | | 3-I (OP146 - AP050) | | | 3-J (OP146 - AP000) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 300 | 363 | | 300 | 313 | | 300 | 263 | | 300 | 213 | | 300 | 0 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 146 | 200 | | 146 | 150 | | 146 | 100 | | 146 | 50 | | 146 | 0 | |
| High Water Level | m | 1,100.0 | 931.0 | | 1,100.0 | 924.7 | | 1,100.0 | 917.6 | | 1,100.0 | 909.5 | | 1,100.0 | 928.0 | |
| Low Water Level | m | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 928.0 | |
| Available Drawdown | m | 22.0 | 31.0 | | 22.0 | 24.7 | | 22.0 | 17.6 | | 22.0 | 9.5 | | 22.0 | 0.0 | |
| Tail Water Level | m | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | |
| Effective Head | m | 154.2 | 211.9 | | 154.2 | 207.7 | | 154.2 | 202.9 | | 154.2 | 197.5 | | 154.2 | 219.2 | |
| Maximum Discharge | $m^3/s$ | 44 | 66 | | 44 | 64 | | 44 | 59 | | 44 | 55 | | 44 | 44 | |
| Installed Capacity | MW | 59 | 122 | 181 | 59 | 115 | 174 | 59 | 104 | 164 | 59 | 95 | 154 | 59 | 78 | 137 |
| Firm Peak Power | MW | 50.1 | 104.4 | 154.5 | 50.1 | 100.4 | 150.5 | 50.1 | 93.1 | 143.2 | 50.1 | 86.9 | 137.0 | 50.1 | 74.4 | 124.5 |
| Energy Production | | | | | | | | | | | | | | | | |
| Average Energy | GWh | 220.8 | 397.5 | 618.3 | 222.3 | 388.4 | 610.7 | 222.3 | 370.5 | 592.8 | 222.3 | 347.9 | 570.2 | 222.3 | 283.2 | 505.5 |
| Firm Energy | GWh | 122.4 | 255.0 | 377.3 | 123.2 | 240.9 | 364.1 | 123.2 | 216.9 | 340.0 | 123.2 | 195.9 | 319.1 | 123.2 | 155.4 | 278.6 |
| Benefit (B) | $10^9$ TL | 67.7 | 135.7 | 203.4 | 67.8 | 130.9 | 198.8 | 67.8 | 122.3 | 190.2 | 67.8 | 114.4 | 182.2 | 67.8 | 96.7 | 164.6 |
| Investment Cost | $10^9$ TL | 627.6 | 989.0 | 1,616.6 | 627.6 | 934.0 | 1,561.6 | 627.6 | 870.4 | 1,498.0 | 627.6 | 797.2 | 1,424.8 | 627.6 | 593.2 | 1,220.8 |
| Annual Cost (C) | $10^9$ TL | 65.0 | 101.9 | 167.0 | 65.0 | 96.3 | 161.4 | 65.0 | 89.7 | 154.8 | 65.0 | 82.3 | 147.4 | 65.0 | 61.4 | 126.5 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 2.6 | 33.7 | 36.4 | 2.7 | 34.6 | 37.4 | 2.7 | 32.5 | 35.3 | 2.7 | 32.0 | 34.8 | 2.7 | 35.3 | 38.1 |
| Benefit Cost Ratio (B/C) | | 1.04 | 1.33 | 1.22 | 1.04 | 1.36 | 1.23 | 1.04 | 1.36 | 1.23 | 1.04 | 1.39 | 1.24 | 1.04 | 1.58 | 1.30 |
| Unit Annual Cost | TL/kWh | 294 | 256 | 270 | 292 | 248 | 264 | 292 | 242 | 261 | 292 | 236.6 | 258 | 292 | 217 | 250 |

# Table 9-9(4) Comparative Study on Reservoir Scale

| Description | Unit | 4-A (OP100 - AP400) | | | 4-B (OP100 - AP350) | | | 4-C (OP100 - AP300) | | | 4-D (OP100 - AP284) | | | 4-E (OP100 - AP250) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 300 | 563 | | 300 | 513 | | 300 | 464 | | 300 | 447 | | 300 | 414 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 100 | 400 | | 100 | 350 | | 100 | 300 | | 100 | 284 | | 100 | 250 | |
| High Water Level | m | 1,094.0 | 950.6 | | 1,094.0 | 946.2 | | 1,094.0 | 941.6 | | 1,094.0 | 940.0 | | 1,094.0 | 936.6 | |
| Low Water Level | m | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | |
| Available Drawdown | m | 16.4 | 50.6 | | 16.4 | 46.2 | | 16.4 | 41.6 | | 16.4 | 40.0 | | 16.4 | 36.6 | |
| Tail Water Level | m | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | |
| Effective Head | m | 149.8 | 224.9 | | 149.8 | 222.2 | | 149.8 | 218.9 | | 149.8 | 217.8 | | 149.8 | 215.6 | |
| Maximum Discharge | $m^3/s$ | 39 | 75 | | 39 | 72 | | 39 | 69 | | 39 | 68 | | 39 | 66 | |
| Installed Capacity | MW | 50 | 146 | 196 | 50 | 139 | 189 | 50 | 131 | 181 | 50 | 129 | 179 | 50 | 124 | 174 |
| Firm Peak Power | MW | 44.0 | 118.0 | 162.0 | 44.0 | 113.7 | 157.7 | 44.0 | 108.4 | 152.4 | 44.0 | 107.0 | 151.0 | 44.0 | 103.5 | 147.5 |
| Energy Production | | | | | | | | | | | | | | | | |
| Average Energy | GWh | 192.1 | 424.2 | 616.3 | 195.8 | 418.3 | 614.0 | 198.9 | 411.3 | 610.2 | 199.6 | 408.5 | 608.1 | 200.3 | 403.7 | 604.0 |
| Firm Energy | GWh | 98.3 | 302.0 | 400.4 | 100.5 | 288.4 | 389.0 | 102.3 | 272.2 | 374.5 | 102.7 | 267.5 | 370.2 | 103.0 | 258.4 | 361.4 |
| Benefit (B) | $10^9$ TL | 59.3 | 151.1 | 210.4 | 59.6 | 146.4 | 206.1 | 59.9 | 140.7 | 200.6 | 59.9 | 139.1 | 199.1 | 60.0 | 135.3 | 195.4 |
| Investment Cost | $10^9$ TL | 567.1 | 1,201.0 | 1,768.1 | 567.1 | 1,152.0 | 1,719.1 | 567.1 | 1,096.7 | 1,663.8 | 567.1 | 1,078.6 | 1,645.7 | 567.1 | 1,039.5 | 1,606.6 |
| Annual Cost (C) | $10^9$ TL | 58.8 | 123.6 | 182.4 | 58.8 | 118.6 | 177.4 | 58.8 | 112.9 | 171.7 | 58.8 | 111.1 | 169.9 | 58.8 | 107.0 | 165.9 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 0.4 | 27.5 | 28.0 | 0.8 | 27.8 | 28.6 | 1.0 | 27.7 | 28.8 | 1.1 | 28.0 | 29.1 | 1.2 | 28.2 | 29.5 |
| Benefit Cost Ratio (B/C) | | 1.01 | 1.22 | 1.15 | 1.01 | 1.23 | 1.16 | 1.02 | 1.25 | 1.17 | 1.02 | 1.25 | 1.17 | 1.02 | 1.26 | 1.18 |
| Unit Annual Cost | TL/kWh | 306 | 291 | 296 | 300 | 283 | 288 | 295 | 274 | 281 | 294 | 271 | 279 | 293 | 265 | 274 |

| Description | Unit | 4-F (OP100 - AP200) | | | 4-G (OP100 - AP150) | | | 4-H (OP100 - AP100) | | | 4-I (OP100 - AP050) | | | 4-J (OP100 - 000) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 300 | 363 | | 300 | 313 | | 300 | 263 | | 300 | 213 | | 300 | 0 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 100 | 200 | | 100 | 150 | | 100 | 100 | | 100 | 50 | | 100 | 0 | |
| High Water Level | m | 1,094.0 | 931.0 | | 1,094.0 | 924.7 | | 1,094.0 | 917.6 | | 1,094.0 | 909.5 | | 1,094.0 | 928.0 | |
| Low Water Level | m | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 900.0 | | 1,078.0 | 928.0 | |
| Available Drawdown | m | 16.4 | 31.0 | | 16.4 | 24.7 | | 16.4 | 17.6 | | 16.4 | 9.5 | | 16.4 | 0.0 | |
| Tail Water Level | m | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | |
| Effective Head | m | 149.8 | 211.9 | | 149.8 | 207.7 | | 149.8 | 202.9 | | 149.8 | 197.5 | | 149.8 | 205.0 | |
| Maximum Discharge | $m^3/s$ | 39 | 64 | | 39 | 60 | | 39 | 55 | | 39 | 50 | | 39 | 39 | |
| Installed Capacity | MW | 50 | 118 | 168 | 50 | 108 | 158 | 50 | 98 | 148 | 50 | 86 | 136 | 50 | 68 | 118 |
| Firm Peak Power | MW | 44.0 | 99.9 | 143.9 | 44.0 | 94.3 | 138.3 | 44.0 | 87.1 | 131.1 | 44.0 | 79.0 | 123.0 | 44.0 | 64.9 | 108.5 |
| Energy Production | | | | | | | | | | | | | | | | |
| Average Energy | GWh | 202.4 | 395.4 | 597.9 | 203.9 | 384.4 | 588.3 | 203.9 | 361.9 | 565.8 | 203.9 | 332.9 | 536.8 | 203.9 | 325.1 | 529.0 |
| Firm Energy | GWh | 104.2 | 245.6 | 349.8 | 104.9 | 226.0 | 330.9 | 104.9 | 202.6 | 307.5 | 104.9 | 178.1 | 283.0 | 104.9 | 135.5 | 240.5 |
| Benefit (B) | $10^9$ TL | 60.2 | 131.1 | 191.3 | 60.3 | 124.7 | 185.0 | 60.3 | 115.8 | 176.1 | 60.3 | 105.4 | 165.7 | 60.3 | 91.1 | 151.4 |
| Investment Cost | $10^9$ TL | 567.1 | 983.0 | 1,550.1 | 567.1 | 915.8 | 1,483.0 | 567.1 | 853.3 | 1,420.4 | 567.1 | 775.2 | 1,342.4 | 567.1 | 532.6 | 1,099.7 |
| Annual Cost (C) | $10^9$ TL | 58.8 | 101.3 | 160.1 | 58.8 | 94.4 | 153.2 | 58.8 | 87.9 | 146.8 | 58.8 | 79.9 | 138.8 | 58.8 | 55.1 | 114.0 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 1.3 | 29.8 | 31.1 | 1.5 | 30.3 | 31.8 | 1.5 | 27.8 | 29.3 | 1.5 | 25.4 | 26.9 | 1.5 | 35.9 | 37.4 |
| Benefit Cost Ratio (B/C) | | 1.02 | 1.29 | 1.19 | 1.03 | 1.32 | 1.21 | 1.03 | 1.32 | 1.20 | 1.03 | 1.32 | 1.19 | 1.03 | 1.65 | 1.33 |
| Unit Annual Cost | TL/kWh | 290 | 256 | 267 | 288 | 245 | 260 | 288 | 243 | 259 | 288 | 240 | 258 | 288 | 169 | 215 |

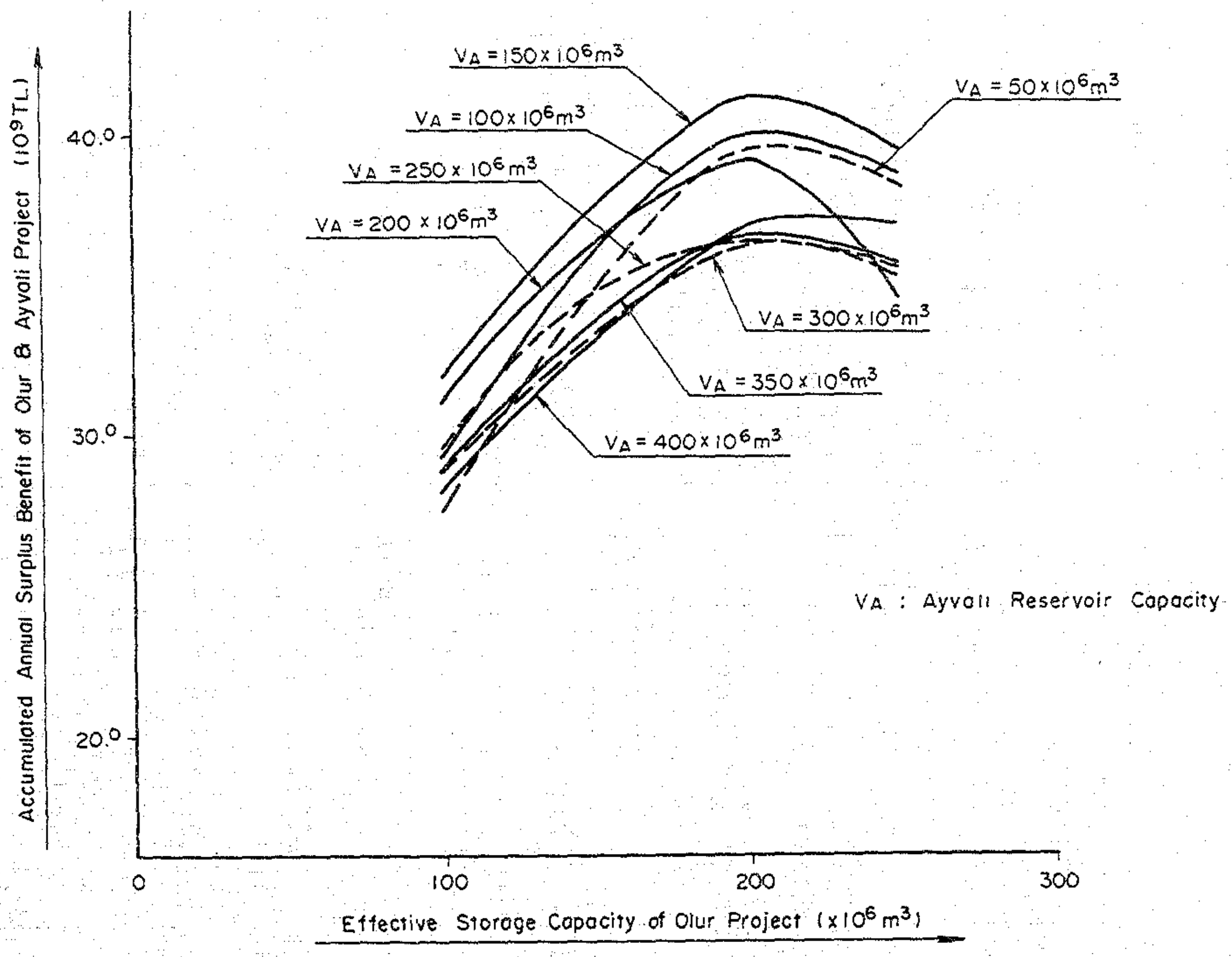



**Fig. 9-12 Comparative Study on Reservoir Scale of Olur Project**

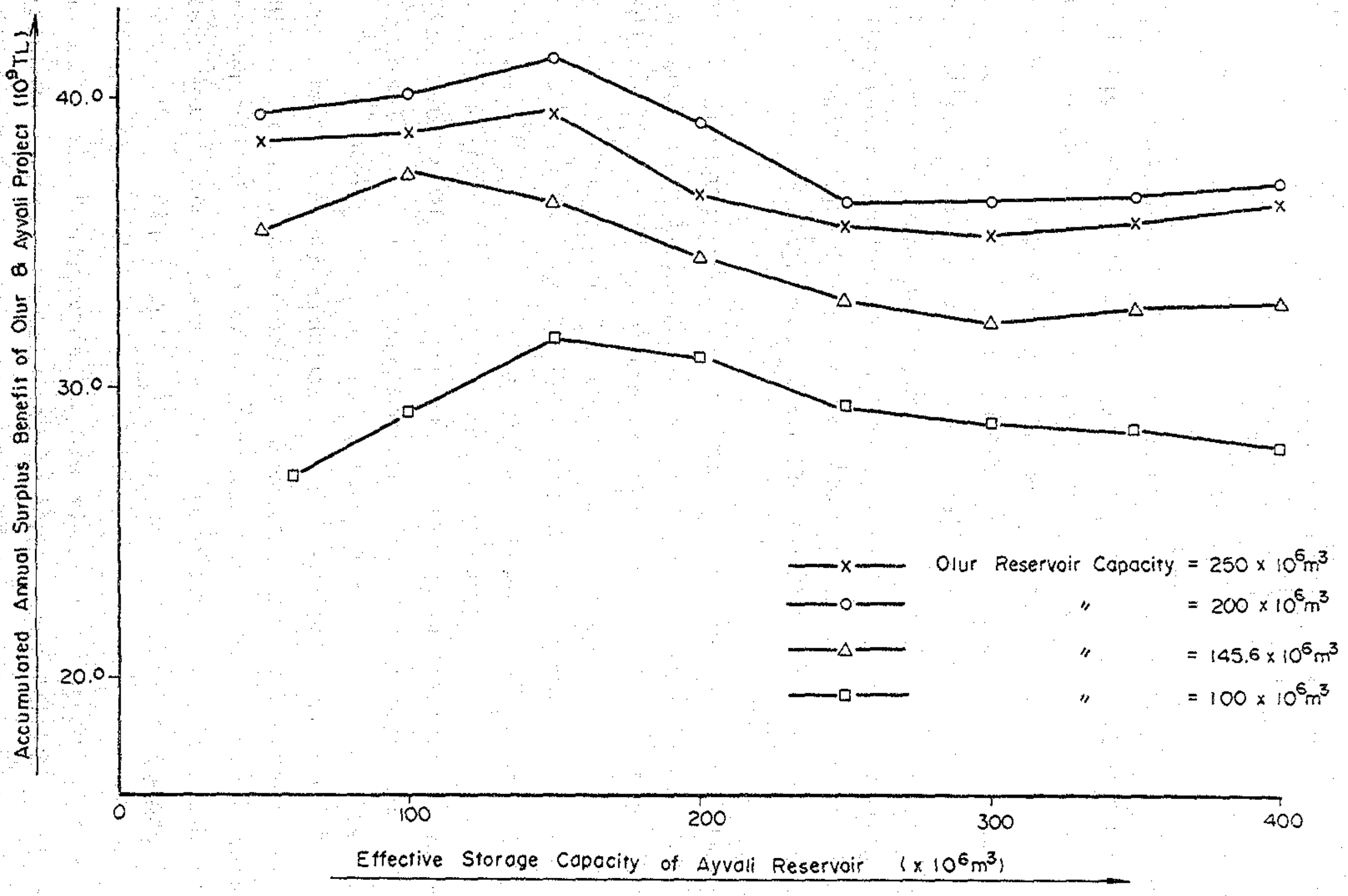



Fig. 9-13 Comparative Study on Reservoir Scale of Ayvali Project

## 9.3 Optimum Development Plan

### 9.3.1 High Water Level and Effective Storage Capacity

(1) Olur Project

As the optimum scale for water storage in the Olur Project, the conclusion of 200 x $10^6$ $m^3$ has tentatively been obtained in the study of 9.2.3. The study of 9.2.3 made comparisons varying storage capacities with low water level of the reservoir as constant. But here, in order to determine the optimum development plan, the low water levels for 200 x $10^6$ $m^3$ and effective storage capacities above and below this were respectively varied, and comparison studies were made using combinations with a number of high water level for the individual effective storage capacities.

In energy calculations by mass curve, the frequency of use of the reservoir is high since operation will be done in a manner to minimize spilled quantity as much as possible And there will be that much higher frequency of reservoir water level dropping to low water level. However, it is conceivable for there to be cases of it being more advantageous to operate at high reservoir water levels, even if spilled water may be increased slightly, and carry out high-head operation. In studying high water level, it is important for the factor of head especially to be reflected in electric energy calculations. Therefore, energy calculations were made by the Dynamic Program (DP) method in which reservoir operation is done ideally judging by the two aspects of available water and head. Flow chart of energy calculation is shown in Fig. 9-14.

The results of the study are as shown in Table 9-10 and Fig. 9-15, and regardless of the size of storage capacity, even if dead storage capacity is set larger than sedimentation capacity and dam height is increased, this will not result in increase of surplus benefit, and the economics of the project will be worsened. Consequently, if the optimum effective storage of Olur Reservoir is taken to be 200 x $10^6$ $m^3$, 1,105 m will be optimum as the high water level of the reservoir.

The runoff regulating effect of Olur Reservoir will extend not only to the Olur Project, but also to the Ayvalı Project, and as described in 9.2.1, the project was optimized in the manner that the combination of the two project as a whole would be most optimum. Therefore, the optimum effective storage capacity of olur Reservoir is to be decided by a study in combination with the Ayvalı Project.

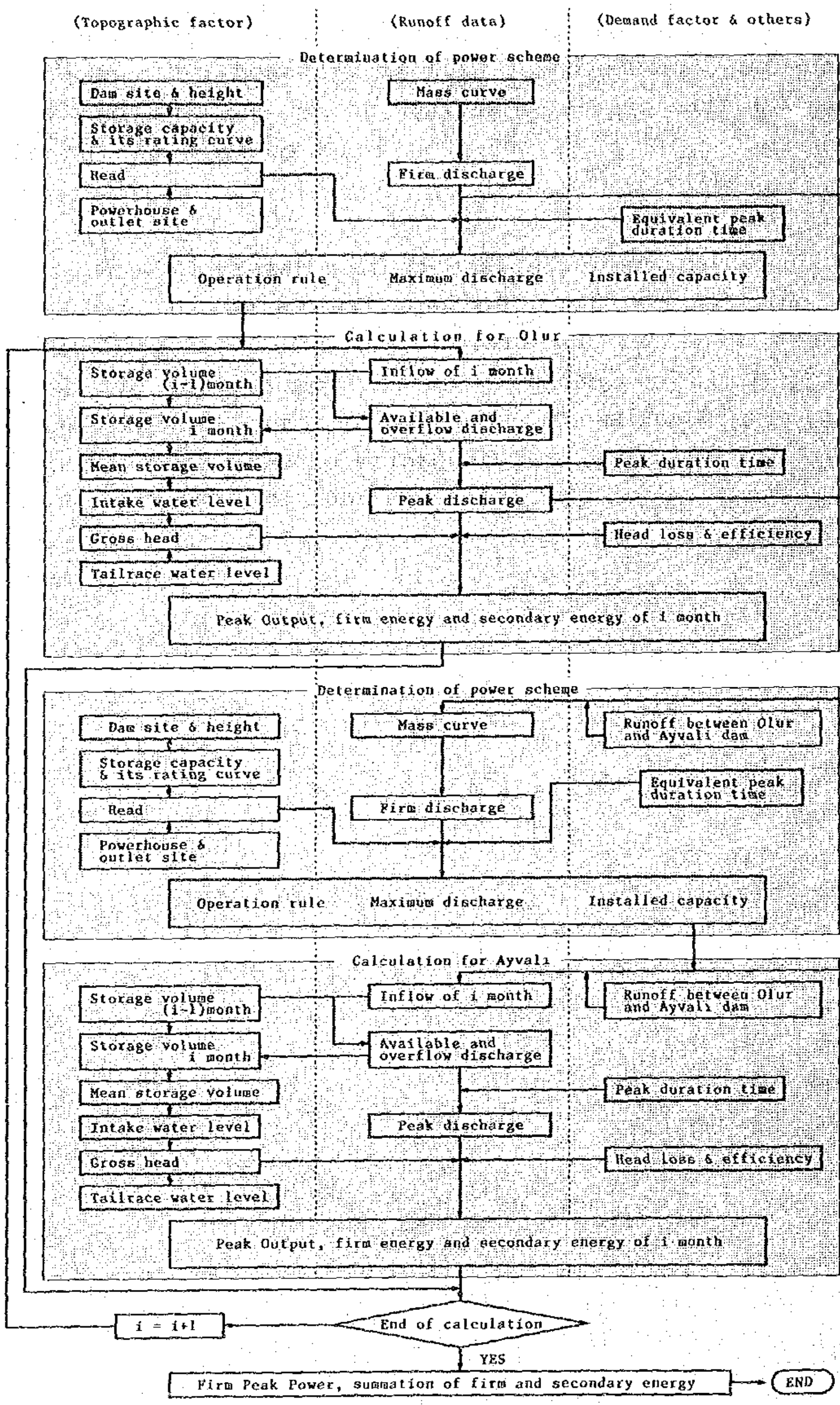



**Fig. 9-14 Flow Chart of Energy Calculation**

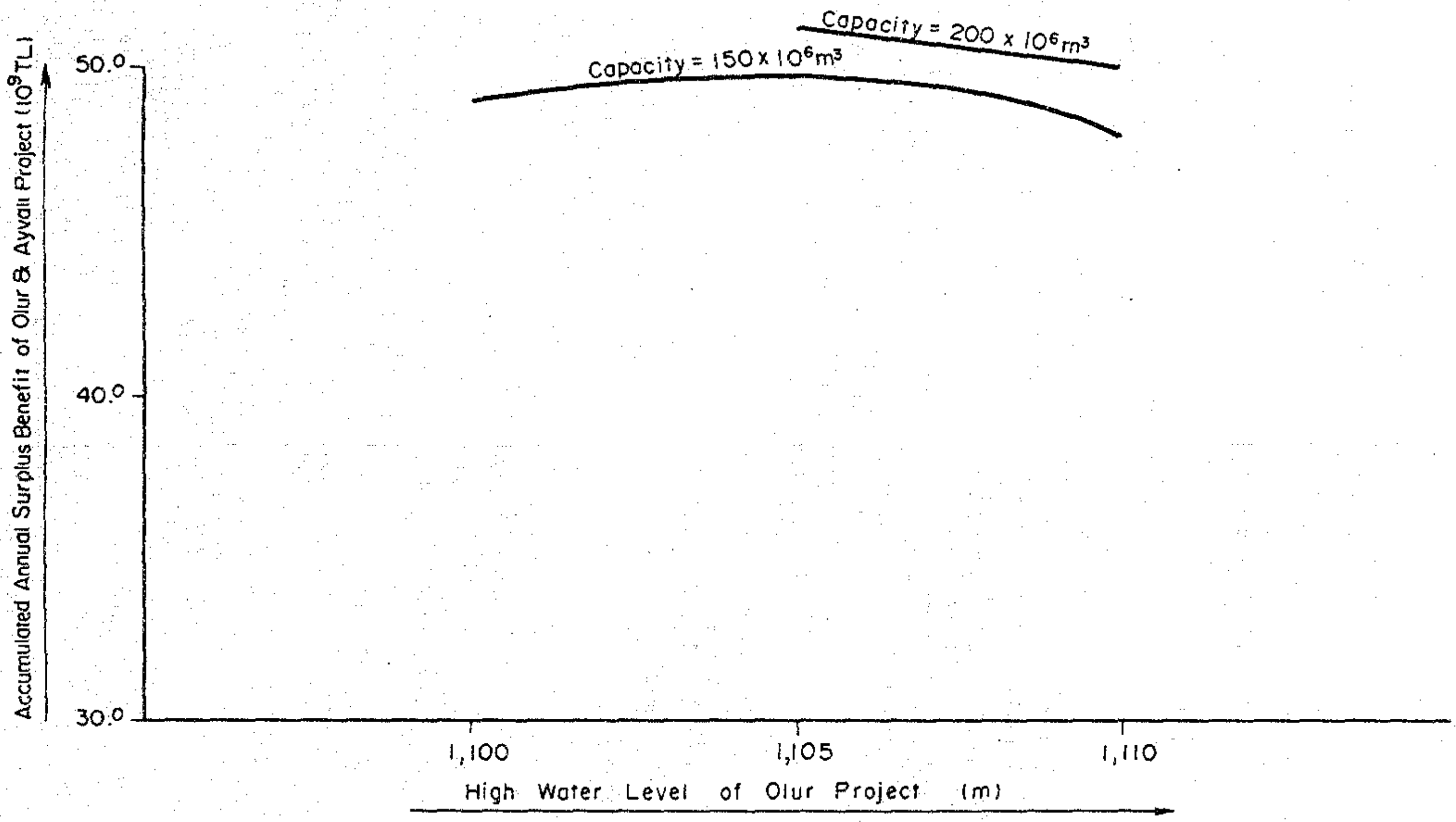



Fig. 9-15 **Optimization Study on Effective Storage Capacity and High Water Level of Olur Project**

## Table 9-10 Optimization Study on Effective Storage Capacity and High Water Level of Olur Project

| Description | Unit | A (OPK1500 - APU1530) | | | B (OPK1505 - APU1530) | | | C (OPK1510 - APU1530) | | | D (OPK2005 - APU1530) | | | E (OPK2010 - APU1530) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 244 | 355 | | 293 | 355 | | 351 | 355 | | 293 | 355 | | 351 | 355 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 150 | 150 | | 150 | 150 | | 150 | 150 | | 200 | 150 | | 200 | 150 | |
| High Water Level | m | 1,100.00 | 930.00 | | 1,105.00 | 930.00 | | 1,110.00 | 930.00 | | 1,105.00 | 930.00 | | 1,110.00 | 930.00 | |
| Low Water Level | m | 1,077.00 | 908.00 | | 1,086.00 | 908.00 | | 1,094.90 | 908.00 | | 1,077.00 | 908.00 | | 1,087.70 | 908.00 | |
| Available Drawdown | m | 23.00 | 22.00 | | 18.60 | 22.00 | | 15.10 | 22.00 | | 28.00 | 22.00 | | 22.30 | 22.00 | |
| Tail Water Level | m | 929.00 | 700.00 | | 929.00 | 700.00 | | 929.00 | 700.00 | | 929.00 | 700.00 | | 929.00 | 700.00 | |
| Effective Head | m | 151.3 | 211.8 | | 157.8 | 211.8 | | 164.0 | 211.8 | | 154.7 | 211.8 | | 161.6 | 211.8 | |
| Maximum Discharge | $m^3/s$ | 45 | 64 | | 45 | 64 | | 45 | 64 | | 48 | 67 | | 48 | 67 | |
| Installed Capacity | MW | 59 | 119 | 178 | 61 | 119 | 180 | 64 | 119 | 183 | 65 | 125 | 190 | 68 | 125 | 193 |
| Firm Peak Power | MW | 55.7 | 108.1 | 163.8 | 58.7 | 108.1 | 166.8 | 61.5 | 108.1 | 169.6 | 57.8 | 113.4 | 171.2 | 60.3 | 113.4 | 173.7 |
| Energy Production | | | | | | | | | | | | | | | | |
| Average Energy | GWh | 238.5 | 406.7 | 645.2 | 238.5 | 406.7 | 645.2 | 247.7 | 406.7 | 654.4 | 241.5 | 409.4 | 650.9 | 252.3 | 408.6 | 660.9 |
| Firm Energy | GWh | 114.1 | 238.5 | 352.6 | 114.1 | 238.5 | 352.6 | 118.5 | 238.5 | 357.0 | 126.5 | 248.0 | 374.5 | 132.3 | 248.0 | 380.3 |
| Benefit (B) | $10^9$ TL | 74.7 | 140.1 | 214.8 | 77.6 | 140.1 | 217.7 | 81.1 | 140.1 | 221.2 | 77.0 | 145.5 | 222.4 | 80.3 | 145.4 | 225.7 |
| Investment Cost | $10^9$ TL | 653.6 | 973.3 | 1,626.5 | 653.2 | 973.3 | 1,626.5 | 706.2 | 973.3 | 1,679.5 | 671.4 | 988.0 | 1,659.4 | 712.7 | 988.0 | 1,700.7 |
| Annual Cost (C) | $10^9$ TL | 65.7 | 100.4 | 166.1 | 67.7 | 100.4 | 168.1 | 73.1 | 100.4 | 173.5 | 69.6 | 101.9 | 171.5 | 74.0 | 101.9 | 175.9 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 9.0 | 39.7 | 48.7 | 9.9 | 39.7 | 49.6 | 8.0 | 39.7 | 47.7 | 7.4 | 43.6 | 51.0 | 6.3 | 43.5 | 49.8 |
| Benefit Cost Ratio (B/C) | | 1.14 | 1.40 | 1.29 | 1.15 | 1.40 | 1.30 | 1.11 | 1.40 | 1.28 | 1.11 | 1.43 | 1.30 | 1.09 | 1.43 | 1.28 |
| Unit Annual Cost | TL/kWh | 276 | 247 | 257 | 284 | 247 | 260 | 295 | 247 | 265 | 288 | 249 | 264 | 293 | 249 | 266 |

(2) Ayvalı Project

Regarding the scale of the reservoir in the Ayvalı Project, as a result of comparison studies fixing low water level at EL. 900 m as shown in 9.2.3 and calculating energy by mass curve, the optimum effective storage capacity is about 150 x $10^6$ $m^3$.

Here, similarly to (1), Olur Project, in order to determine the optimum development plan, the low water levels for 150 x $10^6$ $m^3$ and effective storage capacities above and below this were respectively varied, and comparison studies were made using combinations with a number of high water levels for the individual effective storage capacities, and he energies used in the study were calculated by the Dynamic Program (DP) method.

With a reservoir, there are the effects of averaging inflow, and of storing runoff of the wet season and supplementing in the dry season by discharge. In a case like the Olur Project in which there are projects upstream and downstream, the runoff supplementation effect on the downstream project is exactly the same regardless of whether the effective storage capacity is secured at either the upstream or downstream reservoir. Since the Ayvalı Project can enjoy the effect of the upstream Olur Project, if the effective storage capacity required for averaging inflow is secured at Ayvalı Reservoir, the effect on the Ayvalı Project would not be different regardless of whether any effective storage capacity beyond that is secured at either reservoir, Olur or Ayvalı.

Accordingly, a comparison study was made on the effective storage capacity of Olur Reservoir of 200 x $10^6$ $m^3$ and cases of scales above and below that varying the low water level and effective storage capacity of the Ayvalı Project.

The result of this is as shown in Table 9-11 and Fig. 9-16, and for the Ayvalı Project the surplus benefit would be a maximum in the case of effective storage capacity of Olur Reservoir 200 x $10^6$ $m^3$ and the effective storage capacity 150 x $10^6$ $m^3$, high water level elevation of Ayvalı Reservoir 930 m, and this would be the optimum plan. Consequently, it was finally confirmed that the effective storage capacity of the Olur Project of 200 x $10^6$ $m^3$ selected in (1) above is also optimum.

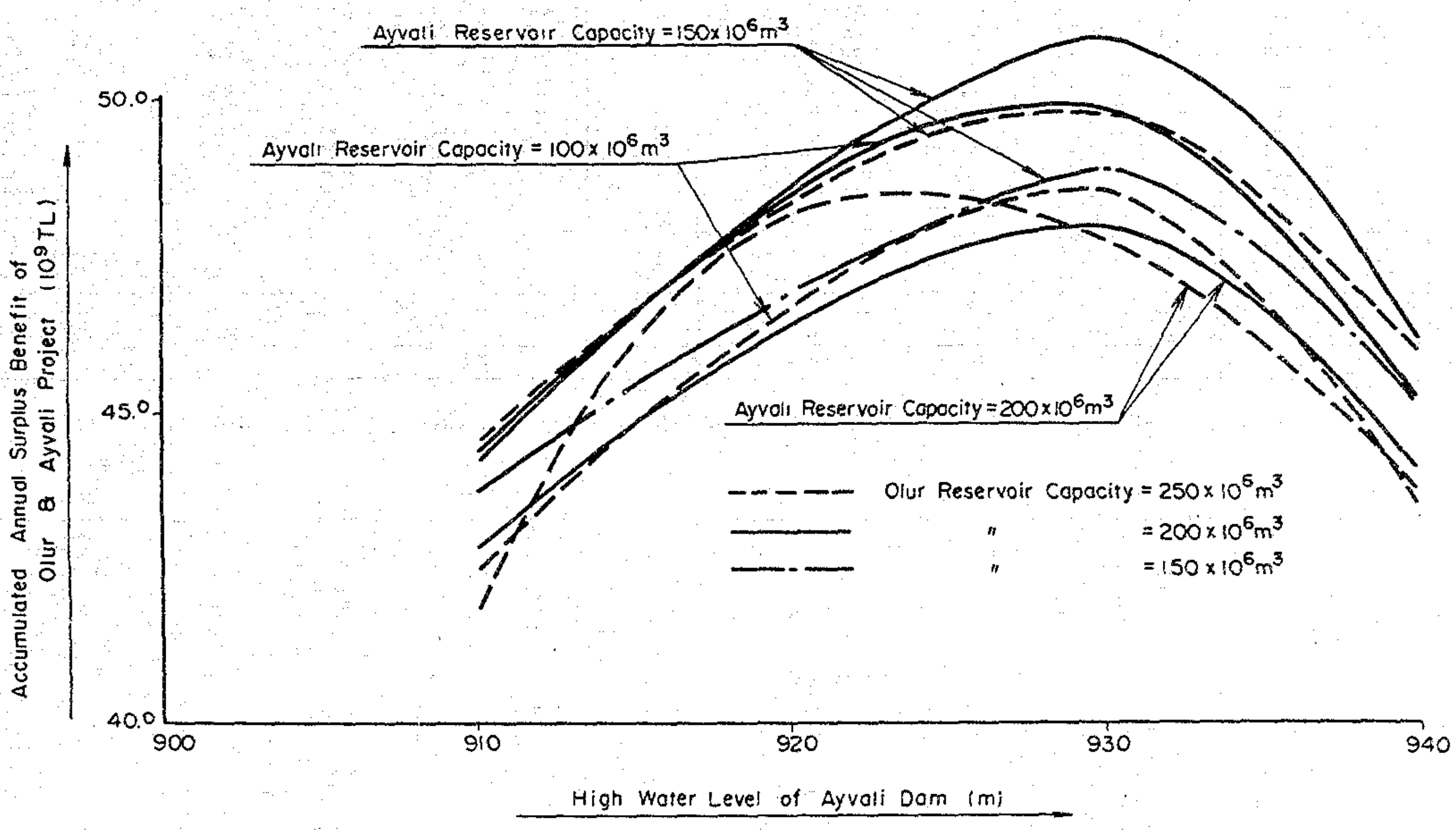



Fig. 9-16 Optimization Study on Effective Storage Capacity and High Water Level of Ayvali Project

## Table 9-11(1) Optimization Study on Effective Storage Capacity and High Water Level of Ayvali Project

| Description | Unit | 1-A (OP2510 - AP2040) | | | 1-B (OP2510 - AP2030) | | | 1-C (OP2510 - AP2020) | | | 1-D (OP2510 - AP2010) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 351 | 447 | | 351 | 335 | | 351 | 279 | | 351 | 216 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 250 | 200 | | 250 | 200 | | 250 | 200 | | 250 | 200 | |
| High Water Level | m | 1,110.0 | 940.0 | | 1,110.0 | 930.0 | | 1,110.0 | 920.0 | | 1,110.0 | 910.0 | |
| Low Water Level | m | 1,078.7 | 929.1 | | 1,078.7 | 916.2 | | 1,078.7 | 903.2 | | 1,078.7 | 888.5 | |
| Available Drawdown | m | 31.3 | 10.9 | | 31.3 | 13.8 | | 31.3 | 16.8 | | 31.3 | 21.5 | |
| Tail Water Level | m | 929.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | |
| Effective Head | m | 158.6 | 220.8 | | 158.6 | 208.5 | | 158.6 | 194.8 | | 158.6 | 177.1 | |
| Maximum Discharge | $m^3/s$ | 52 | 72 | | 52 | 72 | | 52 | 72 | | 52 | 72 | |
| Installed Capacity | MW | 72 | 140 | 212 | 72 | 131 | 203 | 72 | 122 | 194 | 72 | 111 | 183 |
| Firm Peak Power | MW | 60.2 | 122.9 | 183.1 | 63.6 | 115.6 | 179.2 | 63.8 | 107.1 | 170.9 | 63.9 | 98.3 | 162.2 |
| Energy Production | | | | | | | | | | | | | |
| Average Energy | GWh | 244.7 | 426.3 | 671.0 | 252.4 | 406.3 | 658.7 | 253.1 | 385.3 | 638.4 | 253.1 | 363.9 | 617.0 |
| Firm Energy | GWh | 133.4 | 272.0 | 405.4 | 141.9 | 254.5 | 396.4 | 142.3 | 236.7 | 379.0 | 149.4 | 217.5 | 366.9 |
| Benefit (B) | $10^9$ TL | 79.5 | 156.1 | 235.7 | 83.5 | 147.3 | 230.8 | 83.8 | 137.2 | 221.0 | 83.9 | 126.8 | 210.7 |
| Investment Cost | $10^9$ TL | 760.1 | 1,097.7 | 1,857.8 | 760.1 | 1,011.2 | 1,771.3 | 760.1 | 910.1 | 1,670.3 | 760.1 | 871.3 | 1,631.5 |
| Annual Cost (C) | $10^9$ TL | 78.7 | 113.1 | 191.8 | 78.7 | 104.3 | 183.0 | 78.7 | 94.0 | 172.7 | 78.7 | 90.0 | 168.8 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 0.8 | 43.0 | 43.8 | 4.7 | 43.0 | 47.8 | 5.0 | 43.2 | 48.2 | 5.1 | 36.7 | 41.9 |
| Benefit Cost Ratio (B/C) | | 1.01 | 1.38 | 1.23 | 1.06 | 1.41 | 1.26 | 1.06 | 1.46 | 1.28 | 1.07 | 1.41 | 1.25 |
| Unit Annual Cost | TL/kWh | 321 | 265 | 285 | 312 | 256 | 277 | 311 | 244 | 270 | 311 | 247.5 | 273 |

## Table 9-11(2) Optimization Study on Effective Storage Capacity and High Water Level of Ayvali Project

| Description | Unit | 2-A (OP2005 - AP2040) | | | 2-B (OP2005 - AP2030) | | | 2-C (OP2005 - AP2020) | | | 2-D (OP2005 - AP2010) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 293 | 447 | | 293 | 335 | | 293 | 279 | | 293 | 216 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 200 | 200 | | 200 | 200 | | 200 | 200 | | 200 | 200 | |
| High Water Level | m | 1,105.0 | 940.0 | | 1,105.0 | 930.0 | | 1,105.0 | 920.0 | | 1,105.0 | 910.0 | |
| Low Water Level | m | 1,077.0 | 915.2 | | 1,077.0 | 898.1 | | 1,077.0 | 877.2 | | 1,077.0 | 844.1 | |
| Available Drawdown | m | 28.0 | 24.8 | | 28.0 | 31.9 | | 28.0 | 42.8 | | 28.0 | 65.9 | |
| Tail Water Level | m | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | | 928.0 | 700.0 | |
| Effective Head | m | 154.7 | 220.8 | | 154.7 | 208.5 | | 154.7 | 194.8 | | 154.7 | 177.1 | |
| Maximum Discharge | $m^3/s$ | 48 | 69 | | 48 | 69 | | 48 | 69 | | 48 | 69 | |
| Installed Capacity | MW | 65 | 133 | 198 | 65 | 126 | 191 | 65 | 118 | 183 | 65 | 107 | 172 |
| Firm Peak Power | MW | 54.7 | 119.3 | 174.0 | 57.8 | 112.2 | 170.0 | 58.0 | 104.0 | 162.0 | 58.1 | 95.4 | 153.5 |
| Energy Production | | | | | | | | | | | | | |
| Average Energy | GWh | 234.3 | 426.2 | 660.5 | 241.5 | 406.2 | 647.7 | 242.4 | 385.2 | 627.6 | 242.4 | 363.9 | 606.3 |
| Firm Energy | GWh | 119.1 | 262.3 | 381.4 | 120.7 | 245.5 | 366.2 | 121.0 | 228.4 | 349.4 | 127.1 | 209.8 | 336.9 |
| Benefit (B) | $10^9$ TL | 73.3 | 152.6 | 225.9 | 76.9 | 144.0 | 221.0 | 77.2 | 134.2 | 211.4 | 77.3 | 124.0 | 201.4 |
| Investment Cost | $10^9$ TL | 671.3 | 1,089.5 | 1,760.9 | 671.3 | 1,001.6 | 1,673.0 | 671.3 | 924.8 | 1,596.1 | 671.3 | 861.0 | 1,532.4 |
| Annual Cost (C) | $10^9$ TL | 69.2 | 112.2 | 181.8 | 69.6 | 103.3 | 172.9 | 69.6 | 95.4 | 165.0 | 69.6 | 88.9 | 158.5 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 3.7 | 40.3 | 44.1 | 7.3 | 40.6 | 48.0 | 7.6 | 38.7 | 46.4 | 7.7 | 35.1 | 42.8 |
| Benefit Cost Ratio (B/C) | | 1.05 | 1.36 | 1.24 | 1.11 | 1.39 | 1.28 | 1.11 | 1.41 | 1.28 | 1.11 | 1.40 | 1.27 |
| Unit Annual Cost | TL/kWh | 297 | 263 | 275 | 288 | 254 | 267 | 287 | 247 | 263 | 287 | 244 | 261 |

## Table 9-11(3) Optimization Study on Effective Storage Capacity and High Water Level of Ayvalı Project

| Description | Unit | 3-A (OP2510 - APU1540) | | | 3-B (2510 - 1530) | | | 3-C (OP2510 - APU1540) | | | 3-D (OP2510 - APU1540) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total |
| Gross Storage Capacity | $10^6$ m$^3$ | 351 | 447 | | 351 | 355 | | 351 | 279 | | 351 | 216 | |
| Effective Storage Capacity | $10^6$ m$^3$ | 250 | 150 | | 250 | 150 | | 250 | 150 | | 250 | 150 | |
| High Water Level | m | 1,110.0 | 940.0 | | 1,110.0 | 930.0 | | 1,110.0 | 920.0 | | 1,110.0 | 910.0 | |
| Low Water Level | m | 1,078.7 | 922.5 | | 1,078.7 | 908.0 | | 1,078.7 | 892.1 | | 1,078.7 | 872.2 | |
| Available Drawdown | m | 31.3 | 17.5 | | 31.3 | 22.0 | | 31.3 | 27.9 | | 31.3 | 37.8 | |
| Tail Water Level | m | 929.0 | 700.0 | | 929.0 | 700.0 | | 929.0 | 700.0 | | 929.0 | 700.0 | |
| Effective Head | m | 158.6 | 223.3 | | 158.6 | 223.3 | | 158.6 | 199.8 | | 158.6 | 186.5 | |
| Maximum Discharge | m$^3$/s | 52 | 69 | | 52 | 69 | | 52 | 69 | | 52 | 69 | |
| Installed Capacity | MW | 72 | 135 | 207 | 72 | 128 | 200 | 72 | 121 | 193 | 72 | 113 | 185 |
| Firm Peak Power | MW | 59.9 | 124.2 | 184.1 | 63.6 | 116.3 | 179.9 | 63.8 | 108.3 | 172.1 | 63.9 | 99.3 | 163.2 |
| Energy Production | | | | | | | | | | | | | |
| Average Energy | GWh | 243.3 | 429.4 | 672.7 | 252.4 | 409.3 | 661.7 | 253.1 | 388.2 | 641.3 | 253.1 | 366.6 | 619.7 |
| Firm Energy | GWh | 132.6 | 277.0 | 409.6 | 141.9 | 260.3 | 402.2 | 135.6 | 241.1 | 376.7 | 142.5 | 221.5 | 364.0 |
| Benefit (B) | $10^9$ TL | 79.1 | 157.6 | 236.8 | 83.5 | 148.2 | 231.8 | 83.8 | 138.6 | 222.4 | 83.9 | 128.0 | 211.9 |
| Investment Cost | $10^9$ TL | 757.7 | 1,088.1 | 1,845.9 | 757.7 | 1,002.9 | 1,760.6 | 757.7 | 924.3 | 1,682.1 | 757.7 | 862.1 | 1,619.9 |
| Annual Cost (C) | $10^9$ TL | 78.5 | 112.1 | 190.6 | 78.5 | 103.4 | 181.9 | 78.5 | 95.4 | 173.9 | 78.5 | 89.0 | 167.6 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 0.6 | 45.5 | 46.2 | 5.0 | 44.8 | 49.8 | 5.2 | 43.2 | 48.5 | 5.3 | 38.9 | 44.3 |
| Benefit Cost Ratio (B/C) | | 1.01 | 1.41 | 1.24 | 1.06 | 1.43 | 1.27 | 1.07 | 1.45 | 1.28 | 1.07 | 1.44 | 1.26 |
| Unit Annual Cost | TL/kWh | 322 | 261 | 283 | 311 | 252 | 275 | 310 | 245 | 271 | 310 | 243 | 270 |

## Table 9-11(4) Optimization Study on Effective Storage Capacity and High Water Level of Ayvali Project

| Description | Unit | 4-A (OP2005 - AP1540) | | | 4-B (OP2005 - AP1530) | | | 4-C (OP2005 - AP1520) | | | 4-D (OP2005 - AP1510) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total |
| Gross Storage Capacity | $10^6$ m$^3$ | 293 | 447 | | 293 | 355 | | 293 | 279 | | 293 | 216 | |
| Effective Storage Capacity | $10^6$ m$^3$ | 200 | 150 | | 200 | 150 | | 200 | 150 | | 200 | 150 | |
| High Water Level | m | 1,105.0 | 940.0 | | 1,105.0 | 930.0 | | 1,105.0 | 920.0 | | 1,105.0 | 910.0 | |
| Low Water Level | m | 1,077.0 | 922.5 | | 1,077.0 | 908.0 | | 1,077.0 | 892.1 | | 1,077.0 | 872.2 | |
| Available Drawdown | m | 28.0 | 22.0 | | 28.0 | 22.0 | | 28.0 | 27.9 | | 28.0 | 37.8 | |
| Tail Water Level | m | 929.0 | 700.0 | | 929.0 | 700.0 | | 929.0 | 700.0 | | 929.0 | 700.0 | |
| Effective Head | m | 154.7 | 223.3 | | 154.7 | 211.8 | | 154.7 | 199.4 | | 154.7 | 186.1 | |
| Maximum Discharge | m$^3$/s | 48 | 67 | | 48 | 67 | | 48 | 69 | | 48 | 67 | |
| Installed Capacity | MW | 65 | 129 | 194 | 65 | 125 | 190 | 65 | 117 | 182 | 65 | 109 | 174 |
| Firm Peak Power | MW | 54.4 | 120.6 | 175.0 | 57.8 | 113.4 | 171.2 | 58.0 | 105.1 | 163.1 | 58.1 | 96.4 | 154.5 |
| Energy Production | | | | | | | | | | | | | |
| Average Energy | GWh | 233.0 | 428.7 | 661.7 | 241.5 | 409.4 | 650.9 | 242.4 | 387.5 | 629.9 | 242.4 | 366.0 | 608.4 |
| Firm Energy | GWh | 118.4 | 263.9 | 382.3 | 126.5 | 248.0 | 374.5 | 121.1 | 229.7 | 350.8 | 127.2 | 211.0 | 338.2 |
| Benefit (B) | $10^9$ TL | 72.9 | 154.1 | 227.0 | 77.0 | 145.5 | 222.4 | 77.2 | 135.5 | 212.7 | 77.3 | 125.2 | 202.5 |
| Investment Cost | $10^9$ TL | 671.3 | 1,078.5 | 1,749.9 | 671.4 | 988.0 | 1,659.4 | 671.3 | 918.8 | 1,590.2 | 671.3 | 856.0 | 1,527.4 |
| Annual Cost (C) | $10^9$ TL | 69.6 | 111.1 | 180.7 | 69.6 | 101.9 | 171.5 | 69.6 | 94.8 | 164.5 | 69.6 | 88.4 | 158.1 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 3.3 | 43.0 | 46.3 | 7.4 | 43.6 | 51.0 | 7.6 | 40.6 | 48.2 | 7.7 | 36.7 | 44.4 |
| Benefit Cost Ratio (B/C) | | 1.05 | 1.39 | 1.26 | 1.11 | 1.43 | 1.30 | 1.11 | 1.43 | 1.29 | 1.11 | 1.41 | 1.28 |
| Unit Annual Cost | TL/kWh | 298 | 259 | 273 | 288 | 249 | 264 | 287 | 244 | 261 | 287 | 241 | 259 |

## Table 9-11(5) Optimization Study on Effective Storage Capacity and High Water Level of Ayvali Project

| Description | Unit | 5-A (OPK1500 - APU1540) | | | 5-B (OP1500 - AP1530) | | | 5-C (OP1500 - AP1520) | | | 5-D (OP1500 - AP1510) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 244 | 447 | | 244 | 355 | | 244 | 279 | | 244 | 216 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 150 | 150 | | 150 | 150 | | 150 | 150 | | 150 | 150 | |
| High Water Level | m | 1,100.0 | 940.0 | | 1,100.0 | 930.0 | | 1,100.0 | 920.0 | | 1,100.0 | 910.0 | |
| Low Water Level | m | 1,077.0 | 922.5 | | 1,077.0 | 908.0 | | 1,077.0 | 892.1 | | 1,077.0 | 872.2 | |
| Available Drawdown | m | 23.0 | 22.0 | | 23.0 | 22.0 | | 23.0 | 27.9 | | 23.0 | 37.8 | |
| Tail Water Level | m | 929.0 | 700.0 | | 929.0 | 700.0 | | 929.0 | 700.0 | | 929.0 | 700.0 | |
| Effective Head | m | 151.3 | 223.3 | | 151.3 | 211.8 | | 151.3 | 199.8 | | 151.3 | 186.5 | |
| Maximum Discharge | $m^3/s$ | 45 | 64 | | 45 | 64 | | 45 | 64 | | 45 | 64 | |
| Installed Capacity | MW | 59 | 126 | 185 | 59 | 119 | 179 | 59 | 113 | 172 | 59 | 105 | 165 |
| Firm Peak Power | MW | 52.9 | 115.5 | 168.4 | 55.7 | 108.1 | 163.8 | 55.9 | 100.2 | 156.1 | 55.9 | 92.3 | 148.2 |
| Energy Production | | | | | | | | | | | | | |
| Average Energy | GWh | 228.0 | 426.7 | 654.7 | 238.5 | 406.7 | 645.2 | 239.2 | 385.7 | 624.9 | 239.2 | 364.3 | 603.5 |
| Firm Energy | GWh | 109.5 | 253.8 | 363.3 | 114.1 | 238.5 | 352.6 | 116.2 | 220.9 | 337.1 | 116.2 | 202.9 | 319.1 |
| Benefit (B) | $10^9$ TL | 71.1 | 149.0 | 220.1 | 74.7 | 140.1 | 214.8 | 74.9 | 130.6 | 205.5 | 74.9 | 121.1 | 196.0 |
| Investment Cost | $10^9$ TL | 631.5 | 1,062.5 | 1,694.0 | 631.5 | 973.3 | 1,604.8 | 631.5 | 903.4 | 1,534.9 | 631.5 | 840.6 | 1,472.1 |
| Annual Cost (C) | $10^9$ TL | 65.5 | 109.4 | 174.9 | 65.5 | 100.4 | 165.9 | 65.5 | 93.2 | 158.8 | 65.5 | 34.2 | 152.4 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 5.5 | 39.6 | 45.1 | 9.2 | 39.7 | 48.9 | 9.4 | 37.4 | 46.8 | 9.4 | 34.2 | 43.7 |
| Benefit Cost Ratio (B/C) | | 1.08 | 1.36 | 1.26 | 1.14 | 1.40 | 1.29 | 1.14 | 1.40 | 1.29 | 1.14 | 1.39 | 1.29 |
| Unit Annual Cost | TL/kWh | 287 | 256 | 267 | 275 | 247 | 257 | 274 | 242 | 254 | 274 | 238 | 252 |

## Table 9-11(6) Optimization Study on Effective Storage Capacity and High Water Level of Ayvali Project

| Description | Unit | 6-A (OP2510 - AP1040) | | | 6-B (OP2510 - AP1030) | | | 6-C (OP2510 - AP1020) | | | 6-D (OP2510 - AP1010) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total | Olur Project | Ayvali Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 351 | 447 | | 351 | 355 | | 351 | 279 | | 351 | 216 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 250 | 100 | | 250 | 100 | | 250 | 100 | | 250 | 100 | |
| High Water Level | m | 1,110.0 | 940.0 | | 1,110.0 | 930.0 | | 1,110.0 | 920.0 | | 1,110.0 | 910.0 | |
| Low Water Level | m | 1,078.7 | 929.1 | | 1,078.7 | 916.2 | | 1,078.7 | 903.2 | | 1,078.7 | 888.5 | |
| Available Drawdown | m | 31.3 | 10.9 | | 31.3 | 13.8 | | 31.3 | 16.8 | | 31.3 | 21.5 | |
| Tail Water Level | m | 929.0 | 700.0 | | 929.0 | 700.0 | | 929.0 | 700.0 | | 929.0 | 700.0 | |
| Effective Head | m | 158.6 | 225.5 | | 158.6 | 214.5 | | 158.6 | 203.5 | | 158.6 | 191.9 | |
| Maximum Discharge | $m^3/s$ | 52 | 67 | | 52 | 67 | | 52 | 67 | | 52 | 67 | |
| Installed Capacity | MW | 72 | 132 | 205 | 72 | 126 | 198 | 72 | 119 | 192 | 72 | 113 | 185 |
| Firm Peak Power | MW | 59.2 | 121.7 | 180.9 | 63.3 | 114.4 | 177.7 | 63.5 | 106.0 | 169.5 | 63.6 | 97.3 | 160.9 |
| Energy Production | | | | | | | | | | | | | |
| Average Energy | GWh | 240.8 | 426.4 | 667.2 | 252.4 | 406.4 | 658.8 | 253.1 | 385.4 | 638.5 | 253.1 | 364.0 | 617.1 |
| Firm Energy | GWh | 131.3 | 271.5 | 402.8 | 141.9 | 253.6 | 395.5 | 135.6 | 236.3 | 371.9 | 127.2 | 217.1 | 344.3 |
| Benefit (B) | $10^9$ TL | 78.2 | 154.9 | 233.2 | 83.2 | 146.1 | 229.4 | 83.5 | 136.2 | 219.7 | 83.6 | 125.9 | 209.5 |
| Investment Cost | $10^9$ TL | 757.7 | 1,079.4 | 1,837.2 | 757.7 | 991.7 | 1,749.5 | 757.7 | 915.8 | 1,673.5 | 757.7 | 855.3 | 1,613.0 |
| Annual Cost (C) | $10^9$ TL | 78.5 | 111.2 | 189.7 | 78.5 | 102.2 | 180.7 | 78.5 | 94.5 | 173.0 | 78.5 | 88.4 | 166.9 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 0.2 | 43.7 | 43.5 | 4.7 | 43.8 | 48.6 | 5.0 | 41.6 | 46.6 | 5.1 | 37.4 | 42.5 |
| Benefit Cost Ratio (B/C) | | 1.0 | 1.39 | 1.39 | 1.06 | 1.43 | 1.27 | 1.06 | 1.44 | 1.27 | 1.06 | 1.42 | 1.26 |
| Unit Annual Cost | TL/kWh | 326 | 260 | 260 | 311 | 251 | 274 | 310 | 245 | 271 | 310 | 242 | 270 |

## Table 9-11(7) Optimization Study on Effective Storage Capacity and High Water Level of Ayvalı Project

| Description | Unit | 7-A (OP2005 - AP1040) | | | 7-B (OP2005 - AP1030) | | | 7-C (OP2005 - AP1020) | | | 7-D (OP2005 - AP1010) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total | Olur Project | Ayvalı Project | Total |
| Gross Storage Capacity | $10^6$ $m^3$ | 292 | 447 | | 293 | 355 | | 293 | 279 | | 293 | 216 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 200 | 100 | | 200 | 100 | | 200 | 100 | | 200 | 100 | |
| High Water Level | m | 1,105.0 | 940.0 | | 1,105.0 | 930.0 | | 1,105.0 | 920.0 | | 1,105.0 | 910.0 | |
| Low Water Level | m | 1,077.0 | 929.1 | | 1,077.0 | 916.2 | | 1,077.0 | 903.2 | | 1,077.0 | 888.5 | |
| Available Drawdown | m | 28.0 | 10.9 | | 28.0 | 13.8 | | 28.0 | 16.8 | | 28.0 | 21.5 | |
| Tail Water Level | m | 929.0 | 700.0 | | 929.0 | 700.0 | | 929.0 | 700.0 | | 929.0 | 700.0 | |
| Effective Head | m | 154.7 | 225.5 | | 154.7 | 214.5 | | 154.7 | 203.5 | | 154.7 | 191.9 | |
| Maximum Discharge | $m^3/s$ | 48 | 64 | | 48 | 64 | | 48 | 64 | | 48 | 64 | |
| Installed Capacity | MW | 65 | 127 | 192 | 65 | 121 | 186 | 65 | 114 | 179 | 65 | 108 | 173.0 |
| Firm Peak Power | MW | 54.1 | 118.2 | 172.3 | 57.8 | 111.1 | 168.9 | 58.0 | 103.0 | 161.0 | 58.1 | 94.4 | 152.5 |
| Energy Production | | | | | | | | | | | | | |
| Average Energy | GWh | 231.7 | 428.4 | 660.1 | 241.7 | 408.3 | 650.0 | 242.4 | 387.2 | 629.6 | 242.4 | 365.7 | 608.1 |
| Firm Energy | GWh | 117.7 | 263.7 | 381.4 | 126.7 | 246.3 | 373.0 | 121.0 | 229.5 | 350.5 | 127.2 | 210.8 | 338.0 |
| Benefit (B) | $10^9$ TL | 72.5 | 151.7 | 224.3 | 76.9 | 143.1 | 220.1 | 77.2 | 133.4 | 210.6 | 77.3 | 123.2 | 200.5 |
| Investment Cost | $10^9$ TL | 671.3 | 1,061.9 | 1,733.3 | 671.3 | 975.8 | 1,647.2 | 671.3 | 896.0 | 1,567.4 | 671.3 | 839.2 | 1,510.5 |
| Annual Cost (C) | $10^9$ TL | 69.2 | 109.3 | 178.9 | 69.6 | 100.5 | 170.2 | 69.6 | 92.4 | 162.1 | 69.6 | 86.6 | 156.3 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 2.9 | 42.4 | 45.3 | 7.3 | 42.5 | 49.9 | 7.6 | 40.9 | 48.5 | 7.7 | 36.5 | 44.2 |
| Benefit Cost Ratio (B/C) | | 1.04 | 1.39 | 1.25 | 1.11 | 1.42 | 1.29 | 1.11 | 1.44 | 1.30 | 1.11 | 1.42 | 1.28 |
| Unit Annual Cost | TL/kWh | 300 | 255 | 271 | 288 | 246 | 261 | 287 | 238 | 257 | 287 | 237 | 257 |

### 9.3.2 Power Station Scale

(1) Installed Capacity of Olur Project

In the first place, the equivalent peak duration time of a hydroelectric power station should be determined by the demand from the power system as at the point in time that a hydroelectric power station is commissioned. In 1989, the make-up of power sources in entire Turkey was 9,208 MW thermal and 6,597 MW hydro, a total of 15,805 MW, while the maximum power load that year was 8,499 MW. Hence, the reserve margin capability that year was 2,554 MW in terms of dependable output, reaching as much as 30% of maximum load. The annual load factor is 70%. Furthermore, almost all of the hydros which make up 42% of the power supply have large-scale reservoirs capable of runoff regulation over a multiple number of years, and according to present power development plans, such a situation is to be continued in the future also.

Factors determining the installed capacity of a hydroelectric power station are effective head and maximum available discharge as indicated in the equation below, while maximum available discharge is generally determined by firm discharge and equivalent peak duration hours.

Installed Capacity (kW) = 9.8 x Turbine-Generator Efficiency x Effective Head (m) x Maximum Discharge ($m^3/s$)

$$\text{Maximum Available Discharge} = \text{Firm Discharge } (m^3/s) \times \frac{24\ \text{hr}}{\text{Equivalent Peak Duration Hours (hr)}}$$

Of the abovementioned factors, effective head and firm discharge runoff are determined by physical conditions such as effective storage capacity and intake and tail water levels, but equivalent peak duration hours are determined by conditions different from the above.

In Turkey, equivalent peak duration hours of hydroelectric power stations are mostly set at 6 hours or less in case of reservoir-type stations, and at the Yusufeli and Artvin projects downstream of the Olur Project, installed capacities have been decided based on 6 hours. With a situation such as mentioned above, even if a hydroelectric power station is operated to cope with peaks because of its operating characteristics, when the equivalent peak duration hours are shortened by more than this, the scale of the power station would be excessively large. Consequently, it is considered that about 6 hours would be the limit for peak duration hours.

Accordingly, the study of the optimum scale of Olur Power Station was carried out for firm discharge of 12.0 $m^3/s$ with 6 hours as the limit of equivalent peak duration hours, and comparisons were made setting maximum discharges for cases of 8 hours and 10 hours.

The result of the comparative study, as shown in Table 9-12 and Fig. 9-17, is that 6 hours is optimum as the equivalent peak duration hours, and therefore, the optimum scale is maximum discharge of 48 $m^3/s$ and installed capacity of 65 MW.

Table 9-12 Optimization Study on Installed Capacity of Olur Project

| Description | Unit | Case | | |
|---|---|---|---|---|
| | | A | B | C |
| Peak Hours | Hours | 6 | 8 | 10 |
| Maximum Discharge | $m^3/s$ | 48 | 36 | 29 |
| Installed Capacity | MW | 65 | 48 | 39 |
| Firm Peak Power | MW | 57.8 | 40.8 | 33.3 |
| Energy Production | | | | |
| Average Energy | GWh | 241.5 | 228.0 | 222.4 |
| Firm Energy | GWh | 126.5 | 140.0 | 149.4 |
| Benefit (B) | $10^9$ TL | 77.0 | 59.3 | 51.5 |
| Investment Cost | $10^9$ TL | 671.3 | 606.9 | 572.6 |
| Annual Cost | $10^9$ TL | 69.6 | 62.8 | 59.2 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 7.4 | -3.5 | -7.6 |
| Benefit Cost Ratio (B/C) | | 1.11 | 0.94 | 0.87 |
| Unit Annual Cost | TL/KWh | 288 | 275 | 266 |

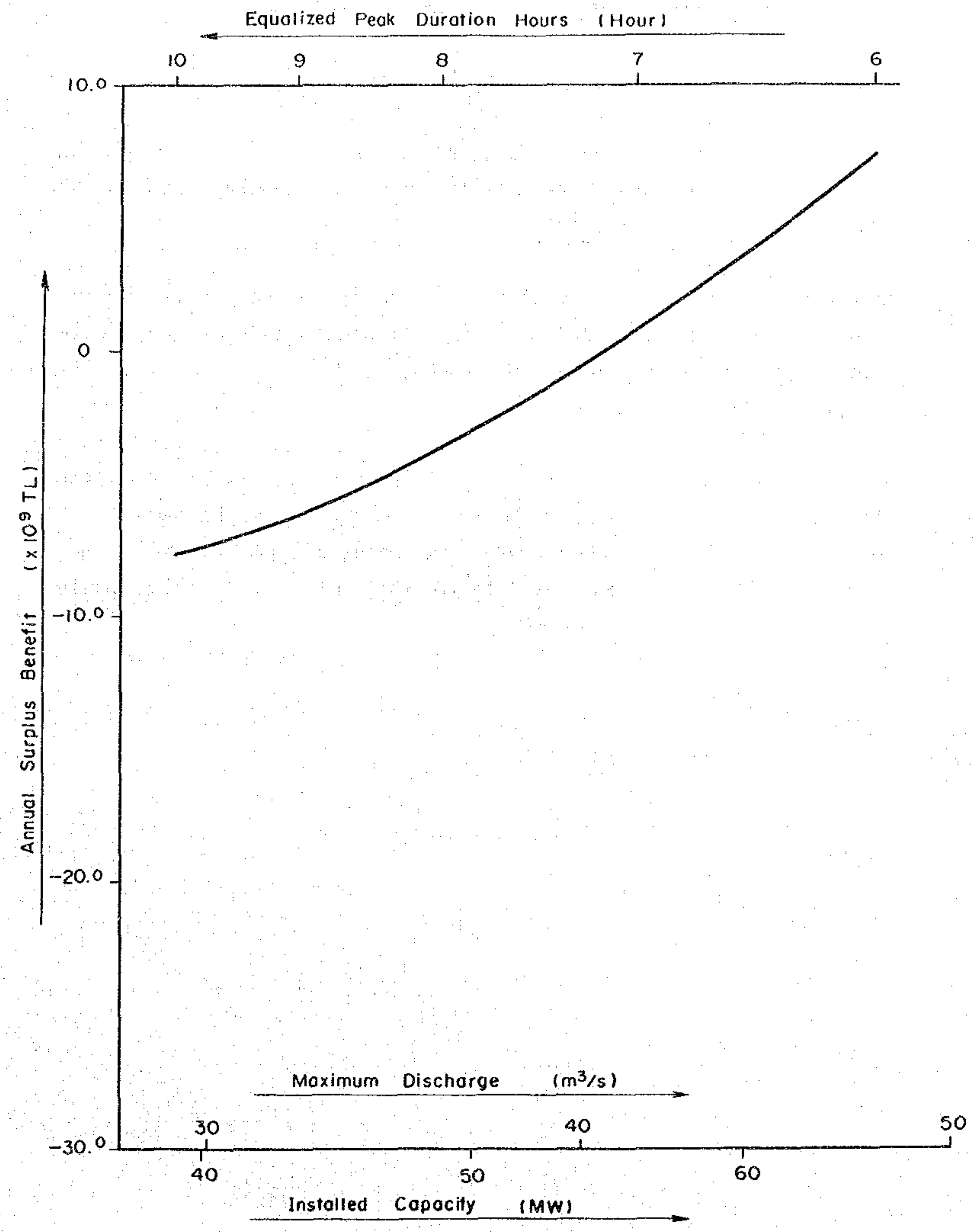



**Fig. 9-17 Optimization Study on Installed Capacity of Olur Project**

(2) Installed Capacity of Ayvalı Project

1) Installed Capacity

It is considered that 6 hours would be the limit as the equivalent peak duration hours for the Ayvalı Project the same as the Olur Project.

Therefore, the study of the optimum scale for Ayvalı Power Station was carried out setting up maximum discharges for the 3 cases of 6 hours, 8 hours, and 10 hours with firm discharge as 16.6 $m^3/s$.

As a result of the comparative study, an equivalent peak duration time of 6 hours is optimum as shown in Table 9-13 and Fig. 9-18, and therefore, maximum discharge of 67 $m^3/s$ and installed capacity of 125 MW will be the optimum scale.

## Table 9-13 Optimization Study on Installed Capacity of Ayvalı Project

| Description | Unit | Case | | |
|---|---|---|---|---|
| | | A | B | C |
| Peak Hours | Hours | 6 | 8 | 10 |
| Maximum Discharge | $m^3/s$ | 67 | 50 | 40 |
| Installed Capacity | MW | 125 | 93 | 74 |
| Firm Peak Power | MW | 113.4 | 78.5 | 66.9 |
| Energy Production | | | | |
| Average Energy | GWh | 409.4 | 398.0 | 393.5 |
| Firm Energy | GWh | 248.0 | 182.0 | 146.5 |
| Benefit (B) | $10^9$ TL | 145.5 | 110.6 | 98.9 |
| Investment Cost | $10^9$ TL | 988.0 | 903.4 | 856.5 |
| Annual Cost (C) | $10^9$ TL | 101.9 | 93.2 | 88.0 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 43.6 | 17.3 | 11.0 |
| Benefit Cost Ratio (B/C) | | 1.43 | 1.19 | 1.12 |
| Unit Annual Cost | TL/KWh | 249 | 234 | 224 |

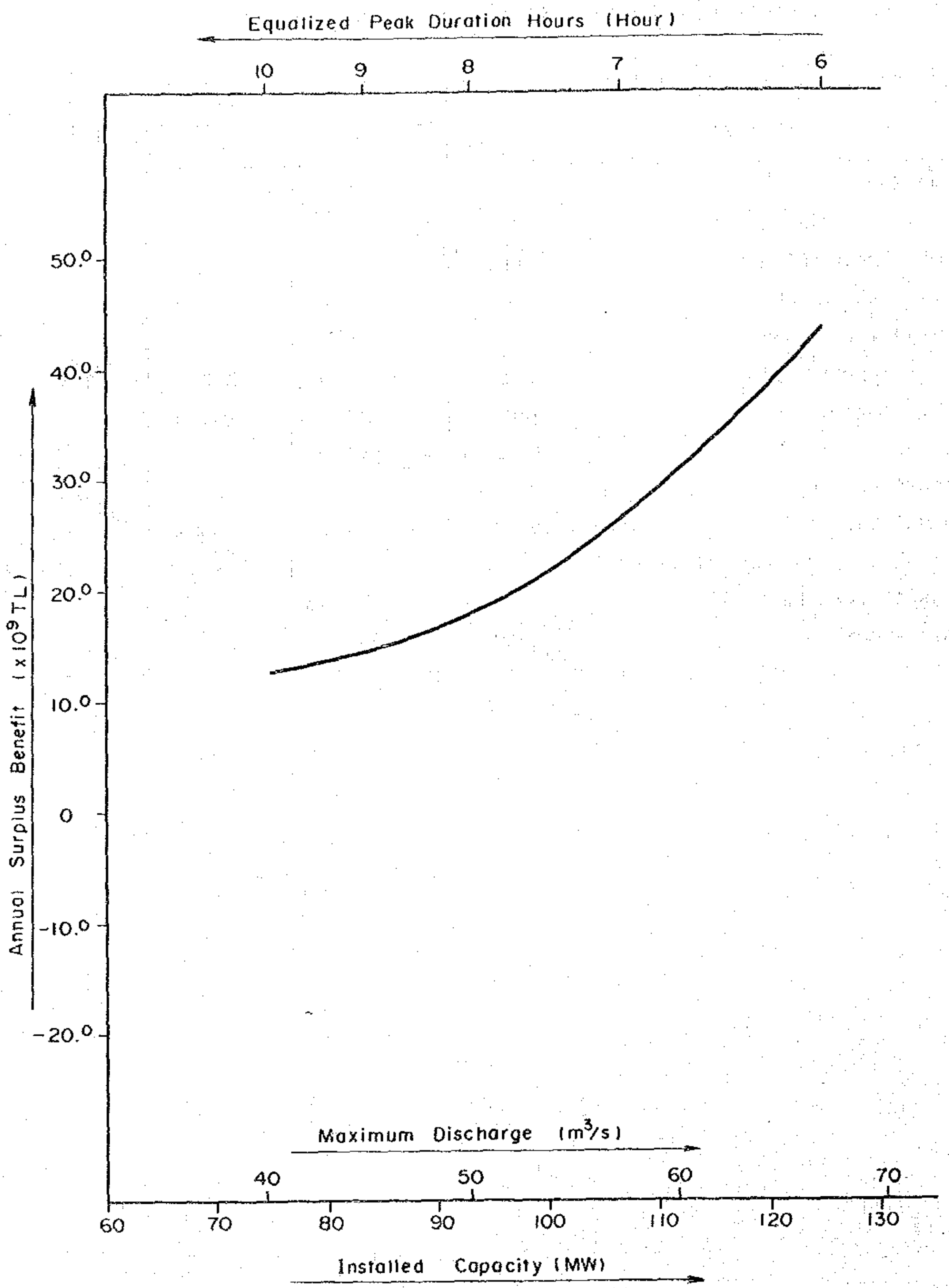



Fig. 9-18 Optimization Study on Installed Capacity of Ayvalı Project

2) Tail Water Level

The power station tailrace outlet of the Ayvalı Project is located 1,000 m downstream from the end of the backwater of Yusufeli Reservoir, and the tail water level is planned at EL. 700 m, 10 m lower than the high water level of EL. 710 m of Yusufeli Reservoir. In this case, the average tail water level of Ayvalı Power Station will be 705.5 m due to water level variation from operation of Yusufeli Reservoir. This, compared with the case of making the tail water level 710 m, the same as the high water level elevation of Yusufeli Reservoir, results in an increase of 550 m in tailrace tunnel length, and even when the increase in head loss in this section in considered, there will be an increase in head of 4.0 m.

On the other hand, in case the discharge water level is made EL. 695 m, the increase in tailrace tunnel length will be 1,200 m, and compared with the case of tail water level made 710 m, the increase in effective head will be only 5.0 m. The result of the comparison study on the optimum tail water level of Ayvalı project is as shown in Table 9-14 and Fig. 9-18, and the case of tail water level made EL. 700 m will be optimum.

### Table 9-14 Optimization Study on Tail Water Level of Ayvali Project

| Description | Unit | Case | | |
|---|---|---|---|---|
| | | A | B | C |
| Tail Water Head | m | 710.00 | 700.00 | 695.00 |
| Effective Head | m | 204.3 | 213.9 | 217.9 |
| Maximum Discharge | $m^3/s$ | 67 | 67 | 67 |
| Installed Capacity | MW | 119 | 125 | 127 |
| Firm Peak Power | MW | 111.2 | 113.4 | 113.5 |
| Energy Production | | | | |
| Average Energy | GWh | 395.8 | 409.4 | 415.3 |
| Firm Energy | GWh | 243.4 | 248.0 | 248.6 |
| Benefit (B) | $10^9$ TL | 142.2 | 145.5 | 146.1 |
| Investment Cost | $10^9$ TL | 972.8 | 988.0 | 1,014.4 |
| Annual Cost (C) | $10^9$ TL | 100.3 | 101.9 | 104.6 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 41.9 | 43.6 | 41.5 |
| Benefit Cost Ratio (B/C) | | 1.42 | 1.43 | 1.40 |
| Unit Annual Cost | TL/KWh | 253 | 249 | 252 |

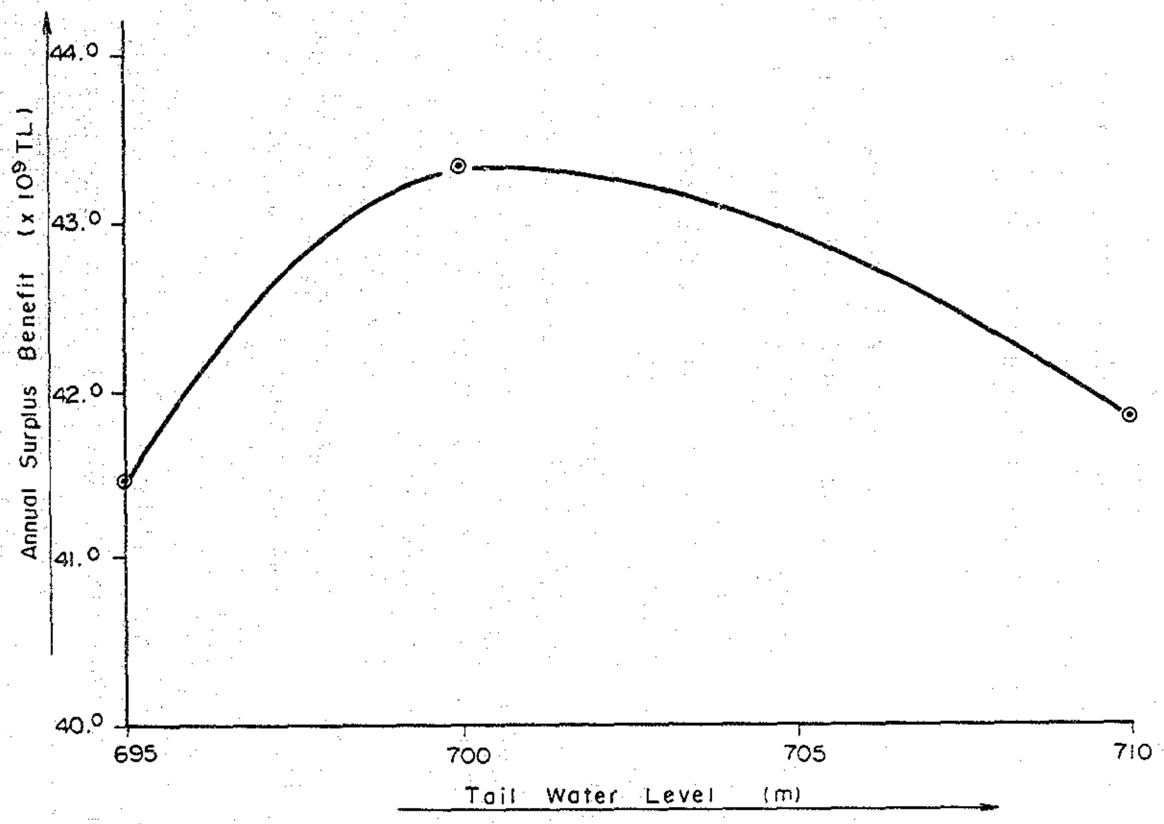



Fig. 9-19 Optimization Study on Tail Water Level of Ayvalı Project

### 9.3.3 Optimum Development Plan

As a result of studies of development plans up to this point, the Oltu Hydroelectric Power Development Project is to be made a two-stage development project consisting of the Olur Project and the Ayvalı Project.

The optimum development plan for the Olur Project is to be reservoir high water level of 1,105 m, effective storage capacity of 200 x $10^6$ $m^3$, maximum discharge of 48 $m^3/s$, and installed capacity of 65 MW.

The optimum development plan for the Ayvalı Project is to be reservoir high water level of 930 m, effective storage capacity of 150 x $10^6$ $m^3$, maximum discharge of 67 $m^3/s$, and installed capacity of 125 MW.

The particulars of the optimum development plans for the Olur and Ayvalı projects are given in Table 9-15.

The reservoir water level, inflow, discharge for power, and spilled water quantity in the Olur Project according to the results of reservoir operation are given in Table 9-16 and Fig. 9-20. The monthly energy production and firm energy production of the same are given in Tables 9-17 and 9-18, and Fig. 9-21. The monthly peak power and peak power durations of the same are given in Tables 9-19 and 9-20. The preliminary construction cost breakdown of the Olur Project is given in Table 9-21.

The reservoir water level, inflow, discharge for power, and spilled water quantity in the Ayvalı Project according to the results of reservoir operation are given in Table 9-22 and Fig. 9-22. The monthly energy production and firm energy production of the same are given in Tables 9-23 and 9-24, and Fig. 9-23. The monthly peak power and peak power durations of the same are given in Tables 9-25 and 9-26. The preliminary construction cost breakdown of the Ayvali Project is given in Table 9-27.

### 9.3.4 Effect on Yusufeli Project

The Yusufeli Project, which is a project downstream of the Olur and Ayvalı projects, already has its definite design completed, and construction work is expected to be started in the middle 1990s.

The Yusufeli Project has not been planned predicated on implementation of the Olur and Ayvalı projects, and although it will have a reservoir with effective storage capacity of 1,080 x $10^6$ $m^3$, the inflow is not completely averaged. As mentioned in 9.3.1, the runoff regulation effects of the reservoirs in the Olur and Ayvalı projects which are upstream projects of the Yusufeli Project, will extend to the Yusufeli Project, and therefore, implementation of the Olur and Ayvalı projects will bring about an increase in the firm discharge of the Yusufeli Project, and the merit of enlargement in scale can be expected.

However, the design for the Yusufeli Project have already been made definite, while it is also expected that a considerable number of years will have elapsed from the time of completion of the Yusufeli Project until completion of the Olur and Ayvalı projects, and it is considered unrealistic to consider the effect of the Olur and Ayvalı projects on the Yusufeli Project on the predication of enlarging the scale of the Yusufeli Project.

Therefore, with the present design of the Yusufeli Project unmodified, by having Olur and Ayvalı Reservoirs take over a part of the effective storage capacity of Yusufeli Reservoir, the effect of the two reservoirs of Olur and Ayvali on the Yusufeli Project was looked upon as the effect of raising the Yusufeli Reservoir operating water level, and energy calculations were made by the Dynamic Program (DP) method for the Yusufeli Project before and after completion of the Olur and Ayvalı projects.

According to the results of calculations, there is almost no spilled water from Yusufeli Reservoir even before completion of Olur and Ayvalı reservoirs, and the increase in energy production due to completion of olur and Ayvalı reservoirs is only about 1.5%, but through the effect of rise in reservoir operating water level, it can be looked forward to dependable output being increased about 5.5%.

#### 9.3.5 Energy Production at Ayvalı Project in Case excluding Olur Project

As described in 9.2.1 the development of the Olur Project and the Ayvalı Project will be implemented simultaneously and commencement of commercial operation, of the Ayvalı Project will be six months after commencement of commercial operation of the Olur Project.

The results of energy production calculation in case development of Ayvalı Project is preceded the Olur project by some reasons are shown in the parentheses in Table 9-15. Because of absence of run-off regulation by the Olur reservoir, firm peak power and annual firms energy would be decreased by 22.8%; annual average, energy would be decreased by 8.1%; annual secondary energy would be increasing by 17.2%.

Table 9-15 Optimum Development Plans of Olur and Ayvalı Projects

| Item | Unit | Olur Project | Ayvalı Project | Total |
|---|---|---|---|---|
| Catchment Area | $km^2$ | 3,509 | 4,517 | |
| Annual Inflow | $10^6$ $m^3$ | 655.7 | 813.0 | |
| Reservoir | | | | |
| High Water Level | m | 1,105.00 | 930.00 | |
| Low Water Level | m | 1,077.00 | 908.00 | |
| Available Drawdown | m | 28.00 | 22.00 | |
| Gross Storage Capacity | $10^6$ $m^3$ | 293.5 | 354.8 | |
| Effective Storage Capacity | $10^6$ $m^3$ | 200.0 | 150.0 | |
| Water Surface Area | $10^6$ $m^3$ | 10.7 | 8.2 | |
| Dam | | | | |
| Type | | Rockfill | Rockfill | |
| Height | m | 136.0 | 175.0 | |
| Volume | $10^3$ $m^3$ | 3,818 | 9,268 | |
| Headrace Tunnel | | | | |
| Type | | Pressure | - | |
| Diameter | m | 4.90 | - | |
| Length | m | 9,659 | - | |
| Penstock | | | | |
| Diameter | m | 4.90 ~ 3.20 | 4.10 ~ 3.80 | |
| Length | m | 436 | 288 | |
| Tailrace Tunnel | | | | |
| Type | | - | Non-Pressure | |
| Diameter | m | - | 5.40 | |
| Length | m | - | 9,261 | |
| Development Plan | | | | |
| Normal Water Level | m | 1,095.7 | 922.7 | |
| Tail Water Level | m | 929.0 | 700.0 | |
| Gross Head | m | 166.7 | 222.7 | |
| Loss of Head | m | 12.0 | 10.9 | |
| Effective Head | m | 154.7 | 211.8 | |
| Firm Discharge | $m^3/s$ | 12.0 | 16.6 | |
| Maximum Discharge | $m^3/s$ | 48 | 67 | |
| Installed Capacity | MW | 65 | 125 | 190 |
| Firm Peak Power | MW | 57.8 | (87.5) 113.4 | 171.1 |
| Annual Energy Production | | | | |
| Average | GWh | 241.5 | (379.7) 409.4 | 650.9 |
| Firm | GWh | 126.5 | (191.5) 248.0 | 374.5 |
| Secondary | GWh | 115.0 | (187.2) 161.4 | 276.4 |
| Annual Benefit (B) | $10^9$ TL | 77.0 | 145.5 | 222.5 |
| Investment Cost | $10^9$ TL | 671.4 | 988.0 | 1,659.4 |
| Annual Cost (C) | $10^9$ TL | 69.6 | 101.9 | 171.5 |
| Annual Surplus Benefit (B-C) | $10^9$ TL | 7.4 | 43.6 | 51.0 |
| Benefit Cost Ratio (B/C) | | 1.11 | 1.43 | 1.30 |
| Unit Annual Cost | TL/kWh | 288 | 249 | 264 |

## Table 9-16 Summary of Operation Study on Olur Reservoir

Unit: $10^6$ $m^3$

| YEAR | INFLOW | POWER DISCHARGE | SPILL |
|---|---|---|---|
| 1940 | 858.45 | 860.38 | 7.07 |
| 1941 | 1069.70 | 908.38 | 142.00 |
| 1942 | 611.34 | 620.72 | 0.0 |
| 1943 | 862.99 | 822.29 | 13.76 |
| 1944 | 673.71 | 680.01 | 0.0 |
| 1945 | 889.34 | 827.94 | 36.69 |
| 1946 | 634.88 | 646.75 | 0.0 |
| 1947 | 830.32 | 788.26 | 12.09 |
| 1948 | 636.38 | 650.89 | 0.0 |
| 1949 | 723.83 | 709.53 | 0.13 |
| 1950 | 755.97 | 732.87 | 0.0 |
| 1951 | 953.46 | 944.86 | 0.02 |
| 1952 | 800.55 | 796.18 | 0.0 |
| 1953 | 1014.96 | 913.76 | 92.94 |
| 1954 | 529.82 | 575.61 | 0.53 |
| 1955 | 600.91 | 538.00 | 0.0 |
| 1956 | 679.53 | 679.94 | 0.13 |
| 1957 | 571.48 | 563.44 | 0.0 |
| 1958 | 680.85 | 657.67 | 0.03 |
| 1959 | 793.19 | 783.71 | 0.0 |
| 1960 | 279.07 | 368.76 | 0.0 |
| 1961 | 411.99 | 376.23 | 0.0 |
| 1962 | 1003.67 | 804.41 | 128.35 |
| 1963 | 865.22 | 854.45 | 24.67 |
| 1964 | 548.64 | 538.52 | 0.0 |
| 1965 | 563.28 | 580.07 | 0.0 |
| 1966 | 609.97 | 560.47 | 0.0 |
| 1967 | 1181.87 | 838.99 | 332.69 |
| 1968 | 690.91 | 718.53 | 0.50 |
| 1969 | 419.76 | 417.21 | 0.04 |
| 1970 | 457.97 | 437.08 | 0.0 |
| 1971 | 554.95 | 533.63 | 0.0 |
| 1972 | 550.09 | 557.23 | 0.40 |
| 1973 | 415.96 | 414.18 | 0.76 |
| 1974 | 341.03 | 376.85 | 0.0 |
| 1975 | 702.88 | 624.40 | 0.0 |
| 1976 | 606.60 | 618.38 | 0.0 |
| 1977 | 653.35 | 664.39 | 0.0 |
| 1978 | 579.58 | 552.67 | 0.0 |
| 1979 | 588.86 | 612.51 | 0.0 |
| 1980 | 528.91 | 497.47 | 0.0 |
| 1981 | 431.38 | 407.52 | 0.00 |
| 1982 | 258.70 | 370.49 | 0.0 |
| 1983 | 680.50 | 531.13 | 0.0 |
| 1984 | 451.96 | 503.65 | 0.0 |
| 1985 | 588.16 | 562.71 | 0.0 |
| 1986 | 766.70 | 719.11 | 34.33 |
| 1987 | 873.06 | 809.02 | 19.02 |
| 1988 | 370.68 | 455.22 | 0.0 |
| 1989 | 635.08 | 524.74 | 0.00 |
| AVERAGE | 655.65 | 630.62 | 16.92 |

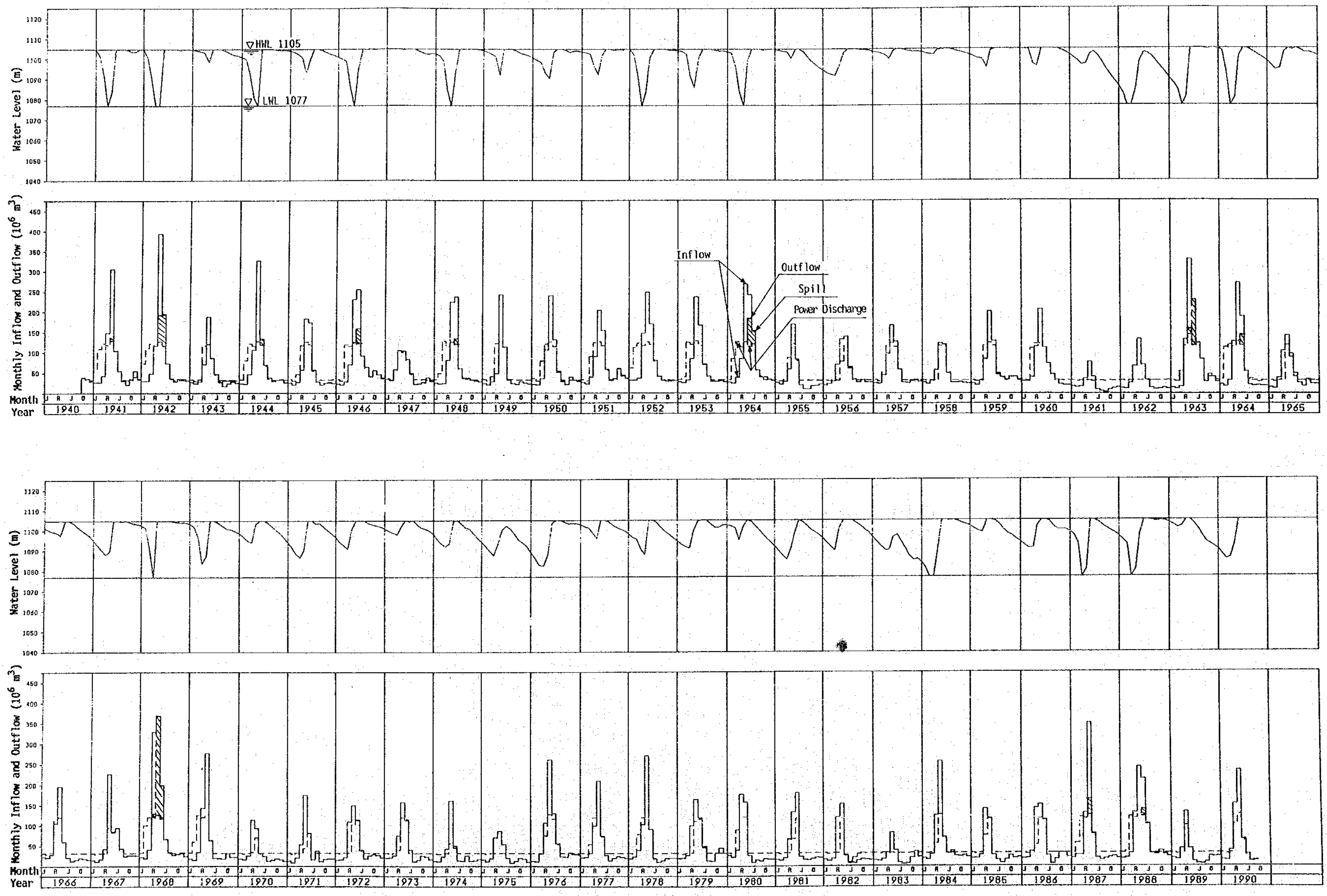



Fig. 9-20 Olur Reservoir Operation

## Table 9-17 Total Energy Generation of Olur Project

Unit: GWh

| NO. | Year \ Month | < OCT > | < NOV > | < DEC > | < JAN > | < FEB > | < MAR > | < APR > | < MAY > | < JUN > | < JUL > | < AUG > | < SEP > | <TOTAL> |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1940 | 14.90 | 13.40 | 12.75 | 23.27 | 41.17 | 42.69 | 39.73 | 47.85 | 41.27 | 21.31 | 12.77 | 12.36 | 323.49 |
| 2 | 1941 | 12.73 | 15.46 | 13.90 | 28.53 | 41.97 | 41.83 | 38.09 | 46.15 | 46.80 | 28.73 | 13.85 | 12.35 | 340.40 |
| 3 | 1942 | 12.76 | 12.41 | 12.78 | 12.81 | 11.54 | 12.74 | 45.90 | 47.04 | 34.08 | 18.14 | 12.75 | 12.27 | 245.22 |
| 4 | 1943 | 12.60 | 12.14 | 12.56 | 12.49 | 30.35 | 42.82 | 38.79 | 46.14 | 46.80 | 26.67 | 13.86 | 12.36 | 307.57 |
| 5 | 1944 | 12.75 | 12.39 | 12.73 | 12.74 | 11.41 | 17.82 | 44.29 | 47.45 | 46.73 | 21.33 | 12.76 | 12.29 | 264.69 |
| 6 | 1945 | 12.63 | 12.17 | 12.57 | 12.50 | 11.22 | 43.57 | 39.88 | 43.64 | 46.80 | 36.15 | 24.49 | 15.47 | 311.09 |
| 7 | 1946 | 21.29 | 17.51 | 13.86 | 13.87 | 12.53 | 22.37 | 41.15 | 39.34 | 31.96 | 18.12 | 12.78 | 12.26 | 257.05 |
| 8 | 1947 | 12.66 | 12.25 | 12.61 | 12.62 | 18.49 | 46.52 | 38.38 | 43.46 | 46.80 | 23.43 | 13.83 | 13.41 | 294.46 |
| 9 | 1948 | 12.77 | 12.41 | 12.80 | 12.75 | 11.42 | 15.76 | 46.25 | 48.30 | 44.29 | 12.73 | 12.80 | 12.31 | 254.59 |
| 10 | 1949 | 12.61 | 12.21 | 12.50 | 12.46 | 11.12 | 29.23 | 44.61 | 47.89 | 45.16 | 20.22 | 12.74 | 12.30 | 273.06 |
| 11 | 1950 | 12.69 | 12.30 | 12.70 | 12.72 | 11.45 | 35.22 | 46.22 | 47.69 | 45.89 | 22.39 | 12.81 | 12.35 | 284.44 |
| 12 | 1951 | 23.51 | 16.45 | 13.83 | 24.32 | 43.79 | 42.32 | 39.29 | 46.27 | 46.75 | 30.92 | 16.00 | 12.41 | 355.86 |
| 13 | 1952 | 12.82 | 12.34 | 12.74 | 12.77 | 15.30 | 47.94 | 42.66 | 47.27 | 45.75 | 27.73 | 15.99 | 12.39 | 305.68 |
| 14 | 1953 | 12.74 | 12.36 | 12.75 | 12.71 | 32.72 | 45.54 | 37.89 | 44.78 | 46.80 | 48.36 | 22.34 | 16.46 | 345.43 |
| 15 | 1954 | 12.79 | 13.45 | 12.78 | 12.81 | 11.53 | 12.73 | 34.57 | 47.41 | 31.95 | 12.74 | 12.61 | 12.03 | 227.41 |
| 16 | 1955 | 12.27 | 11.74 | 12.01 | 11.90 | 11.04 | 11.75 | 11.57 | 30.08 | 45.89 | 24.52 | 12.74 | 12.36 | 207.87 |
| 17 | 1956 | 12.75 | 12.38 | 12.71 | 12.72 | 11.45 | 20.01 | 45.34 | 48.12 | 45.26 | 22.38 | 12.75 | 12.31 | 268.18 |
| 18 | 1957 | 12.68 | 12.32 | 12.68 | 12.65 | 11.38 | 12.58 | 12.30 | 46.42 | 46.51 | 19.22 | 12.74 | 12.30 | 223.79 |
| 19 | 1958 | 12.67 | 12.22 | 12.58 | 12.52 | 11.29 | 12.45 | 44.55 | 47.37 | 45.90 | 18.11 | 14.91 | 12.35 | 256.91 |
| 20 | 1959 | 16.02 | 15.45 | 12.74 | 12.77 | 11.94 | 42.81 | 46.07 | 47.09 | 44.36 | 28.76 | 17.01 | 12.25 | 307.28 |
| 21 | 1960 | 12.31 | 12.15 | 12.52 | 12.45 | 11.17 | 12.21 | 11.61 | 12.09 | 11.71 | 11.90 | 11.76 | 11.30 | 143.17 |
| 22 | 1961 | 11.65 | 11.20 | 11.38 | 11.13 | 9.70 | 10.49 | 10.47 | 11.73 | 12.06 | 12.61 | 12.53 | 11.96 | 136.90 |
| 23 | 1962 | 12.15 | 11.55 | 11.78 | 11.50 | 10.18 | 17.74 | 38.88 | 47.14 | 46.80 | 47.94 | 33.05 | 12.39 | 301.10 |
| 24 | 1963 | 16.00 | 15.46 | 12.78 | 13.84 | 43.17 | 41.78 | 37.99 | 46.03 | 46.80 | 21.30 | 12.72 | 12.24 | 320.11 |
| 25 | 1964 | 12.55 | 12.05 | 12.35 | 12.20 | 10.87 | 11.98 | 12.97 | 46.80 | 38.03 | 15.93 | 12.71 | 12.26 | 210.70 |
| 26 | 1965 | 12.62 | 12.19 | 12.59 | 12.46 | 11.24 | 12.39 | 44.69 | 46.90 | 23.73 | 12.74 | 12.63 | 12.08 | 226.25 |
| 27 | 1966 | 12.37 | 11.85 | 12.09 | 11.91 | 10.58 | 11.52 | 11.12 | 35.69 | 33.01 | 37.27 | 15.97 | 12.34 | 215.73 |
| 28 | 1967 | 12.70 | 12.31 | 12.62 | 12.61 | 38.00 | 41.70 | 44.66 | 48.36 | 46.80 | 26.62 | 12.76 | 12.34 | 321.49 |
| 29 | 1968 | 12.72 | 12.31 | 12.74 | 12.66 | 23.35 | 45.78 | 42.08 | 48.12 | 24.72 | 12.72 | 12.64 | 12.13 | 271.98 |
| 30 | 1969 | 12.47 | 12.02 | 12.33 | 12.22 | 10.91 | 11.97 | 12.94 | 27.67 | 12.36 | 12.75 | 12.64 | 12.09 | 162.36 |
| 31 | 1970 | 12.36 | 11.82 | 12.04 | 11.82 | 10.47 | 11.39 | 11.08 | 16.34 | 32.10 | 12.72 | 12.67 | 12.20 | 167.02 |
| 32 | 1971 | 12.47 | 11.94 | 12.21 | 12.05 | 11.11 | 11.73 | 11.69 | 40.13 | 44.28 | 14.90 | 12.71 | 12.24 | 207.46 |
| 33 | 1972 | 12.61 | 12.17 | 12.51 | 12.42 | 11.14 | 12.27 | 15.05 | 47.42 | 45.90 | 12.75 | 12.71 | 12.17 | 219.10 |
| 34 | 1973 | 12.48 | 12.02 | 12.31 | 12.14 | 10.79 | 11.80 | 11.43 | 21.66 | 17.59 | 12.72 | 12.58 | 12.08 | 159.60 |
| 35 | 1974 | 12.36 | 11.79 | 12.01 | 11.84 | 10.52 | 11.47 | 11.24 | 12.13 | 12.08 | 12.51 | 12.35 | 11.74 | 142.07 |
| 36 | 1975 | 11.96 | 11.44 | 11.63 | 11.37 | 10.39 | 10.96 | 26.23 | 48.27 | 45.90 | 21.33 | 12.75 | 12.28 | 234.50 |
| 37 | 1976 | 12.66 | 12.25 | 12.63 | 12.58 | 11.30 | 20.72 | 45.36 | 47.19 | 28.87 | 12.74 | 12.67 | 12.15 | 241.12 |
| 38 | 1977 | 12.48 | 12.00 | 12.31 | 12.18 | 10.91 | 28.74 | 42.93 | 47.51 | 36.00 | 12.70 | 12.59 | 12.03 | 252.39 |
| 39 | 1978 | 12.29 | 11.77 | 12.04 | 11.91 | 10.65 | 11.71 | 11.65 | 43.14 | 45.90 | 18.13 | 12.72 | 12.17 | 214.07 |
| 40 | 1979 | 12.50 | 12.15 | 12.60 | 12.57 | 11.71 | 33.85 | 46.14 | 47.42 | 12.31 | 12.65 | 12.49 | 11.92 | 238.32 |
| 41 | 1980 | 12.15 | 11.60 | 11.83 | 11.65 | 10.35 | 11.28 | 11.05 | 25.09 | 45.75 | 12.72 | 12.65 | 12.11 | 188.22 |
| 42 | 1981 | 12.38 | 11.87 | 12.16 | 12.00 | 10.68 | 11.65 | 11.64 | 41.73 | 9.97 | 2.84 | 8.33 | 11.70 | 156.94 |
| 43 | 1982 | 12.25 | 11.93 | 12.22 | 12.03 | 10.69 | 11.64 | 11.07 | 11.63 | 11.37 | 11.55 | 11.34 | 10.82 | 138.53 |
| 44 | 1983 | 11.11 | 10.81 | 11.15 | 10.97 | 10.00 | 10.49 | 18.78 | 48.00 | 26.77 | 12.75 | 12.77 | 12.34 | 195.95 |
| 45 | 1984 | 12.69 | 12.23 | 12.58 | 12.50 | 11.20 | 12.33 | 29.46 | 45.78 | 12.34 | 12.68 | 12.51 | 11.93 | 198.24 |
| 46 | 1985 | 12.21 | 11.72 | 11.98 | 11.85 | 10.58 | 11.67 | 19.66 | 46.14 | 44.36 | 12.74 | 12.63 | 12.07 | 217.62 |
| 47 | 1986 | 12.41 | 12.01 | 12.36 | 12.25 | 20.91 | 41.81 | 38.81 | 47.03 | 30.94 | 12.70 | 12.63 | 12.11 | 265.98 |
| 48 | 1987 | 12.40 | 11.92 | 12.21 | 12.07 | 13.04 | 41.82 | 38.72 | 45.27 | 46.80 | 40.47 | 12.74 | 12.33 | 299.80 |
| 49 | 1988 | 12.74 | 12.33 | 12.70 | 12.63 | 11.32 | 12.52 | 38.99 | 17.05 | 12.27 | 12.53 | 12.29 | 11.65 | 179.01 |
| 50 | 1989 | 11.86 | 11.39 | 11.66 | 11.50 | 10.20 | 11.22 | 36.51 | 48.27 | 24.36 | 10.58 | 3.94 | 4.78 | 196.26 |
| | TOTAL | 652.54 | 623.61 | 622.91 | 655.23 | 780.25 | 1157.31 | 1532.45 | 2027.50 | 1757.61 | 978.43 | 680.01 | 608.54 | 12076.38 |
| | AVE | 13.05 | 12.47 | 12.46 | 13.10 | 15.61 | 23.15 | 30.65 | 40.55 | 35.15 | 19.57 | 13.60 | 12.17 | 241.53 |
| | MAX | 23.51 | 17.51 | 13.90 | 28.53 | 43.79 | 47.94 | 46.25 | 48.36 | 46.80 | 48.36 | 33.05 | 16.46 | 355.86 |
| | MIN | 11.11 | 10.81 | 11.15 | 10.97 | 9.70 | 10.49 | 10.47 | 11.63 | 9.97 | 2.84 | 3.94 | 4.78 | 136.90 |

# Table 9-18 Firm Energy Generation of Olur Project

Unit: GWh

| NO. | Month / Year | < OCT > | < NOV > | < DEC > | < JAN > | < FEB > | < MAR > | < APR > | < MAY > | < JUN > | < JUL > | < AUG > | < SEP > | <TOTAL> |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1940 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 10.74 | 9.95 | 11.96 | 11.70 | 12.09 | 12.09 | 11.70 | 139.13 |
| 2 | 1941 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 10.68 | 9.57 | 11.54 | 11.70 | 12.09 | 12.09 | 11.70 | 138.25 |
| 3 | 1942 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 4 | 1943 | 12.09 | 11.70 | 12.09 | 12.09 | 11.31 | 11.00 | 9.76 | 11.54 | 11.70 | 12.09 | 12.09 | 11.70 | 139.16 |
| 5 | 1944 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 6 | 1945 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 11.78 | 10.12 | 10.92 | 11.70 | 12.09 | 12.09 | 11.70 | 139.29 |
| 7 | 1946 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 8 | 1947 | 12.09 | 11.70 | 12.09 | 12.09 | 11.31 | 11.64 | 9.99 | 10.88 | 11.70 | 12.09 | 12.09 | 11.70 | 139.36 |
| 9 | 1948 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 10 | 1949 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.24 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 141.89 |
| 11 | 1950 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.56 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.21 |
| 12 | 1951 | 12.09 | 11.70 | 12.09 | 12.09 | 11.31 | 10.72 | 9.95 | 11.68 | 11.70 | 12.09 | 12.09 | 11.70 | 139.21 |
| 13 | 1952 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 10.90 | 11.82 | 11.70 | 12.09 | 12.09 | 11.70 | 141.28 |
| 14 | 1953 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 11.41 | 9.94 | 11.20 | 11.70 | 12.09 | 12.09 | 11.70 | 139.02 |
| 15 | 1954 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 16 | 1955 | 12.09 | 11.70 | 12.01 | 11.87 | 10.97 | 11.66 | 11.57 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 141.54 |
| 17 | 1956 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 18 | 1957 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 19 | 1958 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 20 | 1959 | 12.09 | 11.70 | 12.09 | 12.09 | 11.31 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.74 |
| 21 | 1960 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.61 | 12.09 | 11.70 | 11.90 | 11.76 | 11.30 | 141.34 |
| 22 | 1961 | 11.65 | 11.08 | 11.13 | 10.77 | 9.23 | 9.89 | 10.00 | 11.63 | 11.70 | 12.09 | 12.09 | 11.70 | 132.96 |
| 23 | 1962 | 12.09 | 11.54 | 11.63 | 11.30 | 9.91 | 10.34 | 9.79 | 11.78 | 11.70 | 12.09 | 12.09 | 11.70 | 135.97 |
| 24 | 1963 | 12.09 | 11.70 | 12.09 | 12.09 | 11.31 | 10.80 | 9.76 | 11.51 | 11.70 | 12.09 | 12.09 | 11.70 | 138.93 |
| 25 | 1964 | 12.09 | 11.70 | 12.09 | 12.09 | 10.87 | 11.98 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.18 |
| 26 | 1965 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 27 | 1966 | 12.09 | 11.70 | 12.09 | 11.89 | 10.49 | 11.33 | 10.92 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 140.18 |
| 28 | 1967 | 12.09 | 11.70 | 12.09 | 12.09 | 11.31 | 10.74 | 11.17 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 140.85 |
| 29 | 1968 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 11.45 | 10.53 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 140.55 |
| 30 | 1969 | 12.09 | 11.70 | 12.09 | 12.09 | 10.91 | 11.97 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.21 |
| 31 | 1970 | 12.09 | 11.70 | 12.04 | 11.76 | 10.32 | 11.14 | 10.87 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 139.58 |
| 32 | 1971 | 12.09 | 11.70 | 12.09 | 12.05 | 11.08 | 11.64 | 11.69 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.00 |
| 33 | 1972 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 34 | 1973 | 12.09 | 11.70 | 12.09 | 12.09 | 10.78 | 11.73 | 11.36 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 141.52 |
| 35 | 1974 | 12.09 | 11.70 | 12.01 | 11.79 | 10.40 | 11.25 | 11.10 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 140.02 |
| 36 | 1975 | 11.96 | 11.38 | 11.48 | 11.11 | 10.04 | 10.53 | 10.47 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 136.64 |
| 37 | 1976 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 38 | 1977 | 12.09 | 11.70 | 12.09 | 12.09 | 10.91 | 11.79 | 10.97 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 141.31 |
| 39 | 1978 | 12.09 | 11.70 | 12.04 | 11.89 | 10.58 | 11.59 | 11.65 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 141.21 |
| 40 | 1979 | 12.09 | 11.70 | 12.09 | 12.09 | 11.31 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.74 |
| 41 | 1980 | 12.09 | 11.60 | 11.78 | 11.51 | 10.15 | 10.99 | 10.82 | 12.01 | 11.70 | 12.09 | 12.09 | 11.70 | 138.53 |
| 42 | 1981 | 12.09 | 11.70 | 12.09 | 12.00 | 10.62 | 11.51 | 11.64 | 12.09 | 9.97 | 2.84 | 8.33 | 11.70 | 126.58 |
| 43 | 1982 | 12.09 | 11.70 | 12.09 | 12.03 | 10.65 | 11.53 | 11.04 | 11.63 | 11.37 | 11.55 | 11.34 | 10.82 | 137.83 |
| 44 | 1983 | 10.95 | 10.51 | 10.79 | 10.55 | 9.49 | 9.89 | 10.30 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 132.15 |
| 45 | 1984 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.35 |
| 46 | 1985 | 12.09 | 11.70 | 11.98 | 11.80 | 10.48 | 11.55 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 140.97 |
| 47 | 1986 | 12.09 | 11.70 | 12.09 | 12.09 | 10.90 | 10.84 | 9.77 | 11.76 | 11.70 | 12.09 | 12.09 | 11.70 | 138.81 |
| 48 | 1987 | 12.09 | 11.70 | 12.09 | 12.07 | 11.11 | 10.81 | 9.74 | 11.32 | 11.70 | 12.09 | 12.09 | 11.70 | 138.50 |
| 49 | 1988 | 12.09 | 11.70 | 12.09 | 12.09 | 10.92 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.65 | 142.30 |
| 50 | 1989 | 11.82 | 11.30 | 11.53 | 11.30 | 9.93 | 10.90 | 11.02 | 12.09 | 11.70 | 10.58 | 3.94 | 4.78 | 120.89 |
| | TOTAL | 602.52 | 582.22 | 599.93 | 596.74 | 539.24 | 575.49 | 551.35 | 596.34 | 582.94 | 593.00 | 591.50 | 576.74 | 6988.00 |
| | AVE | 12.05 | 11.64 | 12.00 | 11.93 | 10.78 | 11.51 | 11.03 | 11.93 | 11.66 | 11.86 | 11.83 | 11.53 | 139.76 |
| | MAX | 12.09 | 11.70 | 12.09 | 12.09 | 11.31 | 12.09 | 11.70 | 12.09 | 11.70 | 12.09 | 12.09 | 11.70 | 142.74 |
| | MIN | 10.95 | 10.51 | 10.79 | 10.55 | 9.23 | 9.89 | 9.57 | 10.88 | 9.97 | 2.84 | 3.94 | 4.78 | 120.89 |

## Table 9-19 Monthly Peak Power of Olur Project

Unit: MW

| NO. | Month Year | < OCT > | < NOV > | < DEC > | < JAN > | < FEB > | < MAR > | < APR > | < MAY > | < JUN > | < JUL > | < AUG > | < SEP > | <TOTAL> |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1940 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 57.77 | 55.30 | 64.32 | 65.00 | 65.00 | 65.00 | 65.00 | 762.39 |
| 2 | 1941 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 57.42 | 53.15 | 62.03 | 65.00 | 65.00 | 65.00 | 65.00 | 757.60 |
| 3 | 1942 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 4 | 1943 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 59.13 | 54.24 | 62.03 | 65.00 | 65.00 | 65.00 | 65.00 | 760.40 |
| 5 | 1944 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 6 | 1945 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 63.33 | 56.21 | 58.71 | 65.00 | 65.00 | 65.00 | 65.00 | 763.25 |
| 7 | 1946 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 8 | 1947 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 62.56 | 55.51 | 58.47 | 65.00 | 65.00 | 65.00 | 65.00 | 761.54 |
| 9 | 1948 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 10 | 1949 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 62.44 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 777.44 |
| 11 | 1950 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 64.20 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 779.20 |
| 12 | 1951 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 57.63 | 55.27 | 62.79 | 65.00 | 65.00 | 65.00 | 65.00 | 760.69 |
| 13 | 1952 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 60.55 | 63.55 | 65.00 | 65.00 | 65.00 | 65.00 | 774.10 |
| 14 | 1953 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 61.33 | 55.20 | 60.23 | 65.00 | 65.00 | 65.00 | 65.00 | 761.77 |
| 15 | 1954 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 16 | 1955 | 65.00 | 65.00 | 64.59 | 63.84 | 63.06 | 62.66 | 64.26 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 773.41 |
| 17 | 1956 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 18 | 1957 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 19 | 1958 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 20 | 1959 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 21 | 1960 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 64.49 | 64.98 | 65.00 | 63.96 | 63.24 | 62.81 | 774.47 |
| 22 | 1961 | 62.64 | 61.55 | 59.84 | 57.89 | 54.96 | 53.15 | 55.56 | 62.54 | 65.00 | 65.00 | 65.00 | 65.00 | 728.13 |
| 23 | 1962 | 65.00 | 64.14 | 62.52 | 60.75 | 58.97 | 55.59 | 54.40 | 63.36 | 65.00 | 65.00 | 65.00 | 65.00 | 744.72 |
| 24 | 1963 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 58.07 | 54.23 | 61.89 | 65.00 | 65.00 | 65.00 | 65.00 | 759.19 |
| 25 | 1964 | 65.00 | 65.00 | 65.00 | 65.00 | 64.69 | 64.39 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 779.08 |
| 26 | 1965 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 27 | 1966 | 65.00 | 65.00 | 65.00 | 63.93 | 62.43 | 60.90 | 60.66 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 767.92 |
| 28 | 1967 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 57.72 | 62.03 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 769.76 |
| 29 | 1968 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 61.57 | 58.52 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 770.09 |
| 30 | 1969 | 65.00 | 65.00 | 65.00 | 65.00 | 64.94 | 64.33 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 779.27 |
| 31 | 1970 | 65.00 | 65.00 | 64.70 | 63.21 | 61.44 | 59.91 | 60.36 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 764.63 |
| 32 | 1971 | 65.00 | 65.00 | 65.00 | 64.78 | 63.66 | 62.56 | 64.93 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 775.92 |
| 33 | 1972 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 34 | 1973 | 65.00 | 65.00 | 65.00 | 65.00 | 64.18 | 63.09 | 63.14 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 775.41 |
| 35 | 1974 | 65.00 | 65.00 | 64.59 | 63.40 | 61.92 | 60.49 | 61.66 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 767.05 |
| 36 | 1975 | 64.31 | 63.25 | 61.71 | 59.73 | 57.71 | 56.59 | 58.18 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 746.48 |
| 37 | 1976 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 38 | 1977 | 65.00 | 65.00 | 65.00 | 65.00 | 64.96 | 63.39 | 60.94 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 774.28 |
| 39 | 1978 | 65.00 | 65.00 | 64.75 | 63.91 | 62.97 | 62.33 | 64.72 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 773.68 |
| 40 | 1979 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 41 | 1980 | 65.00 | 64.46 | 63.31 | 61.89 | 60.40 | 59.06 | 60.13 | 64.58 | 65.00 | 65.00 | 65.00 | 65.00 | 758.84 |
| 42 | 1981 | 65.00 | 65.00 | 65.00 | 64.52 | 63.24 | 61.89 | 64.69 | 65.00 | 55.36 | 15.25 | 44.80 | 64.99 | 694.73 |
| 43 | 1982 | 65.00 | 65.00 | 65.00 | 64.69 | 63.37 | 61.97 | 61.34 | 62.54 | 63.18 | 62.07 | 60.94 | 60.10 | 755.20 |
| 44 | 1983 | 58.86 | 58.41 | 58.03 | 56.72 | 54.54 | 53.15 | 57.24 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 721.95 |
| 45 | 1984 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| 46 | 1985 | 65.00 | 65.00 | 64.41 | 63.44 | 62.41 | 62.07 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 772.33 |
| 47 | 1986 | 65.00 | 65.00 | 65.00 | 65.00 | 64.87 | 58.27 | 54.26 | 63.21 | 65.00 | 65.00 | 65.00 | 65.00 | 760.62 |
| 48 | 1987 | 65.00 | 65.00 | 65.00 | 64.87 | 63.86 | 58.10 | 54.09 | 60.88 | 65.00 | 65.00 | 65.00 | 65.00 | 756.80 |
| 49 | 1988 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 64.70 | 779.70 |
| 50 | 1989 | 63.55 | 62.80 | 61.99 | 60.76 | 59.12 | 58.60 | 61.20 | 65.00 | 65.00 | 56.90 | 21.16 | 26.53 | 662.62 |
| | TOTAL | 3239.36 | 3234.59 | 3225.44 | 3208.32 | 3182.71 | 3094.03 | 3063.10 | 3206.12 | 3238.54 | 3188.19 | 3180.14 | 3204.12 | 38264.61 |
| | AVE | 64.79 | 64.69 | 64.51 | 64.17 | 63.65 | 61.88 | 61.26 | 64.12 | 64.77 | 63.76 | 63.60 | 64.08 | 765.29 |
| | MAX | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 65.00 | 780.00 |
| | MIN | 58.86 | 58.41 | 58.03 | 56.72 | 54.54 | 53.15 | 53.15 | 58.47 | 55.36 | 15.25 | 21.16 | 26.53 | 662.62 |